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ABSTRACT

This three-part report examines chemistry education at the two-year college as revealed by a nationwide study of two-year science education which involved a review of the literature, an analysis of the catalogs and class schedules of 175 representative two-year institutions, and a survey of 82 chemistry instructors. Part I, in an examination of chemistry curricula at two-year colleges, first outlines the results of the catalog/schedule analysis as they relate to seven introductory courses, differentiated by either student majors or level of preparation, and five advanced courses, differentiated by content or specialized area. The section goes on to discuss the design of chemistry curricula at individual colleges in terms of the distribution of advanced and introductory courses by size of college, type of governance, and geographic location. Part II examines the results of the instructor survey, focusing on outcomes desired for students, student characteristics, instructional methods, use of class time and of instructional materials, student evaluation, instructors' educational and employment background, and the assistance available to them. Part III summarizes results and presents conclusions and recommendations. A bibliography and the questionnaire are appended. (JP)

SCIENCE EDUCATION IN TWO-YEAR COLLEGES: CHEMISTRY

by

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May 1980

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PREFACE

This monograph is one of a series of twelve publications dealing with the sciences in two-year colleges. These pieces are concerned with agriculture, biology, chemistry, earth and space sciences, economics, engineering, integrated social sciences and anthropology, integrated natural sciences, mathematics, physics, psychology, and sociology. Except for the monograph dealing with engineering transfer programs, each was written by staff associates of the Center for the Study of Community Colleges under a grant from the National Science Foundation (#SED 77-18477).

In addition to the primary author of this monograph, several people were involved in its execution. Andrew Hill and William Mooney were instrumental in developing some of the procedures used in gathering the data. Others involved in tabulating information were Miriam Beckwith, Jennifer Clark, William Cohen, Sandra Edwards, Jack Friedlander, and Cindy Issacson.

Field Research Corporation in San Francisco, under the direction of Eleanor Murray, did the computer runs in addition to printing the instructor survey employed in that portion of the project dealing with instructional practices. Bonnie Sanchez of the ERIC Clearinghouse for Junior Colleges and Janice Newmark, Administrative Coordinator of the Center for the Study of Community Colleges, prepared the materials for publication. Jennifer Clark did the final compilation of the various bibliographies for each monograph.

Florence B. Brawer coordinated the writing activities and edited each of the pieces. Arthur M. Cohen was responsible for overseeing the entire project.

In addition to these people who provided so much input to the finalization of this monograph, we wish to thank Ray Hannapel and Bill Aldridge of the National Science Foundation, who were project monitors.

Arthur M. Cohen
Project Director

Florence B. Brawer
Publications Coordinator

SCIENCE EDUCATION IN TWO-YEAR COLLEGES: CHEMISTRY

Chemistry is a central science taking from and giving to the other sciences, health sciences, and engineering. Chemistry programs are heavily influenced by the form and function of the institutions in which they are housed. This monograph examines the characteristics of chemistry in two-year colleges in view of its relationship to the other sciences and the diverse functions and heterogeneous student bodies of these institutions. It represents one part of a National Science Foundation (NSF) sponsored study of science education in community, junior, and technical colleges in the United States. The study, conducted by the Center for the Study of Community Colleges, was designed to provide a comprehensive picture of curriculum and instruction in the two-year college. A literature review of the most important studies of two-year college science education was conducted to determine what was already known about curriculum and instruction in the sciences. Curriculum data were gathered from the catalogues and class schedules of a representative national sample of 175 colleges. A random sample of science instructors in the 175 colleges were surveyed to determine instructional practices and to obtain some information on the science faculty.

This monograph explores the curriculum and instructional practices in chemistry and some of the resources available. It also includes recommendations for improving and strengthening these chemistry programs in two-year colleges.

The Two-Year Colleges

These colleges include the public community and junior colleges, private junior colleges, two-year technical institutes, and lower-division two-year centers of university systems. The public institutions, 84 percent of the total, are often characterized as open-door, comprehensive, community colleges; these three terms help account for the character of chemistry programs of two year colleges.

Two-year colleges enroll more than four million students -- one third of all students in higher education. There is great diversity in educational background, abilities, goals and interests among these students, a consequence of the open-door policies. Therefore, many programs and courses must be available. Specifically, in chemistry, not all science intending students are prepared to start at the same place. Furthermore, not all programs requiring chemistry need the same slice of the spectrum of chemical topics. Each chemistry course must be justified in terms of one or more of the functions of the comprehensive colleges: transfer, occupational, general education, remedial, counseling-guidance, and community service.

Additionally, the size and diversity of the student body have implications not only for the structuring of the chemistry curriculum but also for the presentation of chemistry to the students, a topic which is also considered here.

The Literature of Chemical Education in Two-Year Colleges

The literature background for this paper was obtained through a complete search of the Journal of Chemical Education (volumes 40-56, no. 7); the Journal of College Science Teaching (volumes 1-8); Chemistry in the Two-Year College (volumes 1-18); Division of Chemical Education National Meeting Abstracts (1963-1979 spring); the ERIC System; and Dissertation Abstracts (1963-78). Additionally, all publications of the Advisory Council on College Chemistry were reviewed as was an extensive collection of publications, reports, and papers concerned with chemical education and chemistry in the two-year colleges. This collection contains items from American Chemical Society component organizations, the National Science Teachers Association, American Association for Advancement of Science, Chemical Manufacturers Association; National Science Foundation and projects supported by NSF, state community college agencies and many other agencies and organizations. Other publications concerned with education and science also contained occasional references of interest. However, the community college literature contained little of interest to the study of chemistry.

The literature citations in this report are limited; they were selected for their pertinence to the specifics of this document. No attempt has been made to be comprehensive in citations or bibliography herein. However, an additional, comprehensive report is being prepared that will include all of the tables from which this report has been prepared as well as more extensive discussion, and a comprehensive bibliography on chemistry in the two-year colleges. When completed, the report will be available through the ERIC system.

Comprehensive studies relating to the topic of this monograph include the 1965-66 California two-year college chemistry curriculum study (Mooney, 1967); the 1966-67 national two-year college chemistry faculty study (Mooney & Brasted, 1969); the status of introductory college chemistry (Dodson, 1969); the analysis of patterns of introductory chemistry in the two-year colleges (Mooney, 1968); and the description of the chemistry curriculum at St. Petersburg Junior College (McKaig & Gay, 1965). Hill (1974) developed a concept-based unitized chemistry curriculum with units applicable to the needs of diverse student enrollments in beginning chemistry courses. Built-in flexibility in scheduling allows both individualization of course content and self-pacing of time. Most of the other literature references relevant to chemistry in the two-year colleges deal with specific courses or sequences in some way; 114 articles from the Journal of Chemical Education dealing with new approaches and ideas to the teaching of chemistry courses were surveyed by Hansrote (1979).

Guidelines for Two-Year College Chemistry Programs

In 1970 the ACS Committee on Professional Teaching, in collaboration with the COCTYC of the Division of Chemical Education, published the Guidelines for Chemistry Programs in Two-Year Colleges (ACS, 1970) for the expressed purpose of providing guidance to the teaching faculty and the administrators in charge of transfer programs in chemistry at the two-year college. Recommendations for two-year college chemistry programs contained therein include: (1) a one-year course in general chemistry; (2) a one-semester course in elementary chemistry to prepare students for general chemistry; (3) a one-semester course in quantitative analysis, in some situations; (4) a one-year course in organic chemistry, if it can be of the proper quality; and (5) separate courses for chemical technology programs.

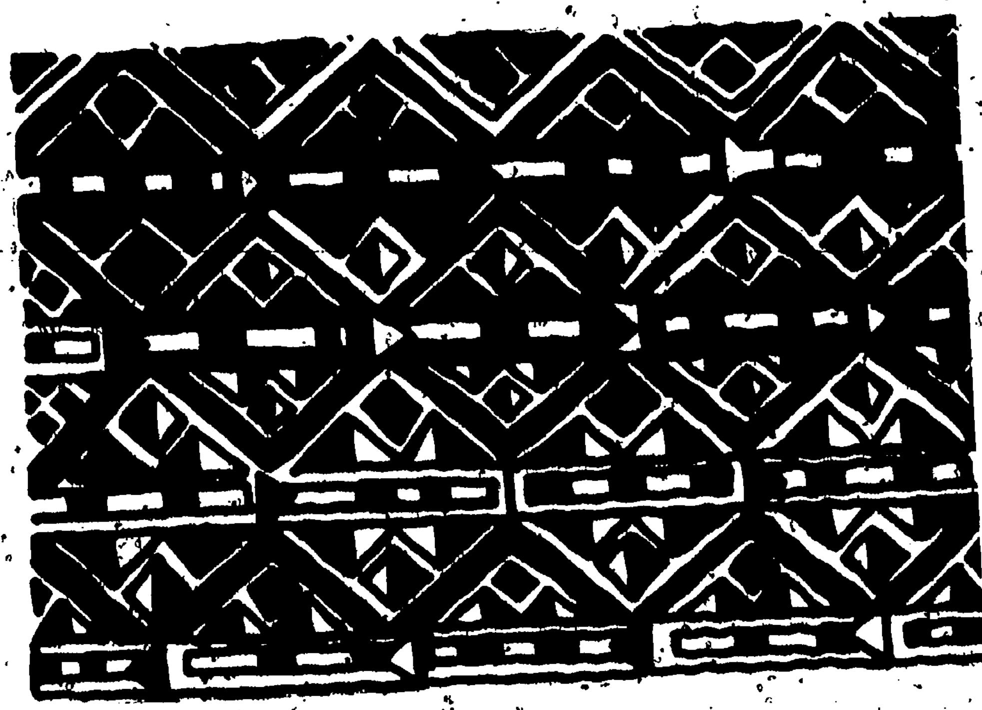
The two-year college Guidelines have not been revised since 1970, although the four-year program document upon which they were based was modified in 1977 (ACS, 1977). This revision includes the following statements related to the first two-years of college chemistry:

> . . .Usually the majority of students . . . take chemistry as a requirement in some other curriculum. Chemistry departments have an important obligation to serve the technical and broader educational needs of such students. . . . Lecture experiments and demonstrations - particularly effective in presenting descriptive material and in generating lasting interest in chemical phenomena - should be designed to provide greater emphasis on these latter aspects. Similarly, efforts should be made to use some of the newer

> types of learning media resources, . . . The first year's work should include an introduction to chemical principles and elementary chemical analysis. One semester or the equivalent should be devoted to basic inorganic chemistry, i.e., to descriptive chemistry dealing in a systematic way with the elements and the structures, properties, and reactions of their compounds. Students with strong high school preparation often complete suitable coverage of these topics in two semesters (or the equivalent in quarters); others may require three semesters. The introductory year is followed by two semesters of organic chemistry (p. 7-9).

The 1969 Conference on Science in the Two-Year College (ACS, 1971) recommended that: "Two-year college faculties respond to the diverse needs of their students by offering an appropriate variety of programs in the sciences . . . . The science content of occupational programs should be the joint concern of faculty in science and faculty in the occupational programs" (p. 2). The curriculum study reported herein is the first to indicate the extent to which two-year college science programs have responded to the diverse curriculum needs of their students.

This paper is divided into three parts. The curriculum study conducted by the Center for the Study of Community Colleges is presented in Part I. Part II discusses results of the survey of instructional practices while the last portion offers recommendations stemming from these investigations.



PART I

THE CURRICULUM STUDY

METHOD[1]

Sample

The selection technique used in this study produced a sample of 175 two-year colleges balanced by college control, region, and size based on data in 1977 Community, Junior and Technical College Directory (AACJC, 1977). Table 1 compares the distribution of our sample with that of the nation's two-year colleges population with respect to size, region, and control.

[1]For a complete methodology of this study, see Hill and Mooney (1979).

Table 1

Percent Distribution of Colleges by Size, Region, and Type of Control: Sample Compared to the National Group

(All figures are percent of national or sample group.)

A. BY SIZE

	Small Colleges			Medium Colleges			Large Colleges		
Enrollment Range	001-499	500-999	1000-1499	1500-2499	2500-4999	5000-7499	7500-9999	10000-14999	15000 or greater
National	15	18	13	17	17	8	5	5	4
Sample	13	16	13	17	19	9	5	6	4

B. BY REGION

Region*	Northeast	Middle States	South	Mid-west	Mountain Plains	West
National	7	13	32	21	10	17
Sample	6	12	31	22	13	16

C. BY THE TYPE OF CONTROL

Type of Control	Public	Private
National	84	16
Sample	84	16

*See Appendix A for list of states in each region.

Procedure

College catalogs and class schedules for the spring 1977 through winter 1978 terms (both semester and quarter colleges were included) were obtained from each of the 175 participating colleges. The curriculum phase of this project utilized the Course Classification System for the Sciences in Two-Year Colleges (Hill & Mooney, 1979) developed specifically for this project to analyze, classify and report the science courses in terms of both the unique features of the two-year colleges and the traditional science disciplines. The CCSS was applied as described below.

Based upon the catalog course description, each science course listed in the catalog was placed into one of six major curriculum areas: Agriculture and Natural Resources, Biological Sciences, Engineering Sciences and Technologies, Mathematics and Computer Sciences, Physical Sciences, or Social and Behavioral Sciences. These areas closely reflect the instructional administrative organization of two-year colleges as well as the organization of national and international science agencies, such as the National Science Foundation.

The second level of classification was executed primarily by the major subject field disciplines within the broad area. For example, the physical science classification has been subdivided into Chemistry - Introductory, Chemistry - Advanced, Geography, Geology, Other Earth and Space Sciences, Physics, Interdisciplinary Physical Science, or Environmental Science and Technology.

Introductory chemistry includes courses or sequences that the student may enter directly from high school; advanced courses are those requiring completion of one or more terms of the general chemistry course for science majors. Since there is a wide variety of courses in both of these groups, subcategories, listed in the following sections were developed to encompass closely-related courses. Courses were placed into subcategories after an analysis of the complete catalog description for that course. Course inclusion was not limited to those courses listed under the chemistry heading in the catalog nor to those taught by members of the chemistry faculty. Rather, any course for which the content is basically chemical in nature was included, regardless of the location in the catalog. Independent study, work-study, clinical, cooperative education, and non-credit continuing education courses were omitted from this study.

After all the science courses were classified, class schedules for the 1977-78 academic year (summer terms were excluded) were inspected, and the number of sections offered (day, evening and weekend) for each term were determined. Prerequisites for entrance into the course and the instructional mode (e.g., lecture, lecture-laboratory, laboratory) of the course were ascertained from the catalogs and schedules.

Introductory Chemistry Courses

This category includes those courses identified from the course and schedule analysis which are generally completed during a student's first year. Such courses introduce the student to chemistry and are concerned with the structure, composition and properties of the various kinds of matter (substances); the changes occurring when various kinds of matter are brought together and subjected to various conditions; and the energy effects associated with such changes. These courses tend to be general in nature and may include material from several subdisciplines (e.g., inorganic, organic, analytical, physical and biochemistry). However, they may also be specialized in approach and selective in topics.

The introductory courses tend to vary in content; level of chemical, physical and mathematical sophistication; and orientation because of the different needs, interests and backgrounds of the student groups for whom they are intended. These courses may rely heavily on laboratory work and prerequisites, especially mathematics, compared to other science courses. Many courses may relate to two or more subcategories (e.g., be intended for both preparatory and non-science students). In such cases, they were assigned to the one most emphasized by the college in the catalog description. The seven subcategories of introductory chemistry courses, differentiated by either student majors or the preparation of the students for whom the included courses are intended, are:

- Chemistry for Non-Science and Non-Technology and Related Occupations
- Chemistry for Allied Health and Other Biology Related Occupations
- Chemistry for Engineering Technology and Related Occupations
- Preparatory Chemistry
- General Chemistry for Science and Engineering
- Introductory Courses for Chemical Technologies
- Chemistry for Other Groups

Descriptions of each of these seven subcategories introduce the sections in which the findings for each group are discussed.

<u>Advanced Chemistry Courses</u>

Chemistry courses based on one or more terms of general chemistry for either science and engineering majors or chemical technology students comprise the advanced category. These courses are concerned with such specialized areas of chemistry as quantitative and instrumental methods of analysis, organic chemistry and biochemistry, chemical engineering and industrial chemistry, clinical chemistry, and physical chemistry. They are intended primarily for students majoring in chemistry, biochemistry, chemical engineering, chemical technology, and the biological and health sciences, including medical laboratory technology. Specialized courses not requiring general chemistry are included in the introductory category. The five subcategories of advanced chemistry courses, differentiated by content or specialized area rather than by student major or preparation as for the introductory courses, are:

Analytical Chemistry Including Instrumental Methods

Organic Chemistry Including Biochemistry

Industrial Chemistry and Chemical Engineering

Clinical Chemistry

Other Advanced Chemistry

Descriptions of these five also accompany the discussion of the findings.

RESULTS

The findings of the Curriculum Study are reported in the following sections. The first two sections present a profile based on the number of courses and then the number of sections; these are followed by a detailed report on each of the twelve subcategories of chemistry courses. This part is concluded by an analysis of the pattern of course offerings in individual colleges.

Chemistry Courses

Ninety-seven percent (97%) of the 175 colleges listed one or more chemistry courses in their 1977-78 catalog and all of these colleges offered at least one chemistry course in their schedules of classes for the spring 1977 through winter 1978 terms (summer excluded). All 97 percent of the colleges included introductory courses in both their catalogs and schedules. However, fewer colleges (79%) included advanced courses in the catalog and even less (72%) scheduled them, a result which argues strongly for the use of schedules when assessing course offerings of colleges rather than the common practice of reviewing catalogs.

Looking at the results in another way, the 1192 chemistry courses, 2528 lecture sections, and 2875 laboratory sections listed on the schedules in 1977-78 produced an average of 7.1 courses, 15.0 lecture sections, and 17.0 laboratory sections for those 169 colleges that offered chemistry.

Table 2 presents the results of the catalog and schedule analysis for each of the 12 subcategories of chemistry courses. One-third of all the chemistry courses were general chemistry; nearly another third were advanced courses; and the remainder, slightly more than one-third, were distributed among the other introductory types. The decreases from catalog to schedule were 10 percent or less, except for analytical chemistry, a phenomenon discussed later.

Chemistry Sections

To obtain a more complete measure of the extent of the chemistry curriculum one must consider the number of lecture and laboratory sections scheduled. This information is also included in Table 2 for each of the 12 subcategories. General chemistry predominates because of the larger enrollment characteristic of this course than the other types (Mooney & Brasted, 1969). Organic chemistry dropped relatively from the course ranking because many programs that require general chemistry do not require the organic; some students transfer to a four-year institution after the general sequence or wait to take organic

Table 2

Chemistry in the Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course in Schedule (n=175)	Percent of Total Chemistry Courses Listed on Schedule (n=1192)	Percent of Total Chemistry Sections Listed on Schedule Lecture (n=2528)	Percent of Total Chemistry Sections Listed on Schedule Lab (n=2875)
Introductory Courses	(97)	(97)	(68)	(83)	(84)
Chem for Non-Sci & Non-Tech Students	61	53	12	17	16
Chem for Allied Health/ Biol Occupations	55	49	14	14	14
Chemistry for Engin Techn/Related Occup	14	10	2	2	2
Preparatory Chemistry	29	26	5	10	6
General Chemistry for Science & Engineering	85	83	33	38	44
Introductory Courses Chemical Technologies	7	4	1	1	1
Chemistry for Other Groups	14	9	2	1	(<1)
Advanced Courses	(79)	(72)	(32)	(17)	(16)
Analytical Chemistry & Instrumental Methods	48	25	5	3	3
Organic Chemistry & Biochemistry	74	64	22	11	11
Industrial Chemistry & Chemical Engineering	7	4	1	1	(<1)
Clinical Chemistry	18	16	4	2	2
Other Advanced Chem	3	1	(<1)	(<1)	(<1)

Notes. 1. 169 colleges (97% of sample) list one or more chemistry courses in the college catalog.

2. 169 colleges (97% of sample) list one or more chemistry courses in schedules of classes.

at the four-year college; and other students change majors, convert to a part-time status, or drop out of college during or after their general chemistry.

The increase in percentage of laboratory sections over lecture sections for general chemistry is a consequence of the practice used by some colleges where two or more laboratory sections are scheduled for each lecture section. It is also influenced by lecture only sections, more preponderant in several other categories than in general chemistry.

Chemistry for Non-Science and Non-Technology Majors (NSM)

> The study of chemistry designed primarily for non-science and technology students, including liberal arts majors, to better acquaint them with the nature and fundamentals of chemistry as well as with chemical aspects of our physical environment and the relationship of chemistry to social, economic, and technological developments. These courses vary widely in the chemical topics included and often are thematically oriented, for example, chemistry of the environment or a historical view of chemistry. They may be multifunctional, serving as the preparatory course, the chemistry course for technicians and/or the whole or part of the chemistry requirement for allied health occupational students (CCSS).

The NSM courses are included in the chemistry curriculum because the conventional general chemistry courses and the more specialized occupationally related courses do not adequately meet the needs of those students who will not be scientists, engineers or technicians but who will be important citizens in a society considerably influenced by science.

The NSM courses offered by 53 percent of the colleges, accounted for 12 percent of the chemistry courses, 17 percent of the lecture sections and 16 percent of the laboratory sections (Table 2).

The four types of NSM courses (Table 3) differ in two ways: content or emphasis, a general approach versus a thematic thrust; and length, one term versus a year sequence. The predominant course is the one term comprehensive type. Only 7 percent of the colleges offered both a short course and a second NSM course or sequence.

Table 3

Chemistry Courses for Non-Science and Non-Technology Majors (NSM), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course		Percent of Total NSM Courses of This Type Scheduled (n values at left)	Percent of Total NSM Courses on Schedule (n=171)
	in Catalog (n=175)	on Schedule (n=173)		
Comprehensive One Term (n=78)*	41	34	83	49
Comprehensive One Year (n=74)	20	17	76	42
Environmental (n=11)	6	4	63	5
Other Specialized (n=8)	2	2	75	4

*Number of courses of this type listed in catalogs. This notation will be used on similar tables throughout the monograph without additional footnotes.

The NSM chemistry courses are more popular in the west (86% of the colleges), midwest (64%) and mountain-plains (54%) regions than in the middle states (43%), south (33%) or northeast (27%); in public colleges (55%) than private (28%); and in large colleges (84%) than in medium (54%) or small (39%). The one-term course predominates in all regions.

The NSM courses, predominantly lecture-laboratory (78%), tended to grant four units of credit (55% of both semester and quarter colleges) and favor three hours per week of lecture (60% quarter, 71% semester). Laboratory work was included in 86 percent of the NSM courses, with three hours of laboratory preferred (44% quarter, 50% semester) over two hours (48% quarter, 24% semester).

There were no prerequisites for 79 percent of the NSM one-term courses or sequences. However, 10 percent required elementary algebra but only 3 percent, a previous chemistry course.

Nomenclature for NSM chemistry courses is confusing; 31 different titles were used for 98 individual courses or sequences. The five most frequently found were general chemistry (16), introductory chemistry (11), introduction to chemistry (9), fundamentals of chemistry (7), and basic chemistry (6). Additional confusion results because many of these titles are similar to those found for the allied health, technician, preparatory, and general chemistry courses.

The development and evaulation of a new lecture-laboratory NSM chemistry course, primarily for students entering under the open admissions program at the Borough of Manhattan Community College is well documented; lecture (Jaffe et al., 1975) laboratory (Markisz et al., 1975); in a PSI format (Spevack, 1973, 1975); and in a closed circuit TV approach (Levine, 1973). Other significant contributions include using "real" samples in laboratory (Nordmann, 1967) and an investigation of the mathematical skills of the NSM chemistry students (Perkins, 1979). Hostettler (1979) gives an extensive bibliography for teachers of NSM courses and Fuller (1974) reviews the decade of increasing interest in this area.

Chemistry for Allied Health and Other Biology Related Occupations (AH)

> The courses included herein are designed primarily for both two-year occupational and transfer students enrolled in any of the allied health, agricultural, natural resources or similar programs. These courses include the study of selected topics from inorganic chemistry, organic chemistry and biochemistry, with applications to living systems as encountered in advanced study or work in these fields. Courses for the occupational programs tend to be shorter; less intense; have lower prerequisites, if any; and are apt to be more specialized than those for the transfer students (CCSS).

The AH chemistry courses have grown in popularity more rapidly than any other type of introductory course. This is probably a consequence of the recent national emphasis placed on occupational and paraprofessional education in the health sciences. Although not mentioned in the Guidelines (ACS, 1970), the AH courses are an excellent response to the recommendation that chemistry departments serve the technical and broader educational needs of students who are not chemistry majors but who are enrolled in first year chemistry courses (ACS, 1977).

The AH chemistry courses, offered by 49 percent of the colleges accounted for 14 percent of the laboratory sections (Table 2). The four types of AH courses (Table 4) differ in three ways: content, inorganic-organic-biochemistry as opposed to separate organic or biochemistry courses; length, one versus two or three terms; and majors, all AH and related students or majors in a specific occupational program.

Although the short course was scheduled by more colleges than the long one, nearly half of the total courses of this type were part of a long course sequence. Only slightly more than one-third of the courses were of the short variety. The separate organic or biochemistry courses require something less than general chemistry as preparation; hence, they are included as introductory courses. Finally, courses for specific programs emphasize the chemical knowledge and techniques required in the program they serve.

Table 4

Chemistry Courses for Allied Health and Other Biology Related Occupations (AH), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total AH Courses of This Type Scheduled (n values at left)	Percent of Total AH Courses on Schedule (n=157)
Inorg. - Org. - Biochem. Short Course (n=56)	29	24	82	36
Inorg. - Org. - Biochem. Long Course (n=86)	25	22	87	48
Organic or Biochem. (n=26)	11	8	58	10
Courses for Specific Programs* (n=24)	8	6	88	13

*Includes food, agricultural, embalming, fisheries, medical laboratory technology, and nuclear medicine chemistry courses.

Only 39 percent of the single course or first term AH courses listed prerequisites. Long courses tend to have more prerequisites than the one term course; 33 to 6 percent require algebra; and 17 percent to 13 percent, high school chemistry. Approximately one third of the organic/biochemistry and specific program courses require a previous college chemistry course.

The inorganic - organic - biochemistry type (short and long courses combined) are more apt to be found in the northeast (45% of the colleges), west (39%) or midwest (38%) regions than the south (33%), middle (24%) or mountain-plains (23%) states. They tend to be in public (36%) rather than private colleges (25%); in technical (39%) or comprehensive (35%) rather than liberal arts (13%) colleges; and in large (44%) or medium (38%) rather than small (26%) colleges. The one term course predominated in all categories except for the west and the small and large colleges, where, in each case, the year course was equal to the short in frequency.

The one-term AH chemistry courses were primarily four (50%) or five (22%) units, with three (52%) or four (20%) hours lecture and three (41%) or two (30%) hours laboratory. However, 17 percent of the courses were non-laboratory. Comparatively, the year courses were primarily four (60%) or five (33%) units with three (68%) or four (24%) hours lecture; and three (55%), two (18%), or four (12%) hours laboratory; only five percent were non-laboratory.

As with the NSM courses, there is no consistency in naming the AH courses; 21 different titles were used for the short courses and 30 for the long. For the short course, 52 percent were named without reference to the health sciences or life processes, using terms such as principles of chemistry, general chemistry or introductory chemistry; 45 percent of the long courses were so named. Titles including health sciences, allied health or similar terms were assigned to 27 percent of the short courses and 12 percent of the long. Titles referring to life processes in some way accounted for the remaining 21 percent of the short courses; whereas, titles including the terms organic or biochemistry were used in 43 percent of the long courses.

Recent developments in the AH chemistry curriculum include course development in conjunction with allied health faculty and professionals (Deckard, 1976-1977; Gaglione, 1975; Laughlin, 1973; Stanitski & Sears, 1975) and use of biologically relevant illustrations (Timberlake, 1974, 1975) and laboratory experiments (Dever, 1975). The AH course appears to be uniquely suited for individualized instructional approaches (Halpern, 1975-1976; Laughlin & Kurnath, 1975; McGhee, 1975-1976) and similar to general chemistry, for studies designed to predict success (Mamantov, 1976; Paul, 1978).

Chemistry for Engineering Technology and Related Occupations (TECH)

> These courses are designed primarily for both two-year occupational and transfer students in any engineering technology, industry-related occupational, or similar programs (other than those that are chemically based). These courses include selected topics from inorganic chemistry with applications to materials science and engineering related activities. Courses designed for a single program tend to be more specialized than those serving several programs (CCSS).

The biology/health sciences and engineering materials science area draw heavily on chemistry in their study and practice. However, because the chemical emphasis in living systems and engineering materials systems is different, the chemical needs of the technicians in the engineering technology areas differ from those of the allied health groups considered in the previous section. Consequently, many community colleges include separate chemistry courses for the engineering related technologies.

TECH chemistry courses were offered by ten percent of the colleges although they accounted for only two percent of all chemistry courses as well as a similar portion of both the lecture and laboratory sections (Table 2).

The TECH chemistry courses were differentiated in terms of length, one-term or two-or-more terms; and audience, designed for several technician programs or for more specialized groups (e.g., corrosion, plastics or water) (Table 5).

Table 5

Chemistry Courses for Engineering Technology and Related Occupations (TECH), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total TECH Courses of This Type Scheduled (n values at left)	Percent of Total TECH Courses on Schedule (n=24)
One Term Course for Technicians (n=14)	6	6	86	50
Two or More Term Course for Technicians (n=14)	3	2	50	29
Specialized Courses* (n=6)	5	3	50	21

*Includes nuclear chemistry, water chemistry, corrosion chemistry, chemistry of plastics, chemistry for industrial safety, chemistry for plumbers, and unit operations.

The TECH courses tended to grant four or five units credit (54% and 25%) and be scheduled for three or four hours lecture (58% and 29%) and three or two hours laboratory (50% and 25%) per week. Seventy percent of the courses included both lecture and laboratory, and 22 percent were lecture only.

TECH chemistry courses are more apt to be found in the midwest (18% of the colleges), west (17%), south (15%), or middle states (14%) regions than mountain-plains (9%) or northeast (9%); in public (17%) rather than private colleges (none); in technical (28%) rather than comprehensive (13%) or liberal arts (7%) colleges; and in medium (18%) or large (18%) rather than small (10%) colleges.

Although 60 percent of the TECH courses had prerequisites listed, only eight percent required a previous chemistry course; 24 percent required mathematics of various levels. Most other prerequisites involved enrollment in a specific curriculum. More than two-thirds of the non-specialized TECH courses (68%) were named technical chemistry, chemistry for technicians, or industrial chemistry; the others had a variety of names similar to those for the non-science and preparatory courses.

Innovations in TECH chemistry courses in two-year colleges include a water chemistry course (Kramer, 1975); an environmental analysis course for conservation students (Loconto, 1977); and an applied course for the science and engineering technology (SET) curriculum (Wolf, 1975).

Preparatory Chemistry Courses (PREP)

> This group includes courses to prepare students for other introductory chemistry courses, primarily the science majors course and are designed for students with no previous chemistry or weak chemical backgrounds whose educational programs require one of the other introductory chemistry courses or sequences. Generally, the courses include an introduction to the principles of chemistry, including the modern concepts of atomic structure as a basis for understanding valence, formulas, equations, and chemical reactions and an emphasis on chemical calculations (CCSS).

In practice, many students enter two-year colleges without high school chemistry or with a weak background in the science. Additionally, many students have avoided the high school mathematics courses recommended for students who intend to pursue science and engineering majors in college; whereas, others may have completed such courses but cannot apply their mathematical skills and techniques to solve problems characteristic of general chemistry. For reasons such as these, the ACS Guidelines (1970) recommended that a one semester course in elementary chemistry be offered for students who have had no previous training in chemistry or who have a poor high school background. Similarly, the ACS Criteria (1977) recommended three semesters for the under-prepared student to accomplish what the well-prepared student could do in two. Such a one semester course would be a suitable prerequisite to substitute for a year of high school chemistry in qualifying the student for the year course in general chemistry.

Studies conducted by the National Association of Secondary School Principals on the causes of the under-preparation of college students, and by the College Board on the decline in SAT scores, have implications for college chemistry. Furthermore, the teaching of college chemistry to under-prepared students who cannot meet the demands of a rigorous college program is becoming a growing national concern of educators (Taft, 1979). Taft infers from the available data that although a relatively small number of students are prepared for the general chemistry course a far larger group need the remedial courses currently offered by many colleges as prerequisites for the more demanding general chemistry courses. Such preparatory courses require considerable faculty time and money; however, they are essential to avoid high dropout rates from the general chemistry courses or the lowering of standards among college graduates in the sciences.

The Subcommittee on the Underprepared Student (Kotnik, 1974) studied chemistry student deficiencies in 391 colleges, including 125 two-year institutions. The six deficiencies reported most frequently by the two-year colleges were identical in rank order with those of the four-year colleges. In all cases, however, the deficiencies were mentioned more frequently by the two-year respondents. These data support a widely-voiced contention that students entering two-year colleges are less well prepared, on the average, for college chemistry than those entering four-year colleges.

PREP chemistry courses were offered by 26 percent of the colleges; they accounted for five percent of all chemistry courses as well as ten percent of the lecture and six percent of the laboratory sections (Table 2). The PREP courses tend to differ from each other in length, one term or two or more terms; in relationship to enrollment in general chemistry, prerequisite to or concurrent with; and in emphasis, introduction to chemistry or chemical calculations. From Table 6 we note that the predominant type is a one term course, introductory to general chemistry offered by 22 percent of the colleges.

PREP courses were less apt than most other types to include laboratory work; only 48 percent were lecture-laboratory, 33 percent were lecture only, and 15 percent were classed as 'other'. Most one-term preparatory courses meet for three (44%) or four (21%) lecture hours and two (26%) or three (33%) laboratory hours per week although 26 percent have no laboratory. Credit is distributed primarily among three (33%), four (35%) and five (26%) unit courses. Prerequisites were minimal, 77 percent require no mathematics, 97 percent no chemistry and 97 percent no test results.

Table 6

Preparatory Chemistry Courses (PREP),

Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total PREP Courses of This Type Scheduled (n values at left)	Percent of Total PREP Courses on Schedule (n=51)
One Term Course Prerequisite to General Chemistry (n=33)	25	22	91	76
Two or More Term Course Prerequisite to General Chemistry (n=4)	1	1	100	8
Concurrent Course with General Chemistry (n=4)	2	2	75	6
Chemical Calculations Course (n=7)	3	1	57	8

PREP courses were more apt to be found in the west (50% of the colleges) or south (24%) region than in the middle states (19%), midwest (15%), northeast (9%) or mountain-plains (5%); in public (25%) rather than private (7%) colleges; in comprehensive (10%) rather than liberal arts (7%) or technical (6%) colleges; and in large (56%) rather than in medium (27%) or small (6%) colleges.

As with the NSM and AH types of courses, there is no agreement on the titles for the PREP courses; 25 different titles were used for 39 one-term courses. The most frequently found were basic chemistry (5), and preparatory chemistry, elementary chemistry, introduction to chemistry and chemistry (all 3).

Our findings on the frequency of preparatory chemistry offerings are lower than those reported nationally by Kotnik (1974). Kotnik determined that 43 percent of the two-year colleges (n=125) and 30 percent of the four-year colleges (n=266) responding to the questionnaire offered remedial programs in chemistry. This study also revealed that the precentage of four-year college remedial programs in chemistry (30%) more nearly approximated their percentages for mathematics (53%), reading (41%) and English (41%) than was the case for the two-year colleges where chemistry (43%) was much lower than mathematics (91%), reading (83%), and English (85%). Considering that 97 percent of the two-year colleges reported problems with under-prepared students, one must ask why more two-year colleges do not have preparatory courses in chemistry?

A variety of approaches have been attempted in both the content and instructional methods for PREP courses (Gay, 1971; Kotnik, 1973; Krannich et al., 1977; Meckstroth, 1974; Santiago, 1971; Sherman & Sherman, 1976) as well as in studying and reporting the success of these courses in preparing students for general chemistry (Coley, 1973; Krannich et al., 1977; Mooney, 1965; Ozsogomonyan & Clinkscales, 1977; Schaumburg, 1973).

General Chemistry for Science and Engineering Majors (GEN)

> These courses satisfy the general chemistry, including qualitative analysis, requirements for students majoring in any of the physical or biological sciences, engineering or pre-professional health sciences programs. They include the study of the fundamental

theory and principles of atomic and molecular structure and chemical interactions as well as the chemical elements and their compounds. Also included are periodic relationships, acids and bases, physical states of matter, electrochemistry, oxidation-reduction, solutions, thermodynamics, kinetics, equilibrium, nuclear chemistry and an introduction to organic chemistry. The laboratory often includes qualitative analysis of common ions and elementary quantitative analysis techniques. These courses are generally organized into a one-year sequence and tend to rely heavily on prerequisites (CCSS).

The basic chemistry course for science majors in a two-year college program should be a one-year course in general chemistry with laboratory (ACS, 1970). Recommended prerequisites for this course are a year of high school chemistry and high school mathematics through the second year of algebra, with a year of high school physics desirable. Furthermore, the course should involve a minimum of three lectures or classroom sessions per week, a minimum of three hours of laboratory per week, and one or more hours of recitation - a minimum of seven or more hours of class per week. The <u>Guidelines</u> also note that many four-year colleges have four to six hours of laboratory per week and suggest that in some cases, eight to ten class hours per week is desirable. The suggestion is also made that the laboratory work may include a limited amount of qualitative analysis as a means for teaching basic equilibrium principles and the chemistry of a limited number of elements. Additionally they report that many freshman courses in four-year institutions include work in quantitative analysis done to a precision of a few parts per 1000, and in sufficient amount to provide experience in gravimetric, titrimetric and very basic instrumental methods. Some large universities have a separate first year course for chemistry majors. Many, however, do not, and most smaller universities and four-year colleges as well as the two-year institutions offer a single course of this type. A strong driving force in this direction is the desire of the professional groups and academic departments in the other sciences and engineering that their students satisfy the general chemistry course requirement through a program at the same level of chemical, mathematical and physical sophistication as do the chemistry majors.

GEN chemistry courses were scheduled by 83 percent of the colleges accounting for 33 percent of the courses, 38 percent of the lecture sections, and 44 percent of the laboratory sections (Table 2). How do the GEN chemistry courses in the two-year colleges compare to the <u>Guidelines</u> recommendations?

Only 45 percent of the GEN chemistry sequences require high school chemistry to enter the first term; another seven percent recommend it. An even smaller group (38%) requires the completion of two years of high school algebra or more mathematics to enter the sequence. Two percent recommended high school physics. At the opposite extreme, 46 percent of the sequences have no prior chemistry prerequisite and 38 percent require no mathematics. Consequently, we conclude that more GEN chemistry sequences fall short of the prerequisites in the <u>Guidelines</u> than meet or exceed them. At this point we must draw attention to the chemistry faculty (63%) responding to the Center Instructor Survey (Appendix B) who indicated that to improve the course they needed students better prepared to handle the course work; this response was the highest of any field on any of the 16 items. Additionally, 35 percent requested stricter prerequisites, a need exceeded only by respondents from physics, mathematics, and biology. Twelve percent of the colleges indicated in the catalog that test results were also considered in determining readiness to enter the general chemistry sequence: five colleges used chemistry tests; five, mathematics tests; two, the ACT; and seven were unspecified. Considering both the prerequisite and survey data, we conclude that many two-year colleges must increase their prerequisites for general chemistry as well as enforce the existing ones and, possibly, validate the student's preparation by an examination.

Now considering the time requirements, only 39 percent of the sequences average seven or more hours per week per term; 49 percent average six hours. However, 14 percent require nine or more hours and 12 percent less than six. The minimum of 3 hours of laboratory per week per term is met by 86 percent of the GEN chemistry courses; in fact, 26 percent require the four to six hours suggested by the Guidelines, but 15 percent require less than three hours. Therefore, we conclude that the majority of the GEN chemistry sequences in the two-year colleges fall short of the total time and suggested laboratory time of the Guidelines, although, six out of seven satisfy the minimum laboratory hour requirement. Most GEN chemistry sequences (56%) grant eight semester units, although 39 percent grant 10 or more units credit.

Since the course descriptions in the college catalogs are highly diverse in style and content, we were unable to conclude in percentages how extensively qualitative analysis is included in general chemistry. Perusal of the descriptions during the classifications suggested that a high percentage include some qualitative analysis during the last term of the sequence but failed to provide any sense of how extensive qualitative analysis is in any course. This same review process provided even less information about the inclusion of work in quantitative analysis in general chemistry.

One of the most important findings of this study is that as the number of contact hours per week for the general chemistry course sequence increases, the more apt the college is to require a previous course in chemistry to enter general chemistry. The data supporting this observation are as follows:

90 percent of the nine contact hour sequences require chemistry;

48 percent of the seven contact hour sequences require chemistry;

38 percent of the six contact hour sequences require chemistry.

Therefore, we must ask how colleges with only six contact hours per week per term for general chemistry justify so little time for the course, especially when they are apt to allow less qualified students to enter. The converse must also be asked. How can these colleges allow students with as little chemistry and mathematics preparation to enter a GEN chemistry course for which so little class time is allowed?

General chemistry sequences may be classified into low level (prerequisites less than stated in the ACS Guidelines); high level (prerequisites equal or exceed the Guidelines, but calculus is not required); calculus based; specialized courses for engineering, biology/health science, or agriculture majors; and separate qualitative analysis courses (Table 7). The low level GEN chemistry sequence predominates. Fifty-eight percent of the high level sequences (13% of all the sequences) satisfy the Guidelines recommendations on class and laboratory hours per week. None of the calculus based or specialized courses meet all the criteria. Consequently, only approximately one of every eight of the GEN chemistry course sequences met the ACS Guideline criteria.

Table 7

General Chemistry Courses for Science and Engineering Majors (GEN), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total GEN Courses of This Type Scheduled (n values at left)	Percent of Total GEN Courses on Schedule (n=366)
High Level[a] (n=85)	21	21	95	22
Low Level[b] (n=284)	68	67	98	76
Calculus Based[c] (n=4)	1	1	100	1
Specialized[d] (n=6)	2	1	33	1
Qual Anal[e] (n=4)	2	1	25	<1

[a]Requires or recommends one year of high school chemistry or equivalent and a minimun of two years of high school algebra as a prerequisite.

[b]Requires less than the prerequisites in a.

[c]Requires completion of a concurrent enrollment in a calculus course.

[d]Courses designed primarily for engineering majors or agriculture majors or biology and health science majors.

[e]Separate courses in qualitative analysis only.

None of the two-year colleges offered a separate general chemistry course for chemistry majors; however, eight percent of the colleges included two GEN chemistry sequences, most of which differed in hours required and prerequisites. The GEN chemistry courses that satisfy all of the Guidelines recommendations are more apt to be located in the west (54% of the western colleges), midwest (23%) or middle states (19%) regions than in the south (11%), mountain-plains (6%) or the northeast (none); in public colleges (24%) than private (4%); in large sized colleges (56%) rather than medium (23%) or small (7%).

Although 26 different titles were used for naming the GEN chemistry courses, there was more agreement than for the other introductory chemistry subcategories. General chemistry was used for 56 percent of the sequences and in combination with other terms such as college; inorganic and qualitative analysis by another 17 percent. College chemistry (9%) in a combination (7%) was the second most popular term followed by inorganic (9% including combinations) and principles (5% including combinations). Qualitative or quantitative analysis were used in 10 percent of the cases. To avoid confusion and misinterpretation in transferring, papers presented at meetings, marketing of instructional materials, and the literature of chemical education, we believe the terms general, college and principles should be reserved for the GEN chemistry type course and other terms used for the NSM, AH, TECH and PREP courses.

The course content for general chemistry - nationally, all types of colleges - has been studied by analysis of final examination questions (Goldsmith, 1978; Young, 1964) and by a rating of topics by faculty (Jones & Roswell, 1973; Nechamkin, 1961); in both methods the later study found a slight shift in emphasis towards more theoretical and less descriptive topics. Additionally, the content has been described for specialized general chemistry courses for students in agriculture and natural resources (Marshall, 1971); engineering (Krakower, 1973) and environmental and applied sciences (Kriz, 1978).

Two-year college faculty have been active in investigating various approaches to the individualization of instruction in general chemistry: audio-tutorial (Haggard, 1972; Howard, 1972, 1974; Hunter, 1973; Stokes, 1974), PSI (Clevenger, 1975; Jones, 1977), programmed learning (Cheek, 1975) and open laboratories (Hamilton & McMahon, 1976). They have also used instructional methods aimed at taking advantage of student interests to make general chemistry relevant (DeLorenzo, 1976; Mitchell, 1979; Suter, 1974). Additionally, they have studied extensively the relationship of test scores to success in general chemistry (Cangemi, 1972; Hein & Reifsnyder, 1962; Mann, 1976, 1977; Miller, 1974; Mooney, 1965) and found that several different tests, along with other factors can be used to predict success or grades or identify students in need of remediation.

<u>Introductory Courses for Chemical Technologies</u> (CHM TCH)

> These courses are designed specifically for first-year students in chemical technology, chemical engineering technology, industrial chemistry or closely related occupational programs. They may include a general chemistry course as well as orientation, introductory laboratory techniques and chemical calculations, organic chemistry, and industrial chemistry courses. They generally emphasize laboratory techniques, industrial chemistry and descriptive chemistry more and the theoretical aspects of chemistry less than the general chemistry courses above (CCSS).

The ACS Guidelines (1970) recommend parallel programs at the two-year college, one for the transfer student (as described earlier), the other designed primarily to train chemical technicians who will enter industry after a two-year program. The Guideline recommendations for specific transfer courses are not appropriate for the terminal technician program; the two purposes are sufficiently different to make it desirable that separate courses be offered in the two programs.

CHM TCH courses, the smallest of the introductory chemistry subcategories, were offered by only four percent of the colleges and accounted for only one percent of all chemistry courses; likewise for both lecture and laboratory sections (Table 2). Table 8 shows the distribution of CHM TCH courses among three types: introduction/orientation, general chemistry, and organic chemistry. General chemistry courses for chemical technicians, offered in three percent of the colleges, constituted the majority of these courses.

Most CHM TCH courses (56%) include three hours of lecture per week. There is no predominant laboratory hour pattern (range 0-9 with 3 and 5 hours each in 19% of courses). Forty percent offered four units credit and 40 percent either five or six units (range 1-7). Both lecture and laboratory were found in 87 percent of the courses.

CHM TCH courses are more apt to be found in the middle west (15% of the colleges) or south (9%) regions than in the middle states (5%), west (4%) or northeast or mountain-plains (both none); public colleges (12%) than private (4%); technical (11%) rather than comprehensive (8%) or liberal arts (none); and large colleges (16%) rather than medium (8%) or small (4%).

Although 60 percent of these courses listed prerequisites, only 30 percent of the first term courses had any listed. Only 38 percent of the course titles specified chemical technology or technicians; the remaining titles were similar to those used for general chemistry and other courses of the chemistry curriculum, adding to confusion.

A study of chemical technology in the two-year colleges is not complete without mentioning the Chemical Technology Curriculum Project (Chem-TeC) program (Pecsok, 1971) and the Wyoming Chemical Technology program (Nelson, 1975; Nelson et al., 1976). The Chem-TeC materials have shaped the curriculum of many two-year college chemical technology programs (Hallman & Neumann, 1976); whereas, the Wyoming project features integration of chemical technology and chemistry in the curriculum in an innovative two-year and four-year college articulation program. Cherim (1975) describes a single course program with a biochemical orientation for laboratory technicians in research laboratories which aims to give an understanding of what modern instruments measure.

Table 8

Introductory Chemical Technology Courses (CHM TCH), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total CHM TCH Courses of This Type Scheduled (n values at left)	Percent of Total CHM TCH Courses on Schedule (n=16)
Introduction or Orientation to Chemical Technology (n=8)	5	2	50	25
General Chemistry for Chemical Technology (n=21)	5	3	43	56
Organic Chemistry for Chemical Technology* (n=4)	1	<1	75	19

*Does not require a general chemistry course as prerequisite.

Chemistry for Other Groups (MISC-I)

> This miscellaneous group includes courses for curricula or groups not covered above such as fire science, police science, and printing. The content varies widely and is dependent upon the relationship of chemistry to the occupation (CCSS).

Some two-year colleges offer chemistry courses for curricula or purposes other than those discussed already - for example, courses for police science or fire science majors as well as the chemistry of printing or textiles. Here again we found examples of colleges serving the technical, and, perhaps, the broader educational needs of their students. These MISC-I courses are closely related to a particular occupational program; generally, the program grants them a minimum of time and prescribes content closely related to the chemical applications encountered in that occupation.

MISC-I courses were limited to nine percent of the colleges and accounted for only two percent of the chemistry courses offered, one percent of the lecture sections, and less than one percent of the laboratory sections (Table 2). They were the least likely of all types of courses to state prerequisites (38% of the courses); also, the least likely to have lecture-laboratory (38%). Furthermore, 53 percent were lecture only courses, the highest of any category. Only one-half of the other introductory chemistry courses listed in the catalogs were actually scheduled.

The MISC-I courses are differentiated by either the occupational group served or the area of applied chemistry considered (Table 9).

Fire science courses predominated, accounting for nearly half of all the MISC-I group, although they were offered in less than half of the colleges listing them in the catalog. The majority of these courses are for three hours lecture per week (61%) and no laboratory (55%). Six of the eight with laboratory use two hours per week. Two-thirds of the courses offer three units of credit.

Table 9

Other Introductory Chemistry Courses (MISC-I), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total MISC-I Courses of This Type Scheduled (n values at left)	Percent of Total MISC-I Courses on Schedule (n=18)
Fire Science (n=17)	8	4	47	44
Printing (n=5)	2	2	20	6
Police Science (n=3)	2	2	100	17
Other* (n=7)	3	<1	25	6

*Includes textiles, cosmetics, and photography chemistry.

MISC-I courses are most apt to be found in the middle west (13% of colleges) or south (11%) regions than in the northeast (9%), west (7%), middle states (5%) or mountain-plains (4%); in public (10%) than private (none) colleges; in large (20%) rather than medium (10%) or small (3%) colleges. In all cases the names of these courses carried the name of the occupational group (e.g., fire science chemistry) or the area of applied chemistry (e.g., textile chemistry). Description of courses related to the fire science (Fashing & Flynn, 1974) and police science (Sauls & Wartell, 1976; Tyndall, 1975) chemistry curriculum show the applications of chemistry needed by these students.

Analytical Chemistry Including Instrumental Methods (ANAL)

> These courses include the study of the theories, principles, and techniques of volumetric, gravimetric, and instrumental methods of analysis, including potentiometric, spectrophotometric, chromatographic and other modern methods organized into courses such as quantitative analysis, instrumental methods of analysis and special techniques for environmental analysis. Special techniques for clinical and industrial materials are included in the clinical and industrial chemistry courses (CCSS).

A one-semester course in analytical chemistry is desirable in a two-year college if such material is not included in the first year course. The course should be based on the one-year general chemistry sequence, and should include lectures and laboratory work, including the use of such instruments as a pH meter and spectrophotometer, as well as experiments in gravimetric and volumetric analysis (ACS, 1970).

Analytical chemistry courses, the second largest category of advanced courses, were offered by only 25 percent of the colleges; they accounted for five percent of the chemistry courses, three percent of the lecture and three percent of the laboratory sections. ANAL courses were listed in the catalog but not scheduled by 23 percent of the colleges (Table 2). The five types of ANAL chemistry courses (Table 10) differ in three ways: content, quantitative analysis techniques or instrumental methods; length, one term or a year; and majors, science and health sciences or chemical technology.

Table 10

Analytical Chemistry Courses (ANAL), Two-Year Colleges, 1977-78

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total ANAL Courses of This Type Scheduled (n values at left)	Percent of Total ANAL Courses on Schedule (n=57)
Quant. Analysis One Term (n=62)	36	18	51	56
Quant. Analysis Chem. Tech. (n=12)	5	7	75	16
Instrum. Methods Chem. Tech. (n=9)	3	3	100	16
Instrum. Methods One Term (n=13)	7	4	54	12
Quant. Analysis One Year (n=19)	5	0	0	0

The predominant ANAL course is the one-term quantitative analysis course for science and pre-professional students. Most (84%) one-term courses grant four or five units of credit and schedule six hours of laboratory (69%) and two hours of lecture (69%). They are most apt to be found in the west (43% of the western colleges), in a public college (20%), and a large college (36%). They are least likely to be offered in the northeast (no colleges) and the small colleges (11%).

The low figures for separate instrumental methods courses are most likely rationalized by the senior level status, post physical chemistry, of instrumental methods for chemistry majors; the lack of such a requirement for other majors; and the growth of separate instrumentally-oriented clinical chemistry courses for clinical laboratory technology programs; as well as the cost of instrumentation.

The recommendations of the analytical chemistry subcommittee of the curriculum committee emphasize the total problem approach and the use of real life samples, and give ideas on the development of procedures and the choice of instruments (Sherren, 1972, 1974 a, b). Two-year colleges include courses consistent with these recommendations (Hayes, 1979; Nordmann, 1972) as well as courses aimed at the interests of non-chemistry majors (Fulkrod, 1976). Several aspects of analytical chemistry of concern to two-year college chemists have recently been studied: student attitudes (Klatt & Sheafer, 1974) and a comparison of the views of medical school and college teachers (Pickral, 1976).

<u>Organic Chemistry Including Biochemistry</u> (ORG)

> Organic chemistry courses involve the study of carbon containing compounds in terms of nomenclature, atomic and molecular structure, molecular geometry, stereochemistry, resonance, and reaction mechanisms for both aliphatic and aromatic compounds, including the hydrocarbons, monofunctional and polyfunctional derivatives, carbohydrates and proteins. These courses may include experiences in fundamental laboratory techniques and related theories as well as preparations, determination of properties, qualitative organic analysis and instrumental techniques. This subcategory also includes the study of the chemistry and metabolism of compounds of biological interest including the chemistry of the molecular components of the cells, metabolism, biosynthesis and properties of proteins, DNA, RNA and molecular genetics. Specialized courses such as physiological chemistry, nutrition, and pharmacology are included with the biological sciences (CCSS).

If adequate faculty and facilities are available, the chemistry of a two-year college can include a year course in organic chemistry, providing that it is of the quality sufficient to allow a student to transfer credit earned in such a course to a four-year institution (ACS, 1970). Such courses are very sophisticated at the four-year colleges and transfer credits may not be allowed unless the course is comparable in quality; furthermore, problems of acceptance will arise for students who wish to transfer with one semester of organic chemistry. Additionally, laboratory work should be offered if a lecture course is offered. As with the lecture course, the laboratory course must be of high quality if transfer credit is to be expected; this may require the use of semimicro equipment and instrumental methods. Two-year colleges should not offer organic instruction for the chemistry majors transfer student unless the course meets quality standards consistent with neighboring institutions. However, since many nonchemistry major students require a less intense and less sophisticated course, it is reasonable to expect two-year colleges to include a year of organic chemistry at a level to satisfy the needs of the non-chemistry major (e.g., pre-medicine, pre-dentistry, and biology) when they cannot justify meeting the guideline requirements. This is consistent with recommendations of the ACS Criteria (1977).

We were unable to evaluate how well the organic chemistry courses of the two-year colleges match the chemistry major courses of the university; however, the course descriptions and recommended programs of study found in the catalogs reveal that the organic courses are intended for pre-medical, pre-dental, pre-pharmacy, pre-veterinary, biological science, biochemistry, forestry, and chemical engineering students among others as well as for chemistry majors.

ORG courses were scheduled by 64 percent of the colleges; an additional 10 percent listed ORG classes in the catalog but did not offer them. They were 22 percent of all chemistry courses and 11 percent of sections, both lecture and laboratory (Table 2).

The five types of ORG chemistry courses (Table 11) differ in three ways: content, organic or biochemistry emphasis; length, one term, two quarters, and a year; and majors, science and health sciences or chemical technology.

Contrary to the ANAL category, the predominant ORG course is the one year course for science majors; only six percent of the colleges offered both the year course and the short course in organic. Organic year courses are more apt to be found in the middle states (76% of the colleges), the west (64%), and the south (61%) regions than in the midwest (56%), mountain-plains (41%) or northeast (9%); in public colleges (61%) than private (29%); in large colleges (80%) than in medium (63%) or small (40%); and in comprehensive colleges (66%) rather than liberal arts (20%) or technical (6%).

Most (96%) of the individual courses of the organic year sequences are four (49%) or five (47%) units with semester colleges favoring four (67%) and quarter colleges five (71%). Three lecture hours were scheduled for 78 percent of the courses (86% semester, 67% quarter). However, laboratory hours were more diverse, three used in half (51%) of the courses (56% semester, 42% quarter) and six in a quarter (25%) of the courses (22% semester, 31% quarter). About 60 percent of the courses were three lecture, three laboratory, four units (36%) or three lecture, six laboratory, five units (23%).

There is more consistency in naming the organic courses, 98 percent of the year sequences are aptly named organio chemistry; only 14 percent of the short courses carry the same title, the others using a qualifier such as elementary, or brief course.

Table 11

Organic Chemistry Courses (ORG), Two-Year Colleges, 1977-1978

Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total ORG Courses of This Type Scheduled (n values at left)	Percent of Total ORG Courses on Schedule (n=235)
Organic - One Year (n=227)	61	56	85	82
Organic - One Term (n=29)	15	10	59	7
Organic - Two Quarters (n=16)	6	5	62	4
Organic - Chemical Technology (n=18)	5	4	72	6
Biochemistry (n=9)	5	2	33	1

Prerequisites for the year course tend to agree with the Guidelines, 74 percent of the sequences require one year of general chemistry; however, 23 percent require only one semester or two quarters. For the short course, prerequisites are evenly divided between one year and one term of general chemistry.

Organic chemistry courses have been studied statewide in California (Mooney, 1967) and Texas (Walters, 1972); additionally, recommendations on content (Bunce, 1972; Butler, 1976) and transfer articulation (AC_3, 1967) are available. Innovations in two-year college organic curriculum include an analytical approach to the laboratory (Campbell, 1971); open-ended instrumental analysis experiments (Vlassis & Cupillari, 1970); a composite organic-biochemistry-analytical program for the whole course (Juster, 1971); and an organic-analytical and instrumental laboratory course for technicians (Sheaffer, 1975-76). Instructional innovations include a tutorial approach (Vikin, 1971), an individualized program (Schoeb, 1973), and a non-lecture approach (Harrison & Harrison, 1975).

Industrial Chemistry and Chemical Engineering (INDUST)

> This area involves the study of the industrial application of chemistry organized into courses such as industrial chemistry, analysis of industrial materials, unit operations, chemical process control and instrumentation, chemical engineering calculations. Special courses based on the general chemistry course and which are related to petroleum, plastics and paint are found here (CCSS).

Colleges with chemical technology or chemical engineering technology programs sometimes include second year chemistry courses other than analytical and organic chemistry. Generally, these are related to chemical engineering or industrial chemistry.

Although seven percent of the colleges listed industrial chemistry or chemical engineering courses in the catalog, only four percent scheduled them and only half of the courses were scheduled (Table 2). The only courses found in more than one college were unit operations (4 courses); chemical engineering calculations (3 courses); industrial laboratory methods (2 courses); and chemical processes (2 courses), all in two colleges. Approximately half

(46%) of these courses grant four units (range 1-5); 91 percent include lecture, and 72 percent laboratory. Forty-five percent schedule three hours lecture (range 2-4) and laboratories spread from two to six hours.

The seven colleges offering these courses are spread nearly evenly among the public institutions in the middle states (2), south (2) and mid-west (3). Four are comprehensive and three technical in emphasis; four of medium and two of small size.

Clinical Chemistry (CLIN)

> These courses involve the study of the theory and practice of qualitative and quantitative chemical analysis of biological fluids, especially human. Includes analysis for carbohydrates (e.g., glucose), enzymes, proteins, lipids, etc. as well as gastric analysis for the stool, urine, and serum contents. They emphasize instrumental methods such as flame photometry, spectrophotometry, electrophoresis, fluorescence, microgasometry, chromatography, and potentiometric techniques and may also include automated techniques and radioisotope methods. They are designed primarily for medical laboratory technology programs (CCSS).

As medical laboratory technology programs have been introduced into the two-year colleges, courses in clinical chemistry have been introduced into the curriculum. The relationship of these courses to the chemistry faculty varies. In some cases, both faculty and facilities are divorced from chemistry; in others, the chemistry faculty instruct in CLIN chemistry using chemistry facilities. These programs are generally not found in states where clinical laboratory technology requires a bachelor's degree and the occupational type of courses are essentially upper division. None of these courses appear to have any relationship to the recently developed majors in clinical chemistry instituted by some universities.

CLIN chemistry courses were offered by 16 percent of the colleges; they account for four percent of the chemistry courses and two percent of each of the laboratory and lecture sections (Table 2). The CLIN chemistry courses may be differentiated in terms of length, one term, two quarters, or one year; and prerequisite, one year of general chemistry, or less than a year. They may also be differentiated as academic type laboratory courses as opposed to clinical laboratory experience courses; only the former are considered in this report. CLIN chemistry course sequences are more apt to be one term (42%) or two quarters (42%) than one year (19%); they are more apt to require a year of general chemistry (50%) than less than a year (31%) or none (8%) - prerequisites were not listed for the remainder. Seventy-two percent of all clinical chemistry courses listed in the catalogs were scheduled.

The mode for CLIN chemistry course units was four (32%), with five next (24%) and a range from 1-10 units. Three lecture hours (41%) is the most frequently used, followed by four (17%) and two (15%) with a range from 1-10 hours. Laboratory hours range from 2-16 hours per week with three and six hours the mode (24%), and 27 percent of the courses in the 8 to 16 hours range.

CLIN chemistry courses are more apt to be found in the middle states (29% of the colleges), south (20%), middle west (18%) or mountain-plains (18%) regions than in the west or northeast, neither of which showed any CLIN courses. They are equally apt to be in public and private colleges (18% each); more apt to be in technical (28%) than in comprehensive (15%) or liberal arts (13%) colleges; and more apt to be in medium sized (23%) than large (12%) or small (10%) colleges.

Most CLIN chemistry courses (74%) are listed in the medical laboratory technology (or similar term) section of the catalog; only 15 percent were listed in chemistry; the remaining ones were found under biology, allied health or medical biochemistry. Clinical chemistry was the most popular title (59%) and clinical or medical biochemistry next (15%), with seven other titles also used.

Other Advanced Chemistry Courses (MISC-A)

> This category includes all other chemistry courses following general chemistry such as physical chemistry, experimental methods, environmental chemistry, and chemical thermodynamics (CCSS).

Occasionally a college will include some other advanced chemistry course, such as physical chemistry. Of the eight courses of this type, only two physical chemistry courses were scheduled in connection with chemical technology programs; one in the south and the other in the west; one with laboratory and the other without. Two other physical courses were listed but not offered as were an inorganic course and an advanced experimental chemistry sequence.

PATTERNS OF COURSES

If two-year colleges are to properly serve the chemical education needs of their heterogeneous student bodies, they must offer several different introductory and advanced courses. Many of them do.

We have considered the subcategories of chemistry courses nationally; herein we look at the total chemistry programs of individual colleges. Because much of the resistance for offering a comprehensive curriculum comes from administrative and sometimes faculty opposition to "proliferating courses" it seemed appropriate to analyze the introductory and advanced chemical courses offered

Table 12

Number of Introductory Chemistry Courses or Sequences Offered by Two-Year Colleges Arranged by Size of College, Control of College and Geographical Region, 1977-78

Number of Introductory Courses or Sequences	(Percent of Total for Each College Group)			
By Size of College	Small Colleges (n=72)	Medium Colleges (n=78)	Large Colleges (n=25)	All Colleges (n=175)
None	7	1	0	3
One	40	12	0	22
Two	33	33	16	31
Three	10	32	20	21
Four or More	10	22	64	23

By Control of College	Public (n=147)	Private (n=28)
None	2	14
One	16	50
Two	31	29
Three	24	4
Four or More	27	4

By Geographical Region

	West (n=28)	Mountain Plains (n=22)	Mid-west (n=39)	South (n=54)	Middle States (n=21)	North-east (n=11)
None	0	5	0	2	5	27
One	7	27	7	33	24	36
Two	14	45	44	26	33	18
Three	25	14	28	24	14	0
Four or More	54	9	21	15	24	18

Table 13

Number of Advanced Chemistry Courses or Sequences Offered by Two-Year Colleges Arranged by Size of College, Control of College and Geographical Region, 1977-78

Number of Introductory Courses or Sequences	(Percent of Total for Each College Group)			
By Size of College	Small Colleges (n=72)	Medium Colleges (n=78)	Large Colleges (n=25)	All Colleges (n=175)
None	49	23	0	30
One	33	40	52	39
Two	12	21	32	19
Three	3	10	8	7
Four or More	3	6	8	5

By Control of College	Public (n=147)	Private (n=28)
None	25	57
One	42	25
Two	20	11
Three	7	7
Four or More	6	0

By Geographical Region	West (n=28)	Mountain Plains (n=22)	Mid-west (n=39)	South (n=54)	Middle States (n=21)	North-east (n=11)
None	18	36	21	31	24	89
One	39	41	41	46	29	11
Two	36	14	23	13	19	0
Three	4	9	8	6	14	0
Four or More	4	0	8	4	14	0

by each college. Tables 12 and 13 show the distribution of introductory and advanced chemistry courses by size of college, type of control and geographical region. Nationally, the average is approximately 2.5 introductory courses or sequences per college for colleges which offer these courses. The average is 1.7 advanced courses or sequences per college for the colleges which offer advanced chemistry. Small colleges scheduled fewer introductory sequences and large institutions, more than the medium; public colleges scheduled more than private; and regional differences were most pronounced between the west and northeast.

Now turning to the advanced courses, the small colleges were divided almost evenly between not offering and including them; on the other hand, all large colleges included at least one advanced course. Three-quarters of the public colleges included advanced chemistry whereas fewer than half of the private colleges did so. As was the case for the introductory sequences, more western colleges and fewer northeastern colleges included advanced chemistry. In contrast to the introductory program, the western colleges have not expanded their advanced chemistry program as much but the middle states colleges include the greatest variety in the advanced programs.

What type of introductory chemistry predominates among the colleges offering one, two, three, and four introductory courses? Also, what are their tendencies in advanced chemistry? For colleges with one introductory program the single sequence tends to be GEN chemistry (61%) with nearly equal distribution among the NSM (16%), AH (11%) and all other types (14%). None of these general chemistry courses meet all recommendations of the ACS <u>Guidelines</u>. These colleges tend not to offer advanced chemistry courses (61%). When they do, however, the tendency is toward a single sequence (21%). The most popular advanced chemistry program is the ORG year course (29%).

For colleges with two introductory programs, GEN chemistry sequences were the most popular (87%) followed by NSM courses (57%) and AH courses (33%). Four colleges have GEN chemistry that meets all of the ACS Guidelines. The two sequences in these colleges are of two different types (e.g., GEN and NSM) in 96 percent of the colleges. Fifty-two percent offer one advanced course, 28 percent offer none. The most popular advanced programs were the ORG year course (56%), ANAL (17%), and CLIN (13%) chemistry.

For colleges with three introductory programs, GEN chemistry was offered by 100 percent with the NSM (78%), AH (43%) and PREP (43%) chemistry courses also popular. With respect to the Guidelines, forty-six percent of the GEN chemistry sequences had seven or more contact hours; 24 percent more than seven; 68 percent require high school chemistry and 38 percent require intermediate algebra or higher mathematics. Three or more laboratory hours were required by 84 percent with 28 percent scheduling four or more. In 84 percent of these colleges, the three introductory courses were of three entirely different types. The ORG year course (62%), ANAL (27%) and CLIN (22%) chemistry were the most frequently included advanced courses. Advanced chemistry courses are offered by 81 percent of the colleges; 43 percent, one course and 22 percent, two.

Colleges with four or more introductory programs tend to be medium or large size; publicly controlled; located in the west, midwest or south; and comprehensive. Ninety-five percent offer GEN chemistry; whereas, the NSM and AH courses were each found in 79 percent with the TECH type (26%), and PREP courses (24%) also popular. Nearly two-thirds (65%) of this group of colleges include four different types of introductory chemistry sequences; 12 percent have two in general chemistry; and 15 percent, two for non-science majors.

Seven colleges (18%) have general chemistry programs which meet the ACS *Guidelines* on all counts. Furthermore, this group of colleges tend to have the most extensive and highest level of general chemistry courses. Half schedule 7 percent or more contact hours, with 26 percent at the nine or more level; additionally, 89 percent include three or more laboratory hours with 40 percent at the four or more level (24% actually have 6 hours). For prerequisites, 68 percent require high school chemistry, and 42 percent intermediate algebra or higher.

Although 95 percent of these colleges offer advanced chemistry they do not have as extensive offerings as at the introductory level. Thirty-eight percent schedule only one advanced course and 38 percent, two. The ORG (year) (80%), ANAL (50%) and CLIN (28%) programs were the most popular advanced offerings.

PART II

THE INSTRUCTOR SURVEY

METHOD

The same random sample of 175 colleges employed in the Center for the Study of Community Colleges Curriculum Study was used in the assessment of instructional practices. After identifying the science courses on the schedules, individual class sections were selected by drawing every thirteenth lecture section in each of the six major science curriculum areas. After randomly selecting the first college, the selection process continued automatically self-randomizing. A questionnaire survey form (see Appendix B) was distributed to the instructor of each section identified as above. Returns were handled in such a way as to guarantee confidentiality to the respondent but still provide for follow-up on the retrieval of surveys from non-respondents.

Questionnaires were mailed to 1683 instructors of sections in all fields in spring 1978, after the completion of the fall term, 1977 to which the survey was confined. One hundred fourteen surveys were not deliverable due to death, retirement, leaves and dismissals and other reasons. Additionally, 77 surveys were returned for cancelled sections. Of the remaining 1492 deliverable surveys, 1275 were returned to the Center, a response rate of 85.5 percent.

The 82 responses from chemistry faculty represented 6.4 percent of the returns compared to 160 (12.5%) from biologists and 45 (3.5%) from physicists. Introductory chemistry sections accounted for 80 percent of the returns and 20 percent came from advanced sections; 83 percent of all chemistry lecture sections were introductory and 17 percent advanced. The percentage of the returns attributable to chemistry, biology and physics faculties was higher than the proportionate representation of these sciences among the sections surveyed: chemistry (5.1%), biology (10.5%), and physics (3.2%).

The findings from this survey of most significance to chemistry are presented and discussed in the following sections. All tables include data for biology and physics as well as chemistry and the data for all twelve groups combined into an all science group.

RESULTS

Goals or Qualities Desired for Students

The abilities students are expected to demonstrate are a function of the goals the faculty member has for the course. Consequently, instructors were asked to select one quality from each of three sets of four that they most wanted their students to achieve in the specified course (Table 14).

Functions of Courses and Student Majors

Sixty-three percent of the chemistry faculty indicated that the course about which they were responding either paralleled or was equivalent to a lower division course at a four-year college. Transfer science and engineering majors were included in 56 percent of the courses, allied health or natural resource majors in 38 percent, and non-science majors, 18 percent. The total of these figures is greater than 63 percent because many introductory chemistry courses are multifunctional, serving two or more groups of student majors.

Chemistry had the highest percentage of all the sciences on courses for transfer science and engineering majors; whereas, only engineering (5.6%) was lower than chemistry in the non-science major category. This reflects the observation that students tend to enroll in chemistry courses as they are required in their programs by the college and where there is a choice they do not elect chemistry (Kunkel, 1969).

Among our respondents, chemistry courses for the occupational groups were about equally divided between the allied health and science-engineering technologies. Remedial courses in chemistry were second highest to mathematics (33%). Of all the sciences, only physics is lower than chemistry in sections described as being for further education or personal upgrading. Only physics, engineering, and agriculture offer a lower percentage of sections designed for the general education of non-science and non-occupational students than does chemistry. These data suggest that chemistry faculty need to look for innovative courses or ways to interest the general student in chemistry.

Table 14

Response to Questions: Instructors may desire many qualities for their students. Please select the one quality in the following list of four that you most wanted your students to achieve in the specified course: by Science Faculty, Two-Year Colleges, Fall Term, 1977.

	Percent of Total Respondents for Each Set			
SET ONE (One only selected)	Chem (n=82)	Biol (n=160)	Phys (n=45)	All Sci (n=1275)
Understand/appreciate interrelationships of science & technology with society.	22	48	16	27
Be able to understand scientific research literature.	0	1	0	2
Apply principles learned in course to solve qualitative and/or quantitative problems.	65	42	76	61
Develop proficiency in laboratory methods and techniques of the discipline.	10	7	9	8
SET TWO (One only selected)				
Relate knowledge acquired in class to real world systems and problems.	23	42	47	48
Understand the principles, concepts, and terminology of the discipline.	67	55	44	43
Develop appreciation/understanding of scientific method.	5	1	4	2
Gain "hands-on" or field experience in applied practice.	4	1	4	6
SET THREE (One only selected)				
Learn to use tools of research in the sciences.	9	1	9	9
Gain qualities of mind useful in further education.	31	40	24	33
Understand self.	1	9	0	9
Develop the ability to think critically.	55	48	67	47

Students

According to the responses to the Instructor Survey, chemistry enrolled an average of 30 students per lecture section. However, only 78 percent of the chemistry students were reported as completing the course with a grade, lower than all fields except for mathematics and the earth sciences.[2]

Of the initial enrollments in chemistry, 53 percent were male and 47 percent female, close to all the sciences and much different from biology favoring females 2 to 1, and physics favoring males 3 to 1. This is explainable because chemistry draws heavily from both the allied health - biological science programs (female dominated) and the engineering - physical science programs (male dominated). There is no significant difference between the male and female completion rates in chemistry, both 78 percent; in contrast, both biology and physics have about 10 percent higher completion rates for males.

Instructional Mode

Major contemporary issues in chemical education include questions about the necessity of laboratory work in introductory courses and the need for the individualization of instruction. Our survey of catalogs and schedules made possible a profile of the lecture and laboratory modes of instruction for each subcategory of chemistry courses (Table 15). These resources were insufficient to reveal the extent to which the various individualized instruction schemes were employed. Overall, the combined

[2] These figures differ from other reported information because initial enrollment dates were not specified. Further, data do not specify whether students were included who completed a course with a grade of F or W.

Table 15

Instructional Mode for Chemistry Courses, Two-Year Colleges, 1977-78

Category of Course	Percent of Courses of A Subcategory: Lec Lab[a]	Lec Only[b]	Lab Only[c]	Other or Unknown[d]
<u>INTRODUCTORY</u>	(79)	(14)	(5)	(2)
Non-Science (NSM)	78	16	3	3
Allied Health (AH)	78	15	5	2
Engineering Techn (TECH)	70	22	9	0
Preparatory (PREP)	48	33	4	15
General Chem (GEN)	85	8	6	1
Chemical Techn (CHM TCH)	87	13	0	0
Other (MISC-I)	38	53	5	5
<u>ADVANCED</u>	(82)	(11)	(7)	(<1)
Analytical-Instr (ANAL)	92	6	2	0
Organic-Biochemistry (ORG)	80	12	8	0
Industr. & Chem Engr. (INDUST)	64	29	7	0
Clinical (CLIN)	83	9	6	2
Miscellaneous Advanced (MISC-A)	100	0	0	0

[a] Lecture-laboratory courses require students to be enrolled in lecture and laboratory sections both whether they are listed combined or as separate sections or courses on the schedule.

[b] Lecture only courses have no related laboratory component or have an optional, separate laboratory course.

[c] Laboratory only courses have no scheduled or required lecture section or course.

[d] The other category includes courses requiring field trips and those which are heavily individualized as well as courses for which no information was available.

lecture-laboratory mode was used in nearly four out of every five chemistry courses, with only one of seven courses using lecture only and one of twenty laboratory only.[3] Only the preparatory and other introductory categories have less than 50 percent lecture-laboratory.

The lower laboratory requirement for preparatory courses is accounted for by an emphasis on problem solving and the fundamentals of chemical communication in many of these courses and the use of personalized systems of instruction in others. The preponderance of the lecture type of the miscellaneous groups is a consequence of their primary purpose, which is to communicate the chemical information necessary for a given occupation.

Use of Class Time

The Instructor Survey delved deeper into the use of instructional techniques than did the catalog and schedule analysis. The faculty were asked what percentage of class time was devoted to those activities listed in Table 16. The almost unanimous use of lecture (98%) and examinations (96%) was expected, as was the high usage of class discussion (83%) and laboratory experiments (80%). However, considering the nature of the subject and the availability of suitable materials, the utilization of lecture demonstration experiments (58%) and media (46%) are disappointing and should be of concern. Furthermore, this is not in line with the Criteria statement (ACS, 1977) calling for use of lecture and demonstration experiments as well as the newer types of learning and

[3] Some colleges list and schedule the laboratory as a separate course but require concurrent enrollment; such cases were counted as a single course in the lecture-laboratory category.

media resources. Chemistry faculty should be aware of the results of research such as that by Talley (1972) and Zimmerman (1972). The former found that the use of 3-dimensional models of each chemical species and interaction under consideration produced significant differences in learning in the areas of analogy, knowledge, comprehension, analysis and evaluation. The latter found that the film treatment of atomic structure and bonding for community college general chemistry students produced higher mean scores on achievement test, retention test, and attitude post test than did lecture-film or lecture only treatments. The low utilization of practical examinations (27%) argues for research and development in this area.

The recent interest in learning theory among chemists, primarily Piaget's work and chemical education, is summarized in a resource paper (Good, Kromhout, & Mellon, 1979) and two papers presented to a two-year college audience (Fowler, 1976-1977; Herron, 1976-1977). Efforts among two-year college faculty to provide instruction directed toward concrete thought processes, with the aim of helping the student advance from the concrete to the abstract (Piaget's formal operational level), include the use of desk-top kits (Baker, 1977) and models to represent or simulate concepts (Grotz, 1976-1977).

In addition to an analysis of the frequency of use of these techniques nationally we established the profile for the average course presented in Table 16. As expected, faculty lectures and student laboratory experiments account for more than two-thirds of chemistry class time with about one-eighth of the time devoted to evaluation items. A comparison of the chemistry profile to those for the average classes in biology, physics or all the sciences may be obtained by examination of the table.

Table 16

Allotment of Class Time in Science Classes, Two-Year Colleges, Fall Term, 1977

Type of Activity	Estimated Percent of Total Class Time			
	Chem (n=82)	Biol (n=160)	Phys (n=45)	All Sci (n=1275)
Lecture	41	44	37	45
Laboratory Experiments	30	23	27	11
Quizzes/Examinations	11	7	8	10
Class Discussion	9	7	11	15
Lecture Demonstration Experiments	3	4	7	3
Film or Taped Media	2	7	1	4
Lab Practical Exams/Quizzes	2	4	1	2
All Others	2	5	8	10

Use of Instructional Materials

To what extent do faculty use print and non-print instructional materials? These questions were asked of the faculty because books occupy a central place in higher education and because different forms of media are often integral to attempts to give every student an "equal eyeball opportunity" to see chemical phenomena, to visualize chemical structures or to see chemical procedures properly performed. Additionally, since media are generally extensively involved in instructional innovation, we asked the faculty to indicate how often they used various materials. The responses are summarized in Tables 17 and 18 for media and printed materials, respectively, with data for chemistry, biology, physics and all sciences included.

Table 17

Utilization of Instructional Media Reported by Science Faculty, Two-Year Colleges, Fall Term, 1977

Type of Instructional Media	Percent of Total Faculty Utilizing Media Frequently (Fr) and Occasionally (Oc)							
	Chem (n=82)		Biol (n=160)		Phys (n=45)		All Science (n=1275)	
	Fr	Oc	Fr	Oc	Fr	Oc	Fr	Oc
Scientific instruments	51	35	42	34	64	31	18	21
Three dimensional models	42	50	34	42	7	49	10	27
Maps, charts, illustr, displays	42	33	35	45	22	36	20	36
Lecture/demonstr expts	38	34	18	36	51	38	10	17
Overhead proj transpar	31	35	45	28	13	40	20	27
Audiotape/film/combin	4	23	7	26	0	4	3	16
Films	2	52	16	59	0	51	9	40
Slides	1	28	26	49	0	16	8	22
Audiotapes/cassettes/records	2	21	6	21	2	11	3	17
Single concept film loops	2	17	4	38	7	47	1	12
Filmstrips	1	15	4	27	0	9	3	16
Videotapes	0	15	3	27	0	11	3	16
Natural or preserved, specimens	2	5	56	28	0	0	9	7
TV	0	4	1	12	0	9	1	8
Other	1	1	2	2	7	0	6	2

Table 18

Utilization of Printed Instructional Materials Reported by Science Faculty, Two-Year Colleges, Fall Term, 1977.

Type of Printed Material	Percent of Faculty Utilizing Type of Material (PU) and Average Number of Pages Assigned (PG)			
	Chem (n=82) PU-PG	Biol (n=160) PU-PG	Phys (n=45) PU-PG	All Sci (n=1275) PU-PG
Textbooks	98-312	96-340	91-254	94-308
Lab materials/workbooks	84-107	80-112	78-34	44-101
Syllabi/handout materials	76-40	74-35	51-18	62-29
Problem books	38-117	6-75	20-40	10-90
Reference books	33-35	39-90	18-15	22-107
Journal/magazine articles	23-30	38-13	7-*	25-23
Newspapers	7-30	11-13	2-*	11-22
Collections of readings	6-73	15-76	7-55	14-126
Other	7-52	7-89	4-170	8-121

*pages not reported.

Evaluation of Students

When queried with respect to the abilities they ask their students to demonstrate on examinations and quizzes, most of the chemistry faculty rated "acquaintance with the concepts of the discipline" as the most important item followed by "mastery of a skill" (Table 19).

The chemists used several factors when determining a student's grade. They gave the greatest emphasis to the results of objective tests and examinations which can be scored quickly, followed by laboratory reports and essay tests (Table 20).

Practically all of the chemistry faculty reported that they used mathematical type problems where the work must be shown as well as the construction of graphs, diagrams and chemical equations. Multiple response and essay questions both were used by about three-quarters of the chemists but with less frequency (Table 21).

Table 19

Importance of Abilities Students Are Asked to Demonstrate on Examinations and Quizzes as Reported by Science Faculty Two-Year Colleges, Fall Term, 1977

Ability	Percent of Total Faculty Considering This Ability Very Important (V) and Somewhat Important (S)							
	Chem (n=82)		Biol (n=160)		Phys (n=45)		All Science (n=1275)	
	V	S	V	S	V	S	V	S
Acquaintance with concepts of the discipline	90	9	91	8	84	9	83	13
Mastery of a skill	71	20	24	42	58	24	51	28
Understanding significance of phenomena and experiments	45	50	59	36	56	31	45	34
Ability to synthesize course content	43	40	51	38	53	36	46	39
Recall of specific information	35	61	62	36	13	58	43	49
Relationship of concepts to student's own values	16	37	26	41	2	29	24	36
Other	1	5	0	0	5	0	3	0

Table 20

Emphasis With Respect to Determination of Grade Given to Various Student Activities by Science Faculty, Two-Year Colleges, Fall Term, 1977

Type of Activity	Percent of Faculty Counting This Type for 25% or more of grade (A) and less than 25% of grade (B)			
	Chem (n=82) A - B	Biol (n=160) A - B	Phys (n=45) A - B	All Sci (n=1275) A - B
Objective tests/examinations (quick score)	61-18	72-13	42-13	60-15
Laboratory reports	40-45	11-43	27-53	10-17
Essay tests/examinations	50-17	44-23	42- 4	41-15
Laboratory unknowns/ practical exams	12-40	19-28	2-24	6-11
Problem sets	4-43	1-10	7-44	5-18
Homework	2-49	1-19	7-47	6-32
Workbook completion	5-13	1-21	0-22	4-14
Regular class attendance	0-32	3-28	0-22	3-32
Papers written outside of class	0-20	2-34	4-11	9-25
Participation in class discussions	0-17	1-25	2-24	2-32
Research reports	1-11	1-18	0- 7	3-14
Oral recitations	0-15	1-11	0-16	2-17

(All other activities listed were less than 10% total for chemistry and are not shown in the table; these include papers written in class, field reports, individual discussions with instructor, non-written projects, and other activities.)

Table 21

Types of Questions Used in Written Quizzes and Examinations, Science Faculty, Two-Year Colleges, Fall Term, 1977

Types of Questions	Percent of Total Faculty Using This Type Frequently (F) and Seldom (S)							
	Chem (n=82)		Biol (n=160)		Phys (n=45)		All Science (n=1275)	
	F	S	F	S	F	S	F	S
Multiple response (multiple choice, true/false etc.)	45	28	84	10	20	38	50	20
Completion	27	39	46	39	13	27	25	32
Essay	33	40	48	29	21	24	31	23
Solution of mathematical type problems with work	81	13	8	37	73	7	49	15
Construction of graphs, diagrams, chem. equations	68	27	6	38	31	36	26	30
Derivation of mathematical relationship	4	54	1	11	22	27	12	29
Other	4	0	6	0	7	0	5	<1

More than 9 of 10 of the chemistry faculty award ABCD grades and over three-fourths also award F grades. Information regarding this grading system reveals that the pass and fail or no credit systems receive little attention from any of the sciences. Reference to Tables 19 through 21 show other factors related to evaluation of students by chemists, as well as the comparison among chemistry, physics, biology and the total group of science faculty.

Degree Attainment

Faculty members responding to our survey were asked to indicate their highest earned degree. Over one-third of the chemistry faculty (35%) hold earned doctorate degrees (in chemistry or another field, such as higher education). Most of the remaining instructors (63%) have master's degrees in chemistry or some other field. This is more than double the percentage (17%) of earned doctorates among chemistry faculty (n=649) in 1967 as well as a small increase in the percentage (93% to 98%) of chemistry faculty holding a master's degree or higher (Mooney & Brasted, 1969). The percentage of degrees in chemistry is probably higher today, primarily because many retirees with master's degrees or less have been replaced by younger chemists with doctorates who in earlier years would have gone into a four-year college or university. Doctorate attainment in chemistry (35%) and physics (31%) is higher than in any other field.

The Conference on Science in the Two-Year College (ACS, 1971) recommends that the minimum academic preparation for a two-year college science teacher be equivalent in level to a master's degree in the discipline to qualify in the subject he teaches. Clearly, any assessment of the needs of the sciences in the two-year colleges needs updated information on the field and recency of the degrees held by the faculty before making recommendations for faculty development programs.

Teaching Experience

In the fall of 1977 over one-third (34%) of the chemistry faculty had been teaching in two-year colleges for more than 10 years; in contrast, less than one-quarter (22%) had less than four years experience. Although there is a slight difference in the questions asked in the 1967 AC_3 study, these results show a drastic change since then, when only 18 percent had been in their present position more than 10 years and 53 percent had less than four years experience there (Mooney & Brasted, 1969[4]).

[4] In 1967, the question asked for years in present position; in 1977 it was years in a two-year college. Only 7 percent of the 1967 group had two-year college experience prior to their present position.

The chemistry faculty reflects more experience in the two-year colleges than does the all science group (78%, 5 or more years, compared to 69%) or the physicists (73%) or biologists (71%). We conclude that overall community college chemistry faculties are aging and suggest this has implications for a needs assessment.

Employment Status

Much concern has been expressed over the recent increase in part-time faculty in the community colleges. Our Instructor Survey, focused on the fall of 1977, predated Proposition 13 in California and subsequent cost-saving actions around the country. At that time we found no substantial change in the full-time percent of chemistry faculty from 1967 (Mooney & Brasted, 1969) to 1977 (83% to 84%); the part-time percentage decreased (17% to 10%). A partial explanation of this could be the decrease in enrollments and elimination of some smaller sections experienced in many colleges even prior to 1978, actions which generally result in fewer part-time positions. The part-time teaching in chemistry across the country today does need much further detailed study, especially in order to determine the effect it is having on the quality of instruction and student retention and performance. We also found the chemistry curriculum to be more committed to full-time faculty than were biology, physics or the all science group.

Assistance Available to Faculty

The 1969 Conference on Science in the Two-Year College (ACS, 1971) recommended that technical and secretarial assistance be provided to science faculty. We asked faculty about the types of assistance available to them and whether or not the faculty member had made use of this assistance. Clerical help, the most frequently available assistance, was utilized by more than two-thirds of the chemists. Laboratory or technical assistance, less available than clerical, was utilized by 57 percent of the faculty but it was available to only 62 percent (Table 22).

We calculated a need or usefulness index for the types of assistance included in the table. This index, defined as the percentage of faculty utilizing a given type of assistance when it was available, is reported in column C of the table. Laboratory help was the most needed or useful form of assistance, used by 92 percent of the chemists to whom it was available; the clerical index was 82 percent. These indices argue strongly for the recommendations from the 1969 Conference.

King and Ullmann (1978) report an average of one full-time laboratory technical assistant for every 4.0 chemistry faculty members as well as one full time secretary for every 15.4 faculty in 21 public community colleges of New York state. Furthermore, these colleges also supplied student laboratory assistants, 3.7 hours per faculty per week and student clerical help, 1.2 hours per faculty per week. The large departments (six or more faculty) tend to have higher faculty to assistance ratios for both types of assistance than is characteristic of the smaller departments (less than six faculty), a relationship that reflects economy of scale. This New York study supports my observations over the last 25 years in community colleges that a ratio of one laboratory technician to every four full-time faculty members, or equivalent, is optimum both educationally and economically.

Colleges desiring to study or review the use of technical assistants may find helpful the published job description for a chemical laboratory technician in a community college (Mooney, 1968-1969).

Table 22

Utilization of Available Assistance by Science Faculties, Two-Year Colleges, Fall Term, 1977

Type of Assistance	Percent of Total Respondents Having This Type Available[a]			Percent of Total Respondents Utilizing This Type			Percent Utilization of Available Assistance[b]		
	Chem	Bio	Phy	Chem	Bio	Phy	Chem	Bio	Phy
Technical (laboratory)	62	58	36	57	49	31	92	84	86
Tutors	61	56	44	54	38	31	89	68	70
Clerical Help	84	86	80	69	77	69	82	90	86
Paraprofessionals	26	24	16	20	19	7	77	79	44
Readers	16	11	11	11	4	7	69	36	64
Library-Bibliography	72	80	58	43	52	24	60	65	41
Media Production	76	76	60	40	54	29	53	71	48
Test Scoring	62	67	38	22	38	11	36	57	29
Other	5	3	2	5	3	2	100	100	100

[a] n=82 for chemistry, n= 160 for biology, and n=45 for physics.

[b] The % utilization = (% utilizing /% available)100.

The high utilization index for tutors (89%) by chemistry faculty is a strong argument for those colleges that do not provide tutorial assistance to chemistry students to make it available. The control and location of chemistry tutors in the two-year colleges is controversial. Based on observations made during consultations and others on site visitations, I recommend they work in the chemistry department under the supervision of chemistry faculty to make more effective use of all possible resources (e.g., models, laboratory equipment, references and faculty) and to minimize the negative effect of a tutor taking an entirely different approach than the instructor, thereby, compounding the conceptual and computational difficulties of the student. Colleges desiring to study or review the use of tutors in chemistry are referred to the tutorial laboratory approach at Bronx Community College (Ukeles, 1976) and to the unpublicized program developed at the College of Marin by Onnig H. Bezirjian. The Project TEACH materials could help train tutors to deal with the specific conceptual and computational problems in chemistry experienced by the tutoree as well as their more general problems of being a student and person (Project TEACH Staff, 1976).

Media production and library-bibliography services appear to be underutilized, a condition suggesting the need for additional study to determine the reason for and ways of effecting improvements in chemistry courses through the use of these resources. This underutilization may be related to the need for instructor release time to develop course and/or materials (see next section). Reference to Table 22 allows comparison of the chemistry, physics, biology, and the all science groups on the provision and utilization of assistance.

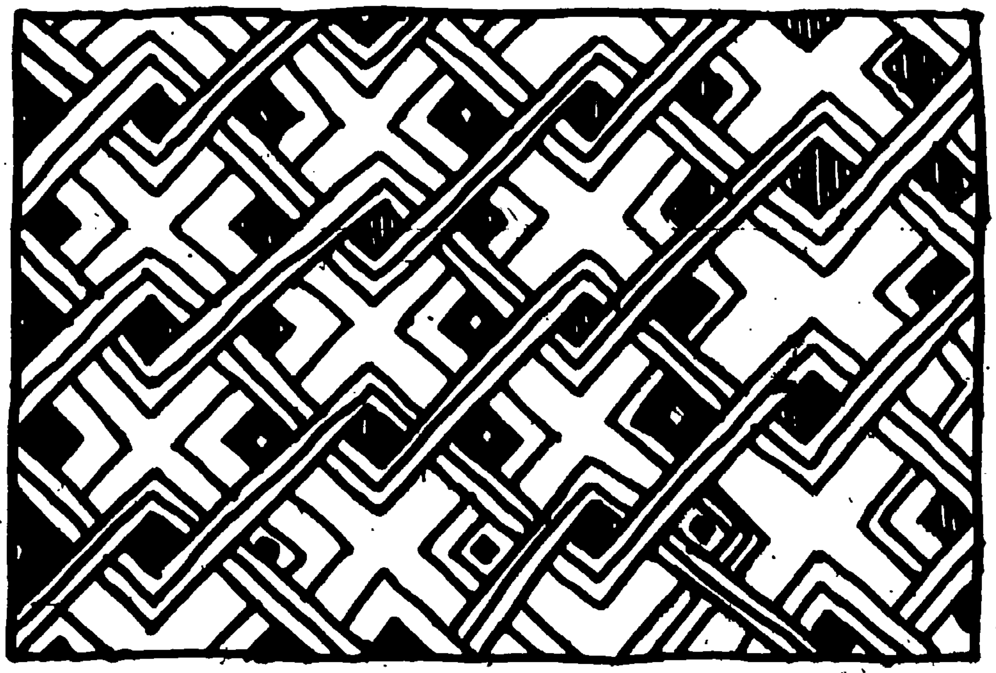
Improvement of Instructional Effectiveness

Since faculty members have ideas for making their courses more effective, we sought their reactions to the effect of sixteen possible changes on their course. Nearly two-thirds of the chemists most desire students better prepared to handle course requirements (Table 23). Not only was this the highest percentage response from the chemistry faculty, it was the second highest from any field on any item, slightly exceeded only by the desire of anthropologists to have more media available. Nearly half of the chemists expressed the desire for instructor released time to develop course and/or material. Reference to the table permits comparisons of the responses from the chemistry, biology, physics and all science groups on each of the items.

Table 23

Ideas for Making Science Courses More Effective in the Two-Year Colleges as Ranked by Science Faculty, Fall Term, 1977

Idea for Improvement	Percent of Total Faculty Respondents			
	Chem n=82	Biol n=160	Phys n=45	All Sci n=1275
Students better prepared to handle course requirements	63	54	56	53
Instructor release time to develop course and/or material	49	42	38	38
Better laboratory facilities	37	31	44	21
Stricter prerequisites for admission to class	35	37	40	30
Professional development opportunities for instructors	28	35	18	24
Availability of more media or instructional materials	26	48	18	36
Smaller class	23	27	16	29
More clerical assistance	20	18	18	17
More interaction with colleagues or administrators	18	18	18	18
More reader/paraprofessional aides	18	9	24	13
Other	16	11	11	10
More freedom to choose materials	11	8	9	9
Larger class (more students)	10	4	22	8
Changed course description	7	5	0	6
Less interference from colleagues or administrators	6	4	4	4
Different goals and objectives	5	5	2	4
Fewer or no prerequisites for admission to class	1	0	0	1



PART III

RECOMMENDATIONS

A major outcome of this study by the Center for the Study of Community Colleges has been to focus attention on what is needed for an idealized chemistry program in a comprehensive two-year college. The elements of this program have been called to our attention directly and indirectly through the literature review and the findings of the curriculum and instructor studies as well as through discussions with faculty during college visitations or meetings of chemical educators.

In order to present a comprehensive chemistry program the following components should be included. Understandably, the full complement of recommendations affords an idealized representation. However, these recommendations can serve as guidelines for an evaluation of a program and for the development of a long range plan for improvement. In another report related to this study and available at a future date through ERIC we discuss obstacles to fulfilling these needs as well as cite references reporting on programs which have shown progress in attaining the goals represented by these statements.

Ideally, two-year colleges need to provide:

1. A comprehensive introductory chemistry curriculum to properly and efficiently deal with the educational needs in chemistry of students who pursue a wide spectrum of educational goals, and are widely heterogeneous in their backgrounds and abilities in the sciences and mathematics, as well as in verbal and visualization areas.

2. An efficient assessment and placement program that will first characterize students who desire to enter chemistry courses in terms of their goals as well as those abilities and achievements correlating with success in chemistry; then, following the assessment, place students in the proper chemistry course, the one intended for their program and in which they have the most reasonable chance for success.

3. An appropriate advanced (second year) curriculum in chemistry for the educational goals (major and transfer institution or employment field) of the students.

4. A remediation program for dealing with students unprepared for enrolling in certain chemistry courses as well as those who are having conceptual and computational difficulties while enrolled in chemistry courses.

These first four needs should be supported by an instructional program that includes:

5. Extensive use of lecture experiments and demonstrations to present descriptive material and generate lasting interest in chemical phenomena as well as to help students at a concrete operational level better deal with chemical topics. If necessary, colleges should plan or renovate their chemistry facilities to facilitate such lecture demonstration experiments.

6. Extensive use of three-dimensional molecular models for both lecture presentations and student use as an aid to student visualization and understanding of chemical structures and interactions.

7. Extensive use of some of the new types of learning and media resources, such as computer aided instruction, slide-tape presentations, programmed instructional materials, and movie and video tape films in classroom, laboratory and/or auxiliary learning situations.

8. Extensive use of a chemistry tutoring program that is characterized by training of persons in the tutoring of chemistry students, by a close working relationship between the staff of tutors and the chemistry faculty, by the use of the instructional materials and media of chemistry in the tutoring, and by an effective referral procedure for students who are having either conceptual or computational difficulties in chemistry.

9. Reasonable laboratory instruction that is at least comparable to the major transfer institutions and that satisfies the employment needs of occupational students. This should be interesting and stimulating to students as well as supportive of the lecture course content and instructive with respect to the skills and techniques required of the students for further study or employment.

10. Multiple instructional strategies that will allow students a choice of methods and materials so that

they may elect the one(s) which are most compatible with their learning style and personal requirements. Such strategies also allow colleges, especially the smaller ones, to offer a more comprehensive chemistry curriculum, thereby better serving the technical and broader educational needs of students not presently being properly serviced because of a limited curriculum. Such strategies might involve various techniques, such as PSI programs, audio-tape courses, regional cooperation in scheduling and use of facilities, or cooperative projects such as the BioCoTie.

11. Extensive interaction between the faculty members and the student in the classroom presentations, the laboratory, office hours and auxiliary learning situations. Such interaction should be concerned with motivating and interesting students in chemistry and its interactions with the other sciences and society as well as instructional concerns.

In order to satisfy the curricular needs (1-4) and the instructional needs (5-11), the colleges need to provide:

12. Suitable technical, secretarial, and tutorial assistance for the chemistry faculty as well as conveniently available media-production and library bibliographic assistance.

13. For each of their chemistry faculty members each year to attend programs such as the Two-Year College Chemistry Conferences, the Division of Chemical Education Conferences and the American Chemical Society national meetings.

14. A chemical education resources library, conveniently accessible and available to the chemistry faculty, which includes journals, reports and documents relevant to chemical education in the two-year colleges.

15. A student follow-up program to provide feedback on the successes, problems and failures of former chemistry students after they have transferred or entered the world of work. Such information is important in validating present practice and determining necessary changes.

16. A student recruitment and retention program is needed to increase the flow into the department of students of all academic interests and abilities, especially the better prepared who are interested in science and engineering and the occupationally-oriented student interested in science related technologies. Once in the program these students must be retained until they have completed the full two years of college level science work and can transfer as fully qualified science or engineering majors or enter employment with the associate degree.

17. An instructional research program that will provide the financing and expertise to allow the chemistry faculty to design and perform new chemical education research related to the unique situation of the two-year colleges as well as replicate some studies reported in the literature as a method of validating their usefulness in the local situation.

18. Chemistry classroom and laboratory facilities that meet all pertinent criteria for laboratory safety and a suitable working environment, as well as make it feasible to carry out an appropriate laboratory program, including use of instrumentation; to effectively utilize appropriate lecture demonstration equipment and models; to provide for appropriate faculty-student interaction; and to allow for effective auxiliary learning programs as well as multiple instructional strategies. This may require extensive changes in present facilities and a reorientation in planning new facilities.

19. A sufficient full-time faculty in chemistry to effectively and efficiently deal with the chemistry program and utilize part-time faculty to take care of the fluctuations in enrollment from term to term and fill in for full-time faculty on leaves. If part-time faculty are used, a program should be provided to insure that their work is properly coordinated with that of the full-time staff and that the standards of instruction and evaluation for the department are maintained.

20. For academic year release time and summer project employment of faculty to carry out curriculum development and instructional research projects relevant to satisfying the curriculum and instructional needs above.

21. For the establishment of one or more advisory committees for the chemistry program of the college. A separate group should be established for chemical technology if the college has that program, and separate groups may be established for other portions of the chemistry curriculum or one group with subcommittees might be employed.

In order to carry out their responsibilities to the students, colleges and profession, the chemistry faculty must not only make effective use of what the college provides for their work (12-21) but they must also assume professional responsibilities such as:

22. When responsible for the allied health, engineering technician, and chemistry for other occupational group courses, faculty and professionals in the occupational fields should cooperate to develop chemistry courses consistent with the educational needs of these occupational groups.

23. Publish in appropriate journals and present papers at professional meetings related to their curriculum developments, instructional research and instructional practices as well as their philosophies on chemical education.

To assist the faculty and administrators of the two-year colleges in discharging their responsibilities to provide for the satisfaction of the needs expressed above, outside agencies (e.g., the American Chemical Society Education Office and Division of Chemical Education and the AACJC, the National Science Foundation and other governmental agencies, state community college agencies, private foundations and research centers, chemical industry groups and other interested organizations) should individually or cooperatively develop:

24. A companion version of the document, Undergraduate Professional Education in Chemistry: Criteria and Evaluation Procedures, for the two-year colleges, entitled Criteria for Education in Chemistry in the Two-Year Colleges.

25. Comprehensive programs for (1) presenting the Criteria document in 24 to college administrators, science administrators and chemistry faculty of the community colleges and for (2) assisting colleges in evaluating their programs in terms of the Criteria and other recommendations, as well as in developing long range programs for effecting compliance with the Criteria and with recommendations such as these.

26. A Center for Research and Development in Chemical Education in the Two-Year Colleges that would stimulate and assist local colleges and groups of colleges in research projects designed to study the curriculum and instruction problems of the chemistry programs of the two-year colleges and develop strategies and materials for dealing with these problems.

27. Create a national funding program for the sciences in the two-year colleges that will combine features of several present National Science Foundation programs with some of those of the Vocational Education Act and similar occupational funding programs. The program should

have two thrusts - one to help institutions achieve compliance with the Criteria and to help institutions move forward from that level with soundly conceived innovations.

28. Recommendations regarding the titling of chemistry courses to avoid the ambiguity reported in findings of this study.

29. Plans to use the Course Classification System for the Sciences in the Two-Year Colleges as the basis for gathering and reporting information about chemistry and the other sciences in these colleges and also as a guide for the classification and evaluation of courses.

30. Strategies for relating chemistry to the non-science and non-technology students. These should include courses and related materials as well as ideas for non-credit public understanding of science programs.

Finally, we believe that the administrators and faculty have the special responsibilities described below, that must be dealt with pragmatically before the needs described above may be satisfied.

The non-science and non-technically oriented administrators need to develop an understanding of - rather than an antagonism towards - the chemistry program. They must understand the unique nature of chemistry as a discipline; the nature of the chemical requirements of other disciplines within the curriculum; of the centrality of chemistry in a comprehensive community college program; of the economic requirements of a chemistry program; of the need to characterize the two-year college student with respect to the abilities required for success in chemistry and the implications of this for courses, assessments and instruction; and of the requirements of the chemistry faculty to develop programs to effectively and efficiently deal with these problems.

Finally, with the colleges' assistance, the chemistry faculty - many of whom are traditionally educated and trained and oriented towards teaching reasonably well prepared science major students - should develop and reorient themselves so they can implement the curriculum and programs described above in an educationally efficient and economically feasible manner.

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*Deals with chemistry in two-year colleges specifically.

APPENDIX A

Region I NORTHEAST

Connecticut

Greater Hartford
Mitchell
Quinebaug

Massachusetts

Bay Path
Bunker Hill
Mt. Wachusett

Maine

University of Maine/ Augusta

New Hampshire

New Hampshire Tech.
White Pines

New York

Cayuga County
Genesee
Hudson Valley
North Country

Vermont

Champlain
Vermont Col. of Norwich U.

Region 2 MIDDLE STATES

Delaware

Delaware Tech. and C.C./ Terry Campus
Goldey Beacom

Maryland

Dundalk
Hagerstown
Harford
Howard
Villa Julie

New Jersey

Atlantic
Middlesex County

Pennsylvania

Allegheny County/Boyce Campus
Delaware County
Harcum
Keystone
Northampton County
Northeastern Christian

West Virginia

West Virginia Northern
Potomac State

Region 3 SOUTH

Alabama

James Faulkner State
John C. Calhoun State
Lurleen B. Wallace State
Northwest Alabama State

Arkansas

Central Baptist
Mississippi County
Westark

Florida

Brevard
Edison
Florida
Palm Beach
Seminole
Valencia

Georgia

Atlanta
Bainbridge
Clayton
Floyd
Georgia Military
Middle Georgia
South Georgia

Kentucky

Southeast

APPENDIX A (continued)

Mississippi

Itawamba
Mary Holmes
Mississippi Gulf Coast/
  Jefferson Davis Campus
Pearl River
Southwest Mississippi
Wood

North Carolina

Chowan College
Coastal Carolina
Edgecombe Tech.
Halifax City Tech.
Lenoir
Richmond Tech.
Roanoke-Chowan Tech.
Wake Tech.

South Carolina

Greenville Tech.
University of South Carolina/
  Lancaster

Tennessee

Jackson State
Martin
Morristown
Shelby State

Texas

Angelina
Lamar University/Orange Branch
San Antonio
Vernon Regional
Weatherford

Virginia

Central Va.
Northern Va./Alexandria
New River
Southern Seminary
Tidewater
Thomas Nelson
Wytheville

Region 4 MIDWEST

Illinois

Central YMCA
Danville
Highland
Kishwaukee
Lincoln Land
Oakton
Waubonsee
William Rainey Harper

Iowa

Clinton
Hawkeye Institute of
  Technology
Indian Hills
Iowa Lakes
Marshalltown
Southeastern

Michigan

Bay de Noc
Delta
Kalamazoo Valley
Kirtland
Monroe County
Oakland
Suomi

Minnesota

Austin
North Hennepin
Northland
University of Minnesota
  Tech.
Willmar

Missouri

St. Paul's
Three Rivers

Nebraska

Metropolitan Tech.
Platte Tech.

Ohio

Edison State
Lorain County
Northwest Tech.
Shawnee State
Sinclair
University of Toledo
  Comm. and Tech.

APPENDIX A (continued)

Wisconsin

District One Tech.
Lakeshore Tech.
Milwaukee Area Tech.
University Center
System/Sheboygan
Western Wisconsin Tech.

Region 5 MOUNTAIN PLAINS

Colorado

Arapahoe
Community College of Denver
Auraria Campus
Morgan
Northeastern

Kansas

Barton County
Central
Coffeyville
Hesston
St. John's

Montana

Miles

North Dakota

North Dakota St. Sch.
of Science

Oklahoma

Connors State
Hillsdale Free Will Baptist
Northern Oklahoma
South Oklahoma City
St. Gregory's

South Dakota

Presentation

Utah

College of Eastern Utah
Utah Tech.

Wyoming

Central Wyoming

Region 6 WEST

Alaska

Ketchikan

Arizona

Cochise
Pima

California

American River
Butte
Citrus
College of San Mateo
College of the Desert
College of the Sequoias
Fresno City College
Hartnell
Lassen
Los Angeles Pierce
Mendocino
Merced
Mt. San Jacinto
Saddleback
San Bernardino Valley
San Diego Mesa
Santa Rosa

Nevada

Clark County

Oregon

Chemeketa
Mt. Hood
Umpqua

Washington

Green River
Lower Columbia
Peninsula
South Seattle

460-006

Center for the Study of Community Colleges

INSTRUCTOR SURVEY

Your college is participating in a nationwide study conducted by the Center for the Study of Community Colleges under a grant from the National Science Foundation. The study is concerned with the role of the sciences and technologies in two-year colleges — curriculum, instructional practices and course activities.

The survey asks questions about one of your classes offered last fall. The information gathered will help inform groups making policy affecting the sciences. All information gathered is treated as confidential and at no time will your answers be singled out. Our concern is with aggregate instructional practices as discerned in a national sample.

We recognize that the survey is time-consuming and we appreciate your efforts in completing it. Thank you very much.

1a. Your college's class schedule indicated that in Fall, 1977 you were teaching:

(Course) ____________________ 11-13 (Section) ____________________

If this class was assigned to a different instructor, please return this survey to your campus facilitator to give to the person who taught this class.

If the class was not taught, please give us the reason why, and then return the uncompleted survey form in the accompanying envelope.

b. Class was not taught because: (explain briefly) ____________________

____

____

Please answer the questions in relation to the specified class.

2. Approximately how many students were initially enrolled in this class? Males ________ 14-16

Females ________ 17-19

3. Approximately how many students completed this course and received grades? (Do not include withdrawals or incompletes.) Males ________ 20-22

Females ________ 23-25

4. **Check each of the items below that you believe properly describes this course:**

a. Parallel or equivalent to a lower division college level course at transfer institutions . . . . . ☐ 1 — 26

b. Designed for transfer students majoring in one of the natural resources fields (e.g., agriculture, forestry) or an allied health field (e.g., nursing, dental hygiene, etc.) . . . . . ☐ 2

c. Designed for transfer students majoring in one of the physical or biological sciences, engineering, mathematics, or the health sciences (e.g., pre-medicine, pre-dentistry) . . . . . ☐ 3

d. Designed for transfer students majoring in a non-science area . . . ☐ 4

e. Designed for occupational students in an allied health area . . . . ☐ 5

f. Designed for occupational students in a science technology or engineering technology area . . . . . ☐ 6

g. Designed as a high school make up or remedial course . . . . ☐ 7

h. Designed as a general education course for non-transfer and non-occupational students . . . . . ☐ 8

i. Designed for further education or personal upgrading of adult students . . . . . ☐ 9

j. Other *(please specify)*:________________ ☐ 0

5a. **Instructors may desire many qualities for their students. Please select the one quality in the following list of four that you most wanted your students to achieve in the specified course.**

1) Understand/appreciate interrelationships of science and technology with society . . . . . ☐ 1 — 27
2) Be able to understand scientific research literature . . . . . ☐ 2
3) Apply principles learned in course to solve qualitative and/or quantitative problems . . . . . ☐ 3
4) Develop proficiency in laboratory methods and techniques of the discipline . . . . . ☐ 4

b. **Of the four qualities listed below, which one did you most want your students to achieve?**

1) Relate knowledge acquired in class to real world systems and problems . . . . . ☐ 1 — 28
2) Understand the principles, concepts, and terminology of the discipline . ☐ 2
3) Develop appreciation/understanding of scientific method . . . . ☐ 3
4) Gain "hands-on" or field experience in applied practice . . . . ☐ 4

c. **And from this list, which one did you most want your students to achieve in the specified class.**

1) Learn to use tools of research in the sciences . . . . . ☐ 1 — 29
2) Gain qualities of mind useful in further education . . . . . ☐ 2
3) Understand self . . . . . ☐ 3
4) Develop the ability to think critically . . . . . ☐ 4

6a. **Were there prerequisite requirements for this course?** Yes ☐ 1 No ☐ 2 — 30

b. **IF YES: Which of the following were required? (CHECK AS MANY AS APPLY)**

1) **Prior course in the same discipline taken in high school** ☐ 1 . . **college** ☐ 7 — 31
2) **Prior course in any science taken in high school** ☐ 2 . . **college** ☐ 8
3) **Prior course in mathematics taken in high school** ☐ 3 . . **college** ☐ 9
4) **Declared science or technology major** . . . . ☐ 4
5) **Achieved a specified score on entrance examination** . ☐ 5
6) **Other *(please specify)*:**________________ ☐ 6

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7. **Over the entire term, what percentage of class time is devoted to each of the following:**

a. Your own lectures	______%	32/33
b. Guest lecturers	______%	34/35
c. Student verbal presentations	______%	36/37
d. Class discussion	______%	38/39
e. Viewing and/or listening to film or taped media	______%	40/41
f. Simulation/gaming	______%	42/43
g. Quizzes/examinations	______%	44/45
h. Field trips	______%	46/47
i. Lecture/demonstration experiments	______%	48/49
j. Laboratory experiments by students	______%	50/51
k. Laboratory practical examinations and quizzes	______%	52/53
l. Other *(please specify)*: ______	______%	54/55

Please add percentages to make sure they agree with total — TOTAL: 100 %

8. **How frequently were each of the following instructional media used in this class?**

Also check last box if you or any member of your faculty developed any of the designated media for this course.

	Frequently used	Occasionally used	Never used	Developed by self or other faculty member	
a. Films	☐ 1	☐ 2	☐ 3	☐ 4	56
b. Single concept film loops	☐ 1	☐ 2	☐ 3	☐ 4	57
c. Filmstrips	☐ 1	☐ 2	☐ 3	☐ 4	58
d. Slides	☐ 1	☐ 2	☐ 3	☐ 4	59
e. Audiotape/slide/film combinations	☐ 1	☐ 2	☐ 3	☐ 4	60
f. Overhead projected transparencies	☐ 1	☐ 2	☐ 3	☐ 4	61
g. Audiotapes, cassettes, records	☐ 1	☐ 2	☐ 3	☐ 4	62
h. Videotapes	☐ 1	☐ 2	☐ 3	☐ 4	63
i. Television (broadcast/closed circuit)	☐ 1	☐ 2	☐ 3	☐ 4	64
j. Maps, charts, illustrations, displays	☐ 1	☐ 2	☐ 3	☐ 4	65
k. Three dimensional models	☐ 1	☐ 2	☐ 3	☐ 4	66
l. Scientific instruments	☐ 1	☐ 2	☐ 3	☐ 4	67
m. Natural preserved or living specimens	☐ 1	☐ 2	☐ 3	☐ 4	68
n. Lecture or demonstration experiments involving chemical reagents or physical apparatus	☐ 1	☐ 2	☐ 3	☐ 4	69
o. Other *(please specify)*: ______	☐ 1	☐ 2	☐ 3	☐ 4	70

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9. **Which of the following materials were used in this class? CHECK EACH TYPE USED. THEN, FOR EACH TYPE USED, PLEASE ANSWER ITEMS A-D.**

	A.	**B.**			**C.**		**D.**			
		How satisfied were you with these materials?			**Did you prepare these materials?**		**How much say did you have in the selection of these materials?**			
Check Materials Used	**How many pages in total were students required to read?**	Well-satisfied	Would like to change them	Definitely intend changing them	Yes	No	Total say	Selected them but had to verify with a chairperson or administrator	Was member of a group that selected them	Someone else selected them
☐ 1 Textbooks	____ 13-15	16 ☐ 1	☐ 2	☐ 3	17 ☐ 1	☐ 2	18 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 2 Laboratory materials and work-books	____ 19-21	22 ☐ 1	☐ 2	☐ 3	23 ☐ 1	☐ 2	24 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 3 Collections of readings	____ 25-27	28 ☐ 1	☐ 2	☐ 3	29 ☐ 1	☐ 2	30 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 4 Reference books	____ 31-33	34 ☐ 1	☐ 2	☐ 3	35 ☐ 1	☐ 2	36 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 5 Journal and/or magazine articles	____ 37-39	40 ☐ 1	☐ 2	☐ 3	41 ☐ 1	☐ 2	42 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 6 Newspapers	____ 43-45	46 ☐ 1	☐ 2	☐ 3	47 ☐ 1	☐ 2	48 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 7 Syllabi and handout materials	____ 49-51	52 ☐ 1	☐ 2	☐ 3	53 ☐ 1	☐ 2	54 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 8 Problem books	____ 55-57	58 ☐ 1	☐ 2	☐ 3	59 ☐ 1	☐ 2	60 ☐ 1	☐ 2	☐ 3	☐ 4
☐ 9 Other *(please specify)* ____	____ 61-63	64 ☐ 1	☐ 2	☐ 3	65 ☐ 1	☐ 2	66 ☐ 1	☐ 2	☐ 3	☐ 4

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10. **Please indicate the emphasis given to each of the following student activities in this class.**

	Not included in determining student's grade	Included but counted less than 25% toward grade	Counted 25% or more toward grade	
a. Papers written outside of class	☐ 1	☐ 2	☐ 3	67
b. Papers written in class	☐ 1	☐ 2	☐ 3	68
c. Quick-score/objective tests/exams	☐ 1	☐ 2	☐ 3	69
d. Essay tests/exams	☐ 1	☐ 2	☐ 3	70
e. Field reports	☐ 1	☐ 2	☐ 3	71
f. Oral recitations	☐ 1	☐ 2	☐ 3	72
g. Workbook completion	☐ 1	☐ 2	☐ 3	73
h. Regular class attendance	☐ 1	☐ 2	☐ 3	74
i. Participation in class discussions	☐ 1	☐ 2	☐ 3	75
j. Individual discussions with instructor	☐ 1	☐ 2	☐ 3	76
k. Research reports	☐ 1	☐ 2	☐ 3	77
l. Non-written projects	☐ 1	☐ 2	☐ 3	78
m. Homework	☐ 1	☐ 2	☐ 3	79
n. Laboratory reports	☐ 1	☐ 2	☐ 3	80
o. Laboratory unknowns and/or practical exams (quantitative and qualitative)	☐ 1	☐ 2	☐ 3	12
p. Problem sets	☐ 1	☐ 2	☐ 3	13
q. Other *(please specify)*: ________	☐ 1	☐ 2	☐ 3	14

11. **Examinations or quizzes given to students may ask them to demonstrate various abilities. Please indicate the importance of each of these abilities in the tests you gave in this course. (CHECK ONE BOX FOR EACH ITEM)**

	Very important	Somewhat important	Not important	
a. Mastery of a skill	☐ 1	☐ 2	☐ 3	15
b. Acquaintance with concepts of the discipline	☐ 1	☐ 2	☐ 3	16
c. Recall of specific information	☐ 1	☐ 2	☐ 3	17
d. Understanding the significance of certain works, events, phenomena, and experiments	☐ 1	☐ 2	☐ 3	18
e. Ability to synthesize course content	☐ 1	☐ 2	☐ 3	19
f. Relationship of concepts to student's own values	☐ 1	☐ 2	☐ 3	20
g. Other *(please specify)*: ________	☐ 1	☐ 2	☐ 3	21

12. **What was the relative emphasis given to each type of question in written quizzes and examinations? (PLEASE RESPOND BY CHECKING ONE OF THE THREE BOXES FOR EACH ITEM.)**

	Frequently used	Seldom used	Never used	
a. Multiple response (including multiple choice and true/false)	☐ 1	☐ 2	☐ 3	22
b. Completion	☐ 1	☐ 2	☐ 3	23
c. Essay	☐ 1	☐ 2	☐ 3	24
d. Solution of mathematical type problems where the work must be shown	☐ 1	☐ 2	☐ 3	25
e. Construction of graphs, diagrams, chemical type equations, etc.	☐ 1	☐ 2	☐ 3	26
f. Derivation of a mathematical relationship	☐ 1	☐ 2	☐ 3	27
g. Other *(please specify)*: ________	☐ 1	☐ 2	☐ 3	28

13. What grading practice did you employ in this class? 29

- ABCDF ☐ 1
- ABCD/No credit ☐ 2
- ABC/No credit ☐ 3
- Pass/Fail ☐ 4
- Pass/No credit ☐ 5
- No grades issued ☐ 6
- Other ________ ☐ 7 *(please specify)*

14. For each of the following out-of-class activities, please indicate if attendance was required, recommended or neither.

	Attendance required for course credit	Attendance recommended but not required	Neither required nor recommended	
a. On-campus educational type films	☐ 1	☐ 2	☐ 3	30
b. Other films	☐ 1	☐ 2	☐ 3	31
c. Field trips to industrial plants, research laboratories	☐ 1	☐ 2	☐ 3	32
d. Television programs	☐ 1	☐ 2	☐ 3	33
e. Museums/exhibits/zoos/arboretums	☐ 1	☐ 2	☐ 3	34
f. Volunteer service on an environmental project	☐ 1	☐ 2	☐ 3	35
g. Outside lectures	☐ 1	☐ 2	☐ 3	36
h. Field trips to natural formation or ecological area	☐ 1	☐ 2	☐ 3	37
i. Volunteer service on education/ community project	☐ 1	☐ 2	☐ 3	38
j. Tutoring	☐ 1	☐ 2	☐ 3	39
k. Other *(please specify)*: ________	☐ 1	☐ 2	☐ 3	40

15a. Was this class conducted as an interdisciplinary course? 41

- Yes ☐ 1
- No ☐ 2

b. IF YES: Which other disciplines were involved? ________ *(please specify)*

____

________ 42- 43-

16. Were instructors from other disciplines involved . . .

	YES	NO	
. . . in course planning?	☐ 1	☐ 2	44
. . . in team teaching?	☐ 1	☐ 2	45
. . . in offering guest lectures?	☐ 1	☐ 2	46

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17a. **Which of these types of assistance were available to you last term? CHECK AS MANY AS APPLY.**

b. Which did you utilize? CHECK AS MANY AS APPLY.

	a. Assistance was available to me in the following areas	b. Utilized
a. Clerical help	47- ☐ 1	48- ☐ 1
b. Test-scoring facilities	☐ 2	☐ 2
c. Tutors	☐ 3	☐ 3
d. Readers	☐ 4	☐ 4
e. Paraprofessional aides/instructional assistants	☐ 5	☐ 5
f. Media production facilities/assistance	☐ 6	☐ 6
g. Library/bibliographical assistance	☐ 7	☐ 7
h. Laboratory assistants	☐ 8	☐ 8
i. Other *(please specify)*: ________	☐ 9	☐ 9

18. **Although this course may have been very effective, what would it take to have made it better? CHECK AS MANY AS APPLY.**

a. More freedom to choose materials . . . ☐ 1 49
b. More interaction with colleagues or administrators . . . ☐ 2
c. Less interference from colleagues or administrators . . . ☐ 3
d. Larger class (more students) . . . ☐ 4
e. Smaller class . . . ☐ 5
f. More reader/paraprofessional aides . . . ☐ 6
g. More clerical assistance . . . ☐ 7
h. Availability of more media or instructional materials . . . ☐ 8
i. Stricter prerequisites for admission to class . . . ☐ 9
j. Fewer or no prerequisites for admission to class . . . ☐ 1 50
k. Changed course description . . . ☐ 2
l. Instructor release time to develop course and/ or material . . . ☐ 3
m. Different goals and objectives . . . ☐ 4
n. Professional development opportunities for instructors . . . ☐ 5
o. Better laboratory facilities . . . ☐ 6
p. Students better prepared to handle course requirements . . . ☐ 7
q. Other *(please specify)*: ________ . . . ☐ 8

Now, just a few questions about you . . .

19. How many years have you taught in any two-year college?

- a. Less than one year . . . . ☐ 1 — 51
- b. 1-2 years . . . . ☐ 2
- c. 3-4 years . . . . ☐ 3
- d. 5-10 years . . . . ☐ 4
- e. 11-20 years . . . . ☐ 5
- f. Over 20 years. . . . . ☐ 6

20. At this college are you considered to be a:

- a. Full-time faculty member . . . . . . ☐ 1 — 52
- b. Part-time faculty member . . . . . . ☐ 2
- c. Department or division chairperson . . . ☐ 3
- d. Administrator . . . . ☐ 4
- e. Other *(please specify)*: ____________________ . . . ☐ 5

21a. Are you currently employed in a research or industrial position directly related to the discipline of this course?

Yes ☐ 1 — 53
No ☐ 2

b. IF YES: For how many years?____________________ 54/55

c. If previously you had been employed in a related industry or research organization, please indicate the number of years:____________________ 56/57

22. What is the highest degree you presently hold?

- a. Bachelor's . . . . ☐ 1 — 58
- b. Master's . . . . ☐ 2
- c. Doctorate . . . . ☐ 3

IMPORTANT INSTRUCTIONS

Thank you for taking the time to complete this survey. Please seal the completed questionnaire in the envelope which is addressed to the project facilitator on your campus and return it to that person. After collecting the forms from all participants, the facilitator will forward the sealed envelopes to the Center.

We appreciate your prompt attention and participation in this important survey for the National Science Foundation.

Arthur M. Cohen
Principal Investigator

Florence B. Brawer
Research Director