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ABSTRACT

Physics instruction is examined as revealed in a study of science education at two-year colleges which involved a review of the literature, an analysis of the catalogs and class schedules of 175 representative institutions, and a survey of 45 physics instructors. Each of the two parts of the report reviews pertinent literature, reports study methodology and findings, and discusses trends and implications. Part I presents a general profile of physics curricula based on the number of courses and sections offered, and then analyzes study findings as they relate to course offerings in seven areas: (1) introductory courses for non-science/technology students: (2) physics for allied health and biology: (3) physics for engineering technology and related occupations: (4) preparatory courses for under-prepared students planning to take engineering sequences: (5) general non-calculus physics: (6) specialized, non-calculus courses, such as those offered in police and fire science curricula: and (7) calculus-based engineering and general physics courses. Part II explores instructional practices and faculty characteristics. This section focuses on laboratory requirements, instructional materials, student evaluation criteria, faculty degree attainment, and faculty suggestions for instructional improvement. Summary conclusions, a bibliography, the questionnaire, and data tables are included in the report. (JP)

SCIENCE EDUCATION IN TWO-YEAR COLLEGES: PHYSICS

by

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August 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: PHYSICS

Two-year community and junior colleges* enroll more than four million students, one-third of all students in American higher education. Current figures show that 40 percent of all first-time, full-time students are in two-year colleges. When the people beginning college as part-time students and those attending the two-year college concurrently with or subsequent to their enrolling in a senior institution are added to this number, the first-year students taking two-year college courses approximate two-thirds of all freshmen.

These students are enrolled in a wide range of courses--transfer, occupational, remedial, continuing education, community service, and terminal degree. And they come from all walks of life, different cultural and ethnic backgrounds, and represent a wide range of ages.

Despite this awareness of both the size and the diversity of two-year college students, many questions prevail. For example, how many of these students are enrolled in science courses? What are the most popular classes? Do courses vary in different types of institutions?

This monograph, one part of a National Science Foundation (NSF) sponsored study of science education in America's community, junior, and technical colleges, answers these questions and poses areas for future investigation.

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*The two-year 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, terms which help account for the character of physics programs of two-year colleges.

Concerned with the current state of physics education in two-year colleges, it is divided into three parts. The first part is concerned with curriculum, the second with instructional practice, each including an overview of the pertinent literature. The final part presents recommendations stemming from the findings of the Center for the Study of Community Colleges' study of sciences in two-year colleges.

This study of the sciences included a literature review of the most significant studies of education in the sciences in two-year colleges. Curriculum data for 1977-78 were gathered from the catalogs and class schedules of a representative national sample of 175 colleges and a Course Classification System for the Sciences was developed to organize these data. Finally, a random sample of science instructors in 175 colleges was surveyed in order to determine instructional practices and to obtain information about the science faculty.

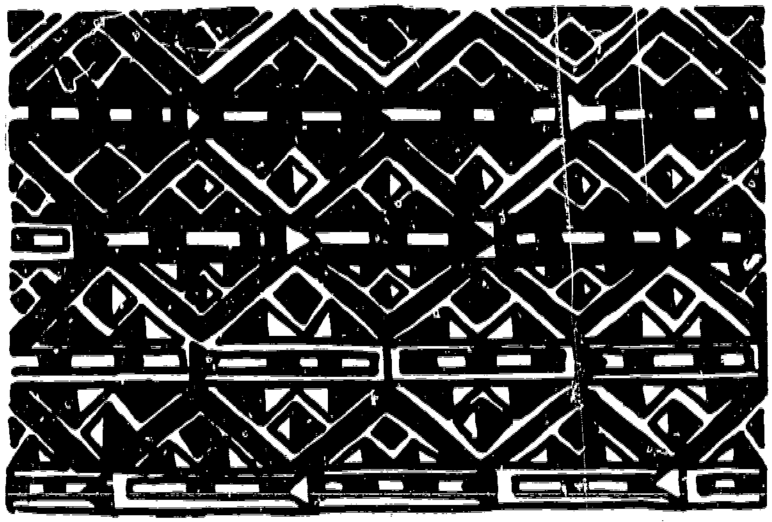
Physics is a central science taking from and giving to the other sciences as well as engineering, the health sciences, and the arts. Any physics program is heavily influenced by the form and function of the institution in which it operates. This monograph examines the characteristics of physics in the two-year colleges in view of the discipline's relationship to the other sciences, the diverse institutional functions, and the heterogeneous student body that populate these colleges.

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 physics, not all science intending students are prepared to start at the same place. Furthermore, not all programs requiring physics need the same slice of the spectrum of physical topics. These differences tend to create the variety of introductory physics courses described later (see Part I). Each physics course must be justified in terms of one or more of the functions of the comprehensive college: 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 physics curriculum but also for the presentation of physics to the students, a topic which is also considered in this monograph.

The literature background for this monograph on physics in the two-year colleges was obtained through a search of the American Journal of Physics (volumes 34-47, no. 8); The Physics Teacher (volumes 4-7, no. 5); The AAPT Announcer (volumes 1-9, no. 3); CRPTYC (volumes 1-7, no. 1); The Journal of College Science Teaching (volumes 1-8); the ERIC system and Dissertation Abstracts (1963-1978). Additionally, all publications of the Commission on College Physics were reviewed as was an extensive collection of publications, reports, and papers concerned with physics education and physics in the two-year colleges. This collection contains items from the American Institute of Physics, the American Association of Physics Teachers, the National Science Teachers Association, American Association for the Advancement of Science, the National Science Foundation and projects supported by NSF, state community college agencies, and other agencies and organizations. Other publications concerned with education and science also contained occasional references of interest. Compared to the above sources, little of interest to this study was found in the community college periodical literature.

The literature citations in this report are limited. They were selected for their correlation with the specifics of this document, and no attempt was made to be comprehensive in citations or bibliography. However, an additional, comprehensive report includes all of the tables from which this report has been prepared, a more extensive discussion, a survey of the literature, and a comprehensive bibliography on physics in the two-year colleges. The report is available through the ERIC system (Hill & Mooney, 1979).



PART I

THE CURRICULUM STUDY

The Sample

The first step in our study of the curriculum in two-year colleges was to assemble a representative sample of colleges (see Table 1.* An earlier study conducted for the National Endowment for the Humanities by the Center for the Study of Community Colleges was used as the starting point. This study had already assembled a sample (balanced by college control, region and size) of 178 colleges. Using this sample as the initial group, the presidents of these colleges were invited to participate in the current study. Acceptances were received from 144 of these schools.

*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*

BY SIZE

Enrollment Range	Small Colleges 001-499	500-999	1000-1499	Medium Colleges 1500-2499	2500-4999	5000-7499	Large Colleges 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

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

BY THE TYPE OF CONTROL

Type of Control	Public	Private
NATIONAL	84	16
SAMPLE	84	16

*All figures are percent of national or sample group.
**See Appendix A for list of states in each region.

At this point a matrix was drawn up with cells representing nine college size categories for each of six regions of the country. Using the 1977 Community, Junior, and Technical College Directory (AACJC, 1977), the ideal size/region breakdown for a 175 college sample was calculated. The remaining 31 colleges were selected by arraying all colleges in the under-represented cells and randomly selecting the possible participants. This technique produced a balanced sample of 175 two-year colleges. Table 1 shows how close our sample is to the percentage breakdowns of the nation's two-year colleges. The list of participating colleges is found in Appendix A.

Procedure and the Course Classification System for the Sciences (CCSS)

College catalogs and class schedules for the spring 1977 through winter 1978 terms (both semesters and quarters 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 (CCSS) in Two-Year Colleges (Hill & Mooney, 1979) developed specifically for this project to analyze, classify and report 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 professional associations and 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 was subdivided into Chemistry--Introductory and Advanced Chemistry, Geography, Geology, Other Earth and Space Sciences, Physical Science, or Environmental Science and Technology.

Since there is a wide variety of physics courses, subcategories, listed in the sections which follow, were developed to encompass closely-related courses. The placement of a course into a subcategory was made after an analysis of the complete catalog description for that course. We were not limited to those courses listed under the physics heading in the catalog nor to those taught by members of the physics faculty; we included any course for which the content is basically physical in nature, 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. Prerequisite requirements for entrance into the course and the course's instructional mode (e.g., lecture, lecture-laboratory, laboratory) were ascertained from the catalogs and schedules.

Physics Courses

This subject area of the CCSS includes courses and programs concerned with the properties and interaction of energy and matter as well as with the fundamental concepts involved in physical phenomena; courses which provide experience in interpreting the physical world are also included. Physics courses, often combined into sequences, include the study of some combination of mechanics of solids and fluids, heat, sound, optics--geometrical and physical, wave motion, electricity, magnetism, atomic and nuclear physics, and other modern physics topics such as relativity, plasma, lasers, etc. Many sequences deal with all, or most of, the above topics, but are differentiated because they vary in the total time required and in the mathematics used for analysis. Further differentiation is by the groups of students served, a primary criteria in establishing the categories for physics courses. Categories are provided for physics courses based on calculus, primarily for physical science and engineering majors; for general physics courses based on trigonometry and algebra, designed for biology, health science, and other science related students; technical physics courses serving the engineering technologies, industrial technologies and the trades; and for those courses oriented towards allied health occupations or other biology related occupations. Separate categories are also included for the more descriptive, non-science major type course, for preparatory courses and for courses which do not fit a specific category. Most physics courses include laboratory experience and mathematical prerequisites.

RESULTS

The findings of the Curriculum Study are reported in the following sections. The first two 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 seven subcategories of physics courses. This part is concluded by an analysis of the pattern of course offerings in individual colleges.

Physics Courses

Ninety-one percent of the 175 colleges listed one or more physics courses in their 1977-78 catalog; however, only 89 percent offered physics courses on their schedules for the spring 1977 through winter 1978 terms (summer excluded). The percentages for non-calculus physics courses were the same, 91 percent and 89 percent; 61 percent listed calculus based courses with 53 percent scheduling these more advanced programs. The discrepancy between the catalog and schedule figures 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 another way, the 888 physics courses--1591 lecture sections and 1643 laboratory sections--listed on the schedules in 1977-78 produced an average of 5.7 courses, 10.2 lecture sections and 10.5 laboratory sections for those 156 colleges offering physics. Compared to chemistry, physics had 74 percent as many courses, 63 percent lecture sections, and 57 percent laboratory sections. These figures are the consequence of the lower demand for physics that results in less frequent scheduling of courses.

Table 2 presents the results of the catalog and schedule analysis for each of the seven subcategories of physics courses. One-third of all physics courses were the non-calculus general physics; more than one-quarter, the calculus based engineering and general physics; slightly more than one-fifth, technical physics; and the remaining aproximately one-sixth were distributed among the non-science, allied health, and preparatory and miscellaneous groupings. The decreases from catalog to schedule were from five to eight percent of the colleges for the majority of the subcategories.

Table 2

Physics 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 Physics Courses Listed on Schedule (n=888)	Percent of Physics Sections Listed on Schedule: Lecture (n=1591)	Percent of Physics Sections Listed on Schedule: Lab (n=1643)
Physics for Non-Sci & Non-Tech Students (NSM)	37	31	8	12	11
Physics for Allied Health/Biol Occup (AH)	25	19	6	4	3
Physics for Engin Tech/ Related Occup (TECH)	47	42	21	31	28
Preparatory Physics (PREP)	10	7	2	3	1
General Physics (Non-Calc) (GEN)	77	75	33	29	33
Other Non-Calc Physics (MISC)	3	1	(<1)	(<1)	(<1)
Engineering & General Physics (Calc Based) (ENGR GEN)	61	53	28	21	24

Notes: 1. 160 colleges (91% of sample) list one or more physics courses in the colleges' catalog.

2. 156 colleges (89% of sample) list one or more physics courses in schedule of classes.

Analysis of Table 3 shows that the western colleges offer more of each type of physics course than any other region, except for the TECH courses while the northeastern colleges devote the least attention to the NSM, GEN and ENGR GEN types. Public comprehensive lead the NSM, GEN and ENGR GEN categories and the technical colleges each of the others. Except for preparatory courses, large colleges tend to offer more of all types of physics courses than do the medium or small.

Physics Sections

To obtain a more complete measure of the extent of the physics curriculum, one must consider the number of lecture and laboratory sections scheduled. This information is also included in Table 2 for each of the seven subcategories of physics. There were more lecture sections of technical physics (28% of all lecture sections) and more laboratory sections of general physics (33%). These two areas reverse positions for the second highest, and engineering physics is third highest in both lecture and laboratory. These three account for 81 percent of the lecture and 85 percent of the laboratory sections. The discrepancy between the numbers of courses and lecture sections is understandable when one considers the higher percentage of lecture only technical physics courses (Table 26) and the greater scheduling of multiple sections. General physics and engineering physics have a greater share in laboratory sections because they have fewer lecture only courses; additionally, they showed a greater tendency than did any other type of course to be scheduled with several laboratory sections combined into a single lecture.

Table 3

Distribution of Physics Courses in Two-Year Colleges by Geographical Region, Control of College, Emphasis of College and Size of College, 1977-78

Type of Course	REGION: Percent of Total Colleges in a Region — Northeast (n=11)	Middle States (n=21)	South (n=54)	Midwest (n=39)	Mountain Plains (n=22)	West (n=28)
Non-Science/ Non-Tech (NSM)	9	19	26	22	27	61
Allied Health/ Biol Occup (AH)	18	19	15	19	18	25
Engineering Tech (TECH)	18	19	11	20	14	7
Preparatory (PREP)	9	10	2	6	0	18
General (Non-Calc) (GEN)	45	71	74	72	77	89
Other Non-Calc (MISC)	0	0	0	3	0	4
Engineering/Gen (Calc Based) (ENGR GEN)	9	57	48	52	55	79

	CONTROL: Percent of Total Colleges — Public n=147	Private n=28	EMPHASIS: Percent of Total Colleges — Compr n=142	Lib Art n=15	Tech n=18	SIZE: Percent of Total Colleges — Small n=72	Medium n=78	Large n=25
NSM	36	7	36	7	11	14	33	64
AH	23	7	20	0	33	6	24	48
TECH	49	4	41	0	83	25	50	64
PREP	8	0	6	0	17	28	6	20
GEN	82	36	86	47	6	58	82	96
MISC	1	0	<1	0	6	0	0	8
ENGR GEN	60	25	63	27	6	31	64	88

Physics for Non-Science and Non-Technology Students (NSM)

Includes those courses which provide a descriptive introduction to the fundamental concepts of physics including work and energy; heat, sound, light and electrical energy; energy of motion and molecular energy. These courses are designed primarily for non-science and non-technology students and require little, if any, mathematical background. Some courses deal primarily with the physical concepts related to energy or the environment. Others are designed for specialized groups such as education or music and speech (in which sound and acoustics are the focus) (CCSS).

The NSM physics courses, offered by 31 percent of the colleges, accounted for only eight percent of the physics courses offered; however, they did represent 12 percent of the lecture sections and 11 percent of the laboratory sections (Table 2). This increase in sections over course percentage is a consequence of a greater multiple section scheduling of NSM courses than for some other categories. Less than two-thirds (63%) of these courses include both lecture and laboratory; whereas, one-third (33%) are lecture only courses (Table 26). Less than half (46%) of these colleges had any prerequisite.

The NSM physics courses were more apt to be found in the west (61% of the colleges) than the mountain plains (27%), south (26%), midwest (22%), middle states (19%), or northeast (9%) regions. Public (36%) and comprehensive (36%) colleges showed more interest in these courses than did the private (7%), liberal arts (7%), or technical (11%) schools. Large colleges (64%) were more apt to include NSM courses than were medium (33%) or small (14%) institutions (Table 3).

Within the NSM physics classification, the courses differ primarily in two ways (Table 4): content or emphasis, a general approach versus a thematic or special interest thrust; and length, one term versus a two or three term

Table 4

Physics Courses for Non-Science and Non-Technology Majors (NSM), 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 NSM Courses of This Type Scheduled (n values at left)	Percent of Total NSM Courses on Schedule (n=74)
Short Courses (One Term) (n=55)	29	23	78	58
Long Courses (2 or 3 Terms) (n=29)	7	6	83	32
Physics of Music/Sound/ Acoustics (n=6)	3	3	100	8
Physics for Elem Educ (n=1)	1	1	100	1
Energy and Environment (n=1)	1	0	0	0

Notes:
3 colleges offered both a short course and a music/sound course.
1 college offered both a long course and a music/sound course.
1 college offered both a long course and a short course whereas 2 others listed both but offered only 1.
1 college offered two different short courses.

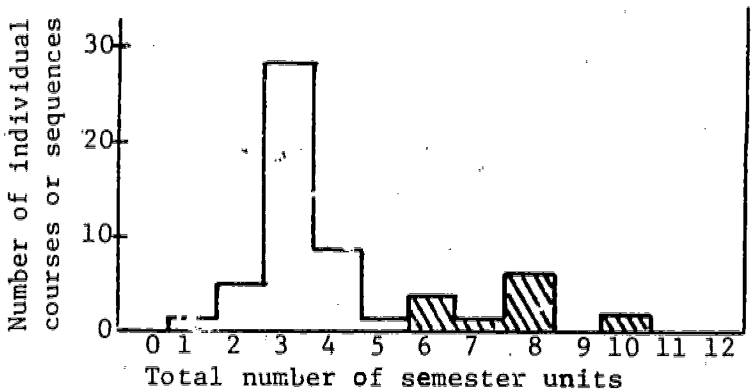
sequence. The predominant combinations of these variables, accounting for 90 percent of all NSM physics courses, were the one term general type ([illegible]) and the longer general course (32%). The only special interest or thematic course found in more than one college was the physics of music and sound course, primarily for students in the performing arts (8%).

The distribution of units, total contact hours, and laboratory hours for the short and long courses is shown in Tables 5 through 7. The short courses average 2.7 lecture hours per week and the long courses, 6.0 total weekly lecture hours for the sequence. The short course is mainly three units (65%) and three hours total (47%). Only 56 percent of these include laboratory. Most (67%) NSM individual courses or sequences have no prerequisites whereas 23 percent require only elementary algebra. Sequential courses account for the difference in this and the earlier prerequisite figure.

This study does not support the observation (Manka, 1973) that the two-year schools are providing leadership in the development of the emphasis courses (e.g., physics of music and acoustics, physics and art, physics for journalism) since they usually have a greater flexibility (lower inertia) than four-year colleges. Indeed, the recent literature is replete with references to such courses with only a few of these reported by two-year colleges. It is possible that Manka is confusing this area with community college service courses designed for allied health and engineering technology occupational programs.

Two such courses for art majors have been reported (Day, 1976; Waldmann, 1973). "Light and Vision," a one semester, three unit, non-laboratory course developed by Waldmann was designed to include material relevant

Table 5. Total Number of Semester Units* for Courses and Sequences, Physics for Non-Science and Non-Technology Majors (NSM), Two-Year Colleges, 1977-78.



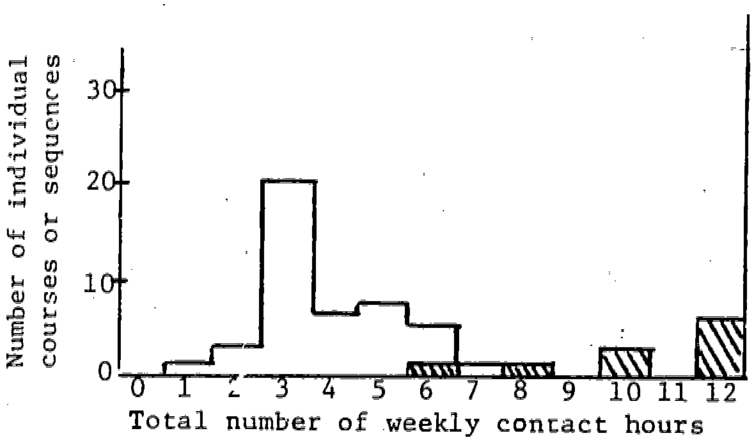
Short NSM Courses

Long NSM Courses

Short course average=3.1 units
Long course average=7.5 units

*All quarter course sequences converted to semester units for this table.

Table 6. Total Number of Semester Weekly Contact Hours* for Courses and Sequences, Physics for Non-Science and Non-Technology Majors (NSM), Two-Year Colleges, 1977-78.



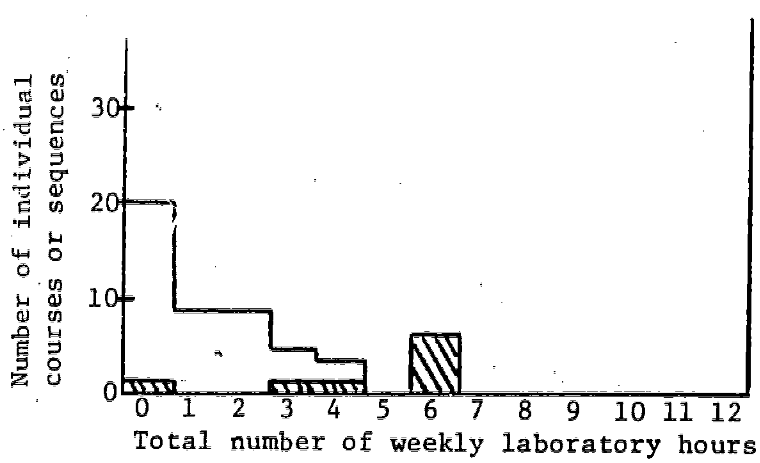
Short NSM Courses

Long NSM Courses

Short course average=3.8 hours
Long course average=10.5 hours

*All quarter courses converted to semester equivalents for this table.

Table 7. Total Number of Semester Weekly Laboratory Hours* for Course and Sequences, Physics for Non-Science and Non-Technology Majors (NSM), Two-Year Colleges, 1977-78.



Short NSM Courses

Long NSM Courses

Short course average=1.9 hours
Long course average=5.1 hours

*All quarter courses converted to semester equivalents for this table.

and interesting for art students and to give the art students a good chance of success. "Sound and Light in the Arts," described by Day, is a four unit, three hour lecture, three hour laboratory course for speech, drama, music, visual communications technology, and art majors. Thematic approaches include an environmental physics course (Kitay, 1974) and a course from a historical viewpoint (Engelberg, 1978).

Representative of some four-year college efforts in this area are career-oriented physics courses for the non-science major (Ulrich et al., 1979); physics in sports activities (Connolly, 1976); physics and society (Dickinson, 1979); environmental physics (Saperstein, 1976); a historical-humanistic approach based on Piagetian principles (Prigo, 1978); particles for poets (Erlichson, 1979); special relativity for general students (Fishbone, 1973); the nature of things--a study of natural phenomena (Coker, 1978); holography as a liberal arts course (Huang, 1978); and electronics for everyone (Mooney, P., 1979) as well as light and color (Brown et al., 1976) and musical acoustics (Kelly, 1979).

In spite of declining university enrollments, some four-year colleges have maintained and even increased physics enrollments through a strong commitment to general education and a diversification of general education offerings (Baldwin & File, 1976). The Center's Curriculum Study suggests that two-year colleges could increase their commitment to general education and possibly increase their enrollment by diversification of these physics offerings.

People who consider moving in this direction may wish to become acquainted with several dissertations involving studies that consider various aspects of physics for non-science majors. Edie (1969), for example, studied attempts to alter enrollment trends in physics by appealing to a wider group of non-science majors. He concluded that to be successful, the physics faculty must consider the relative academic quality of the physics course compared to other university courses and the relative difficulty of attaining high grades within the physics courses compared to that expected in other university courses. Other considerations in developing such courses have been studied by Stahl (1969), who showed that the difficulty many students experience in such courses has a linguistic basis; Spoeri (1973), who showed that most non-science majors can deal with conceptual development based on such themes and thematic approaches as symmetry and the conservation laws; Brunschwig (1972), who showed that the use of inexpensive kits for out-of-class use resulted in improved learning; and Niman (1969), who developed instructional materials to help with mathematical formulation. Graham (1975) reported that the learning of physics concepts can be achieved as effectively through the use of qualitative methods as through the use of the quantitative approach and at no sacrifice to interest in or opinion of physics; Steele (1974) found that students using individualized learning packets showed greater achievement and more positive attitudes towards physics that those taught by the traditional methods; and Chuaphanich (1975) reported that students with well-defined concepts of the role of physics in the undergraduate curriculum had a low dropout rate and a high overall grade distribution compared to students lacking such concepts.

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

> Includes courses designed primarily for the non-transfer allied health occupational students. Many such courses include selected topics from the major areas of physics (solid mechanics, fluid mechanics, heat, sound, electricity, magnetism, electromagnetic radiations, and atomic and nuclear physics) which have particular applications in the human health sciences. Other courses are more limited with respect to the included physical topics and the health or biological application because they serve specific groups such as radiological technicians, respiratory therapists or optical technicians (CCSS).

The AH physics courses, offered by 19 percent of the colleges, represented six percent of all the physics courses in 1977-78 but only four percent of the lecture sections and three percent of the laboratory sections (Table 2). This decrease in percentage from courses to sections is the result of two factors: few of these courses are scheduled for more than one section a term and many only once a year. Less than half (48%) of these courses include both lecture and laboratory whereas nearly half (45%) are lecture only courses (Table 26). Most (87%) of these courses had some type of a prerequisite.

The offering of AH physics courses by regions was more nearly the same than for any other type. Again, the west (25%) was the highest, followed by the midwest and middle states (both 19%), the mountain plains and northeast (both 18%) and the south (15%). Technical (33%) and public (23%) colleges were more apt to offer AH physics than the comprehensive (20%), liberal arts (none) or private (7%) institutions. Additionally, large colleges (48%) were more active in this area than the medium (24%) or small (6%) institutions (Table 3).

The major differentiation among the AH physics courses was the group for which they were intended (Table 8).

Table 8

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

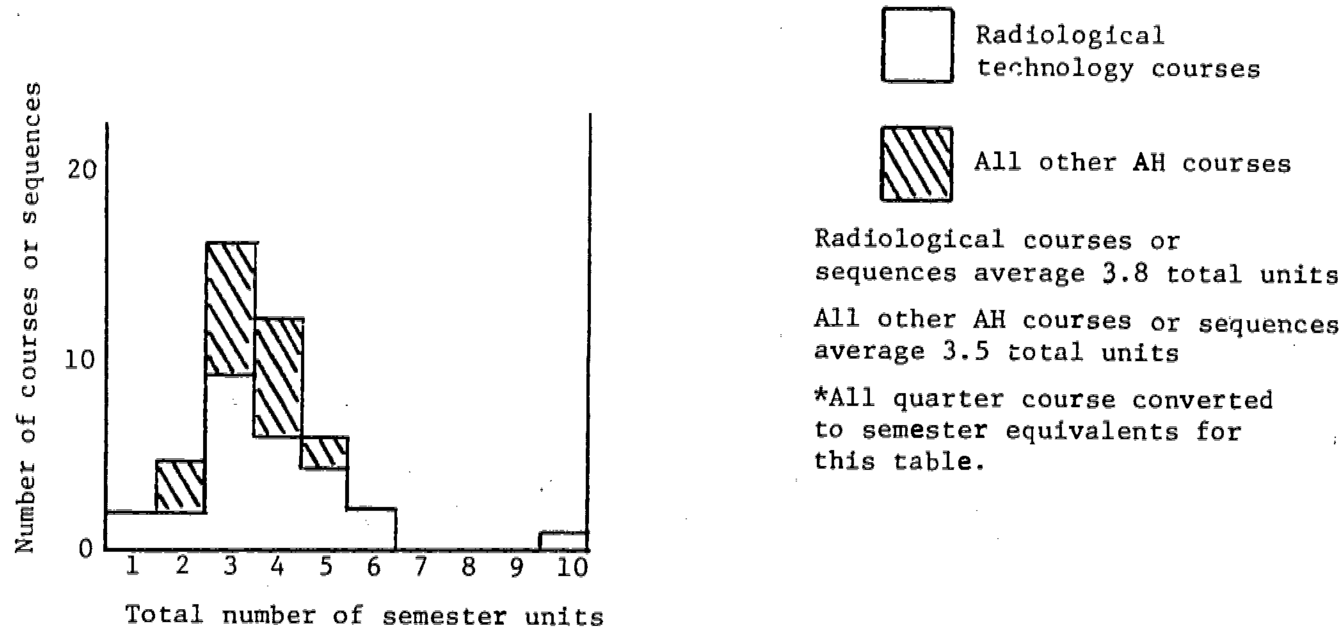
Type of Course	Percent of Colleges Listing This Type Course in Catalog (n=175)	Percent of Colleges Listing This Type Course on Schedule (n=175)	Percent of Total AH Courses of This Type Scheduled (n values at left)	Percent of Total AH Courses on Schedule (n=54)
Allied Health (n=9)	5	5	89	15
Radiological Technology (n=48)	18	13	73	65
Optical Technologies (n=7)	3	3	100	13
Respiratory Therapy (n=6)	3	1	40	4
Nuclear Medicine (n=3)	1	1	0	4

Approximately two-thirds (65%) of these courses were designed for radiological technicians; one-fifth (21%) for other specific technologies (optical, respiratory and nuclear) and nearly one-sixth (15%) were designed to serve several technologies. The distribution of units and total hours for the radiological technology physics courses are compared to those of the other AH courses, as a group, in Tables 9 and 10. The small ratio for the radiological courses of 4.5 total contact hours average to 3.8 total units average is a consequence of the 54 percent of these courses that are non-laboratory. Sixty-five percent include three or more total lecture hours. The ratio for the other AH courses, 4.3 total hours average to 3.5 total units average, is not much different than for the radiological group. However, these are more a to have laboratory and only 41 percent non-laboratory. Fifty-nine percent include three or more total lecture hours.

Only 38 percent of the radiological courses or sequences had mathematical prerequisites, 25 percent requiring intermediate algebra or more. Likewise, 38 percent of the other AH groups stated mathematics prerequisites but 12 percent were at the intermediate algebra level.

The allied health physics courses are closest to the pure service courses defined by Kimbrough (1976), courses in which instructors taught only that material which another department wanted them to teach. This implies that the instructor teaches physics only to the extent that there are applications in another area (e.g., hospital lab work) requiring the use of physics for performing or understanding. This also requires that the students be able to transfer this knowledge of basic physics; consequently, the instructor must simultaneously teach applications along with the basic theory.

Table 9. Total Number of Semester Units* for Courses and Sequences, Physics Courses for Allied Health and Biology Related Occupations (AH), Two-Year Colleges, 1977-78.

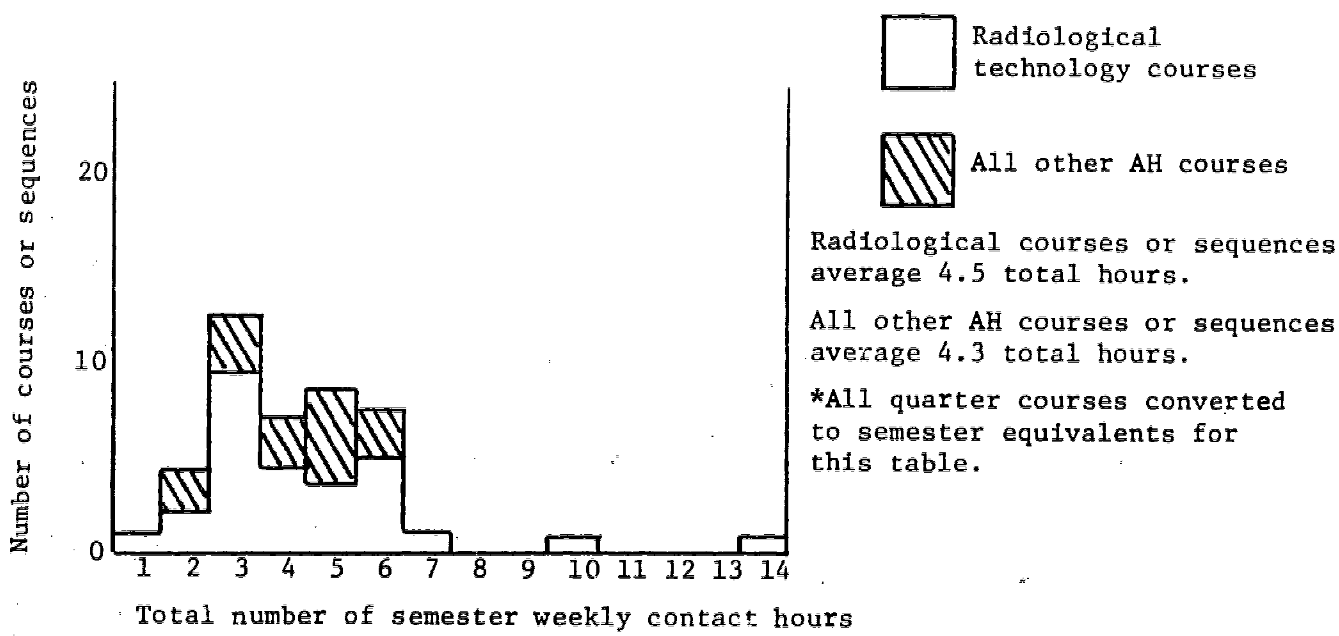


Radiological courses or sequences average 3.8 total units

All other AH courses or sequences average 3.5 total units

*All quarter course converted to semester equivalents for this table.

Table 10. Total Number of Semester Weekly Contact Hours* for Courses and Sequences Physics Courses for Allied Health and Biology Related Occupations (AH), Two-Year Colleges, 1977-78.



Radiological courses or sequences average 4.5 total hours.

All other AH courses or sequences average 4.3 total hours.

*All quarter courses converted to semester equivalents for this table.

We found only 44 percent of the AH physics courses listed in the catalogs and schedules as physics courses. Practically all of the others (53%) were listed as courses in radiological technology, dental assisting, opthamological or optometric technology, etc. The remaining seven percent were included in a generalized science category.

Discussions of the traditional inadequacy of physics instruction in training programs for radiologic technologists have been included with a description of a multi-institutional approach to improving the physics program for these students (Chaney et al., 1974) and recommendations to physicists who are teaching such courses (Muriel, 1975). Muriel's recommendation that the physicist must learn from radiologists, technicians, and health-affiliated specialists to be more effective in designing courses is given credence by Chaney's description of the Denver experience.

Physics for Engineering Technology and Related Occupations (TECH)

> Includes technical physics and other courses designed primarily for occupational and transfer students in any of the engineering technology, industrial technology or related trades programs. These courses include the study of selected topics from the major areas as in the allied health category but with particular applications in engineering and materials systems. This category also includes more specialized courses for groups such as electronics, fluid-related technologies, and construction occupations (CCSS).

Although the TECH physics courses represent about one-fifth (21%) of all physics courses, they accounted for 31 percent of the lecture sections and 28 percent of the laboratory schedule (Table 2). This percentage increase over courses reflects the considerable multiple scheduling pattern found for the TECH courses; the lower laboratory figure is a consequence of more lecture only courses in this group than some of the other large groups of courses (Table 26).

The TECH physics courses were more apt to be found in the midwest (20% of the colleges), middle states (19%) and northeast (18%) than in the mountain plains (14%), southern (11%) or western (7%) colleges. They are more apt to be offered by technical (83%), public (49%) colleges, and large (64%) colleges than by comprehensive (41%), liberal arts (none), private (4%) colleges, medium (50%) or small (25%) institutions (Table 3).

Overall, three-fourths of the TECH physics courses are lecture-laboratory and 17 percent lecture only, making them more similar to the science major courses than the non-science, allied health or preparatory.

TECH physics courses are differentiated in terms of students for whom they are intended, technicians/technologists as opposed to trades and in terms of length, one term versus two quarters or a year (Table 11). Over half (53%) of the TECH physics courses are parts of the long courses for technicians and one fifth (20%) are short courses for these students. These courses are also the most apt to be scheduled if listed in the catalog (82% and 45% respectively). The average number of units, total weekly, lecture hours, laboratory hours and total student contact hours for each of these types of TECH physics courses are reported in Table 12. The percentage of non-laboratory courses is also reported therein. It is interesting to note that long courses are more apt to include a laboratory than short ones. Furthermore, the technician-oriented courses include more units, lecture hours, laboratory and total hours than do the trades courses. This supports the fact that technician programs are more scientifically based than are the trades curricula. Table 13 reveals that a much higher level of mathematics

Table 11

Physics 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=182)
Short Courses, Tech. (One Term) (n=39)	13	11	95	20
Long Courses, Tech. (2 or 3 Terms) (n=117)	27	25	82	53
Short Courses, Trades (One Term) (n=24)	9	7	62	8
Long Courses, Trades (2 or 3 Terms) (n=27)	7	5	59	9
Courses for Specific Tech.* (n=19)	8	4	47	5
Courses for Specific Trades** (n=12)	5	4	75	5

*Includes electronics, nuclear, wastewater, chemical, fluid related

**Includes automotive mechanics, tool and die, construction, fire science, printing, business machine repair.

Table 12

Average Number of Units of Credit and Hours for Technical Physics Courses (TECH), Two-Year Colleges, 1977-78*

	Average Per Sequence or Course					
Type of Course	No. of Courses or Seqs.	No. of Units	Total No. of Weekly Lec Hours	Total No. of Weekly Lab Hours	Total No. of Weekly Contact Hours	Percent of This Type of TECH Courses That Are Non-lab
Short Course, Tech	24	3.2	2.7	1.6	4.0	21
Long Course, Tech	45	7.5	6.0	4.6	10.1	9
Short Course, Trades	15	2.7	2.4	1.3	3.2	33
Long Course, Trades	9	3.6	4.7	3.8	8.4	0
Courses for Specific Tech	9	2.6	2	1.6	3.6	38
Courses for Specific Trades	7	2.6	2	2.5	3.3	43

*All quarter course units and hours converted to a semester basis.

Table 13

Mathematical Prerequisites for Technical Physics Courses (TECH), Two-Year Colleges, 1977-78

Type of Course	Number of Courses or Sequences	Percent of Total Courses or Sequences of This Type: None	Two Courses*	Three or Four Courses**
Short Course, Tech	24	38	21	42
Long Course, Tech	45	18	20	62
Short Course, Trades	15	73	20	7
Long Course, Trades	9	56	44	0
Courses for Specific Tech	9	50	12	38
Courses for Specific Trades	7	71	14	14

*Equivalent to two years high school mathematics commencing with algebra or two courses in technical mathematics not including intermediate algebra or trigonometry. Includes concurrent enrollment.

**Interpret as intermediate algebra and trigonometry. Includes concurrent enrollment.

is required for entry into the technician courses than for the trades; also the long courses for technicians require more than the short courses.

The long course for technicians is more apt to be found in the middle states (38%), midwest (36%), or south (31%) than in the mountain plains (23%) states, northeast (18%) and western (14%) colleges. Public colleges (32%) and technical institutions (67%) are more apt to include such courses than are private (4%) or comprehensive (25%) or liberal arts (none); likewise for the medium (33%) and large (32%) compared to small (19%) colleges.

A decade ago the physics community took a detailed look at the technical physics courses in the two-year colleges (Aldridge, 1970) and found that technical physics was commonly taught by physicists, although the teaching of such courses by technology teachers was not rare. The national conference cited in Aldridge's report recommended that physics teachers should take the primary responsibility for such courses, whether individually or in a team of a physics and a technology instructor. The stimulus for the Tech Physics Project that produced the Physics of Technology instructional modules came from this conference. The modules resulted from the recommendation that many new instructional materials should be produced in the modular format with definite student learning goals for each module. The conference identified two major groups of technical physics teachers at that time, those who prefer a course with the textbook as the major instructional tool and those who prefer to build their own courses. Recommendations for the modules were aimed at the production of instructional materials useful to each group. The Physics of Technology modules have been described by DiLavore (1973) and a discussion of instructional strategies for the modules is available (Nelson, 1975).

An analysis of physics instructional patterns for engineering technology programs (Hilbelink, 1974) classified instructional patterns at that time as "classical" with small lecture sections, associated but separate laboratory instruction, and written examinations emphasizing engineering applications as opposed to general principles. No general agreement was found among the physics faculty or technology school administrators as to the primary objective (general education or preparation for specialized study) to be served by physics courses in technical programs. Both groups did agree however, that neither the conventional liberal arts physics courses (the non-science and general types) nor the beginning course is fully appropriate for students in technology programs. Both groups saw a need for additional "hands on" learning experiences with systems and devices, more adequate provisions for individual differences, and systematic opportunities for in-depth problem-solving activity. Despite these expressed concerns, most teachers and administrators indicated a basic satisfaction with their current practice. Hilbelink found few institutions experimenting with or contemplating immediate use of behavioral objectives, Tech Physics Project materials, or individually paced instruction that might satisfy some of these expressed needs. An update of this study appears to be in order because it was conducted before the modules were commercially available, because PSI programs appear to have spread greatly in physics, and because Piaget-based innovations have influenced many physics programs in the last five years. Cox (1972) described the use of a PSI approach in a technical physics course. A relatively new development in physics for technicians is the physics component of the new Science and Engineering Technology Curriculum (1977), a program in which physics and chemistry are part of the technician's specialty (Wolf, 1975).

Preparatory Physics (PREP)

> These courses are for the underprepared student pursuing an educational goal which requires one of the engineering or general physics sequences, technical physics or, less frequently, an allied health physics course. Underprepared students characteristically have no previous physics or weak physics, mathematics, or problem solving backgrounds and these courses emphasize the fundamentals of physics or the solving of typical physics problems analytically, or both. This category also includes problem solving courses taken concurrently with a general, calculus or non-calculus, or technical physics course (CCSS).

PREP physics courses, the smallest subcategory except for the miscellaneous group, accounted for only two percent of the courses, three percent of the lectures, and one percent of the laboratories (Table 2). PREP physics courses were found in a limited number of colleges: 18 percent of the western; 17 percent of the technical; 28 percent of the small and 20 percent of the large institutions; all other categories were 10 percent or less (Table 3).

The preparatory courses were either separate courses designed to prepare for some other introductory physics sequence (78%, 57% one term only) or separate problems courses taken concurrently with some other sequence (21%). They average 3.2 semester units per course or sequence and 3.7 total contact hours, with 36 percent of the courses non-laboratory. Mathematics prerequisites were required for 37 percent of the separate courses or sequences with no common level required.

Several approaches to the preparatory course have been tried (Bauman, 1976; Gerson, 1976; Layton, 1976; Wall, 1978). Wall used a course in a two-year college to introduce the student to problem solving as a prerequisite to general physics. Bauman described a mathematical preparation for physics course designed to teach logical thinking and raise a student from one Piagetian stage to another; on the other hand, Gerson employed a remedial laboratory program based on a Piaget model for engineering and science freshmen prior to their entering the calculus sequence. Layton used physics subject matter to develop formal reasoning in students.

General Physics (Non-Calculus) (GEN)

> The courses in this category involve characteristically, a one-year study of the fundamental theories and principles of physics associated with the mechanics of solids and fluids, heat, sound, electricity, magnetism, electromagnetic radiations, and atomic and nuclear physics. This study is generally based on mathematics through intermediate algebra and often trigonometry. These courses are requirements for transfer biological and health science students (unless the calculus course is required) as well as for earth science, architecture, and industrial and engineering technologies (when a comparable technical physics course is not available) (CCSS).

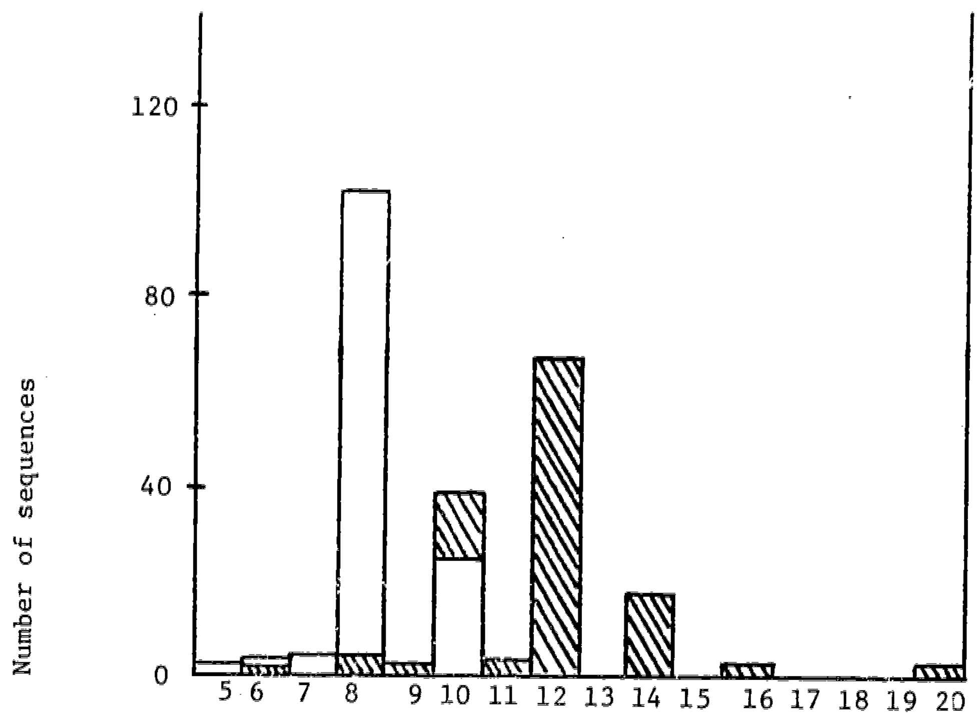
Non-calculus GEN physics courses accounted for one-third of all the physics courses, 29 percent of the lectures, and 33 percent of the laboratories (Table 2). The higher laboratory figure is a consequence of scheduling patterns involving two or more laboratory sections per lecture section as well as lecture only courses. Most (92%) of the GEN physics courses included lecture and laboratory.

The non-calculus GEN physics course was most frequently found in all categories except for the technical colleges. They were more apt to be found in the western (89%), mountain plains (77%), southern (74%) colleges, midwest (72%) or middle states (71%) than the northeast (45%); in public (82%) than private (36%) colleges; in comprehensive (86%) than liberal arts (47%) or technical (6%) colleges; and in large (96%) and medium (82%) than in small (58%) colleges (Table 3).

The non-calculus GEN physics course was the most monolithic, over 98 percent of the sequences were one year courses covering the general physics content and designed for biology, health science, geology, natural resources, architecture, and industrial technology, among others. Only two other sequences were found--one, a second year program, building on rather than a continuation of the first-year course, and, the other, general physics for the transfer physical science--engineering technology students as opposed to biology oriented students. These GEN Physics sequences average 8.3 semester units per sequence, primarily eight (78%) and ten (18%) unit sequences (Table 14). Additionally the sequences average 11.6 total weekly contact hours with 50 percent requiring 12 hours; 29 percent, 10 hours; and 13 percent, 14 hours (Table 14). This time is distributed into lecture (6.5 total weekly lecture hours average), primarily six (72%) and eight (21%) hours, and laboratory (5.1 total weekly laboratory hours average), primarily six (47%) and four (56%) hours (Table 15). Prerequisites range from none to the completion of three and a half or four years of high school mathematics or equivalent in college, including two years of algebra and trigonometry with nearly 80 percent requiring a minimum of two years of algebra or more. Over one-third require the three and a half years including trigonometry (Table 16).

There has been an increasing concern over the last decade regarding the adequacy of the traditional general physics (non-calculus) course for the health science students, especially the pre-medical group (Liboff & Chopp, 1979). One result of this concern has been the introduction of the introductory calculus-based, general physics course for biology and health science majors. Another is the publication of textbooks for the non-calculus

Table 14. Total Number of Semester Units and Weekly Contact Hours at Two-Year Colleges, 1977-78.



Total Number of Semester Units for General Physics Sequences. Mean=8.3 units.

Total Number of Weekly Contact Hours for General Physics Sequences. Mean=11.6 Hours.

All quarter courses converted to semester equivalents.

Table 15. Total Number of Weekly Lecture and Laboratory Hours (Semester), General Physics Sequences (GEN), Two-Year Colleges, 1977-78.

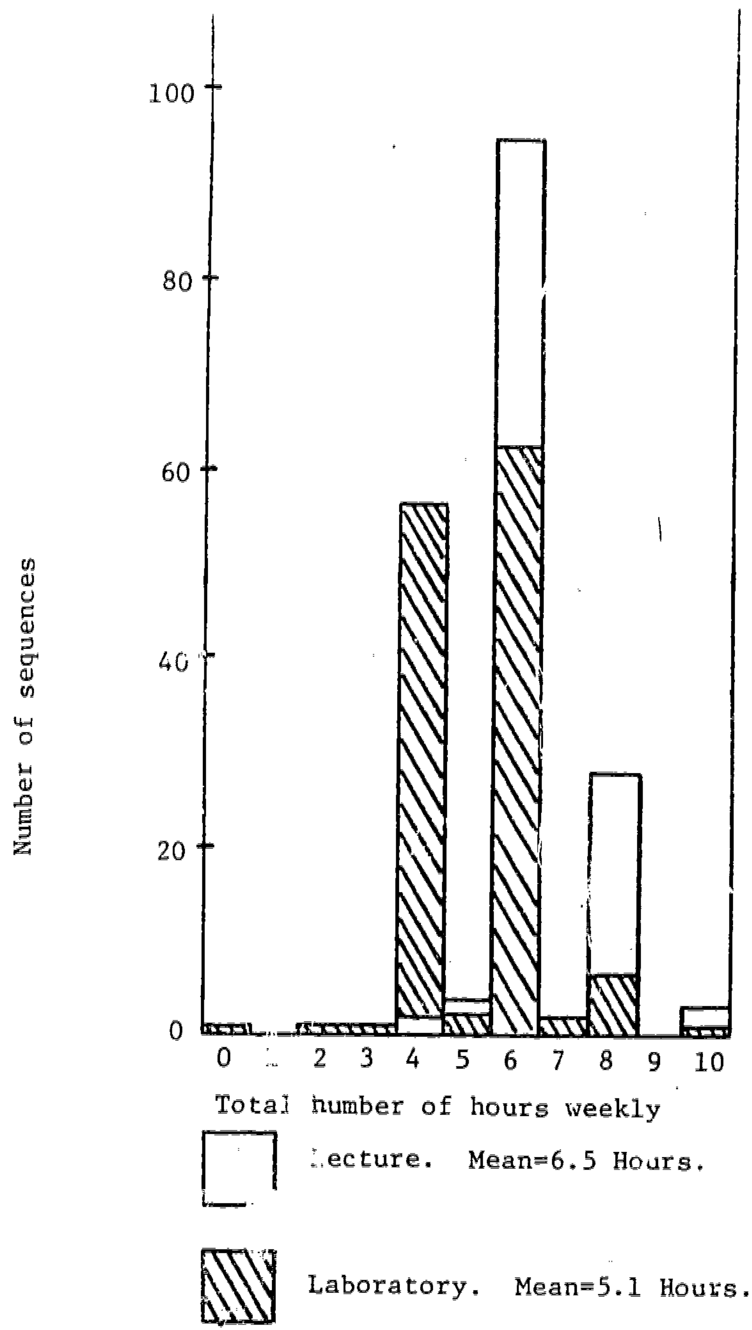
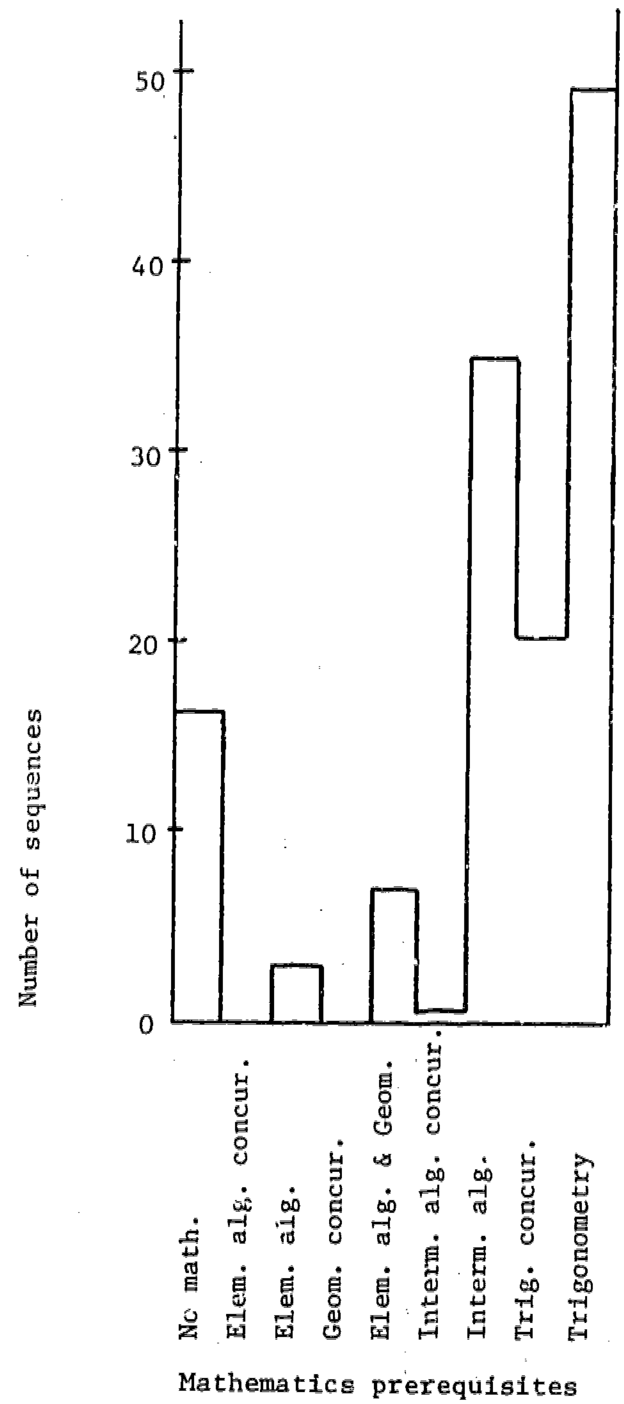


Table 16. Mathematical Prerequisites for General Physics (Non-Calculus) Sequences (GEN), Two-Year Colleges, 1977-78.



general physics that have a biological application emphasis. Liboff and Chopp as well as Iona (1979) report on the new Medical College Admissions Test (MCAT) format and content, verifying that with one exception, the non-calculus general physics year course seems to be the proper preparation for the MCAT. This exception is the material on nuclear structure, which many instructors find difficult to completely cover in the traditional one-year format. We found several colleges in our Center for the Study of Community Colleges' Study that included a short modern physics course available to students who had completed either the general or the engineering physics sequence, a finding which supports their observation. They also found the new MCAT considerably more oriented to physics than in the past, not only in terms of subject matter but also in terms of reasoning techniques. These techniques put additional requirements on the physics course; techniques involving charts, tables, graphs, data-interpretation, and problem-solving skills.

Liboff and Chopp observed that physics educators have tended to ignore the wide range of applications of physics to medicine. Further, they noted that because of the lack of specialized physics in medical school, medical students are disadvantaged in physics and unable to cope with advances in technology requiring a stronger base than the usual general physics. To remedy this, they suggested that at least one and probably two semesters of additional physics be added to all pre-medical programs. These new courses should be specialized material in the physics of medicine and require both a year of calculus and a year of introductory physics as prerequisites. Two-year colleges should encourage such a move because this will require pre-medical students to complete their general physics earlier in their undergraduate program, thereby reversing the trend in many four-year colleges of recommending this course in the junior year. Present practice causes many students to transfer from the two-year college without this physics course.

Attempts by two-year colleges to make the general physics course more compatible with the future needs of the students include splitting the program into two separate groups (Dickison, 1977), and infusing medical and biological applications for one section. For technology, pre-architecture and related students in the other group, a non-lecture, inquiry, open-laboratory approach was employed that utilized several physics of technology modules. Faculty who elect such a split in their general physics course may find the physics for architects course developed by Salamo et al. (1979) of interest for the technology side.

Another two-year college physicist has aimed at students' personal interests by enhancing general physics with musical acoustics (Winter, 1973). Neither the PSI nor the Piaget trends have been ignored in general physics in the two-year college (Gash, 1976; Smith, 1977). Faculty concerned with the PSI approach may also find the experience of McFarland et al. (1978) valuable.

Faculty have shown concern about student readiness or preparation for general physics as well as engineering physics; Hudson and McIntire (1976) studied the correlation between analytical skills in algebra and trigonometry and success in introductory physics and found a correlation between improvement in math skills and improvement on physics tests.

Other Non-Calculus Physics (MISC)

> These courses serve curricula or purposes other than those in the five categories described above. Examples include radiation physics and optics for non-allied health groups; fire and police science courses; the Malmstead-Enke type electronics for scientists courses; and non-calculus based modern physics based on the general physics course (CCSS).

The MISC non-calculus courses represent less than one percent of the courses as well as lecture and laboratory sections (Table 2). They were offered in less than 10 percent of the colleges in all regional, control, emphasis and size categories (Table 3).

Engineering and General Physics (Calculus Based) (ENGR GEN)

> This subcategory includes the study of mechanics of solids and fluids; heat; sound; electricity and magnetism; geometrical, wave and quantum optics; and modern physics organized into a one- to two-year sequence of courses emphasizing the fundamental theories and principles of physics using the calculus as a basis for analysis and problem solving. There are two, three and four semester and three, four and five quarter sequences; therefore, the content arrangement among the individual courses varies widely as do the lecture and laboratory hours per week and units. These sequences require completion of or concurrent enrollment in the first calculus course for the first physics course and often add calculus courses as pre- or co-requisites to the sequential physics courses. The engineering physics courses are designed primarily for physics, chemistry, engineering and mathematics majors. The category also includes calculus based courses for biological and health science students and for some of the more sophisticated engineering technology programs (CCSS).

Mathematically and physically the most sophisticated courses, ENGR GEN physics accounted for 28 percent of the total physics courses but only 21 percent of the lectures and 24 percent of the laboratories (Table 2). This pattern is a consequence of the longer sequences for ENGR GEN in many colleges and their lower frequency of scheduling.

These calculus based courses were more apt to be found in the west (79% of the colleges) than in the middle states (57%), mountain plains (55%), midwest (52%), south (48%), or northeast (9%); in public (60%) than private (25%); in comprehensive (63%) than liberal arts (27%) or technical (6%) schools; and in large (88%) or medium (64%) colleges than in small (31%) institutions (Table 3).

We found calculus based courses designed for the physical science and engineering students (97% of the courses), others for the biology and health science majors (2%), and one, in a catalog but not scheduled, for the technology students. There were separate modern physics courses (1%) in addition to those devoted to the classical physics topics. Among the physics courses for the engineering students there were two major groupings: the short courses of one year or four quarters duration (60% of these courses found in 34% of the colleges) and the long courses of one and a half to two year duration (40% of these courses found in 19% of the colleges) (Table 17). Because practically all of these courses were of the engineering student type, the remainder of this analysis deals with the calculus based engineering physics courses and compares the short and long courses for engineering students.

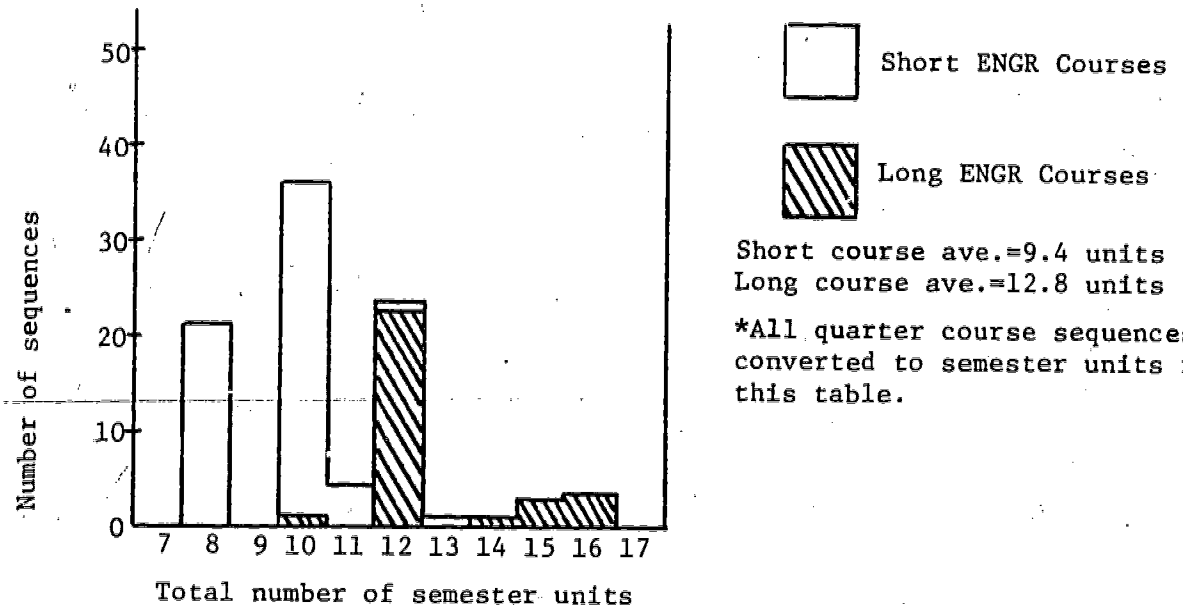
The courses overall average 10.6 semester units per sequence (range 8-16), offering primarily ten (38%), twelve (25%) and eight (23%) units (Table 18). There is a wide range (10-24 hours) in the total number of weekly contact hours for the sequence. The average is 15.2 hours with the most frequent being 14 (26%), 12 (22%), and 18 (17%) (Table 18). The most frequent total number of weekly laboratory hours for these sequences were six (35%), four (21%) and nine (20%), although they were spread from four to twelve hours plus one non-laboratory sequence; the average was 6.6 hours (Table 21).

Table 17

Engineering and General Physics (Calculus Based Courses) (ENGR 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 ENGR GEN Courses of This Type Scheduled (n values at left)	Percent of Total ENGR GEN Courses on Schedule (n=244)
Long Course (1½ -2 years) (n=115)	20	19	83	39
Short Course (1 yr or 4 quarters) (n=179)	42	34	79	58
Modern Physics (n=10)	4	1	20	1
General Physics with Calculus (n=11)	3	2	55	2
Technical Physics with Calculus (n=2)	1	0	0	0

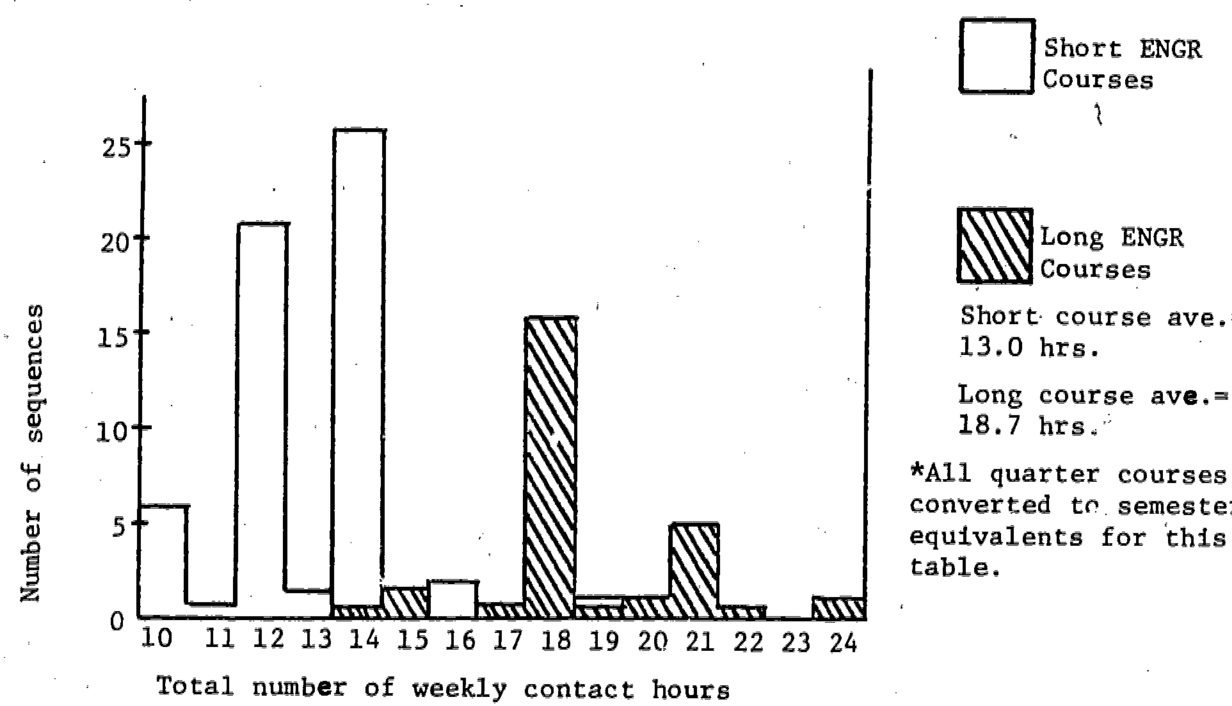
Table 18. Total Number of Semester Units* for Sequences Engineering Physics--Calculus Based Courses (ENGR), Two-Year Colleges, 1977-78.



Short course ave.=9.4 units
Long course ave.=12.8 units

*All quarter course sequences converted to semester units for this table.

Table 19. Total Number of Semester Weekly Contact Hours* for Sequences, Engineering Physics--Calculus Based Courses (ENGR), Two-Year Colleges, 1977-78.



Short course ave.= 13.0 hrs.

Long course ave.= 18.7 hrs.

*All quarter courses converted to semester equivalents for this table.

Table 20. Total Number of Semester Weekly Lecture Hours* for Sequences, Engineering Physics--Calculus Based Courses (ENGR), Two-Year Colleges, 1977-78.

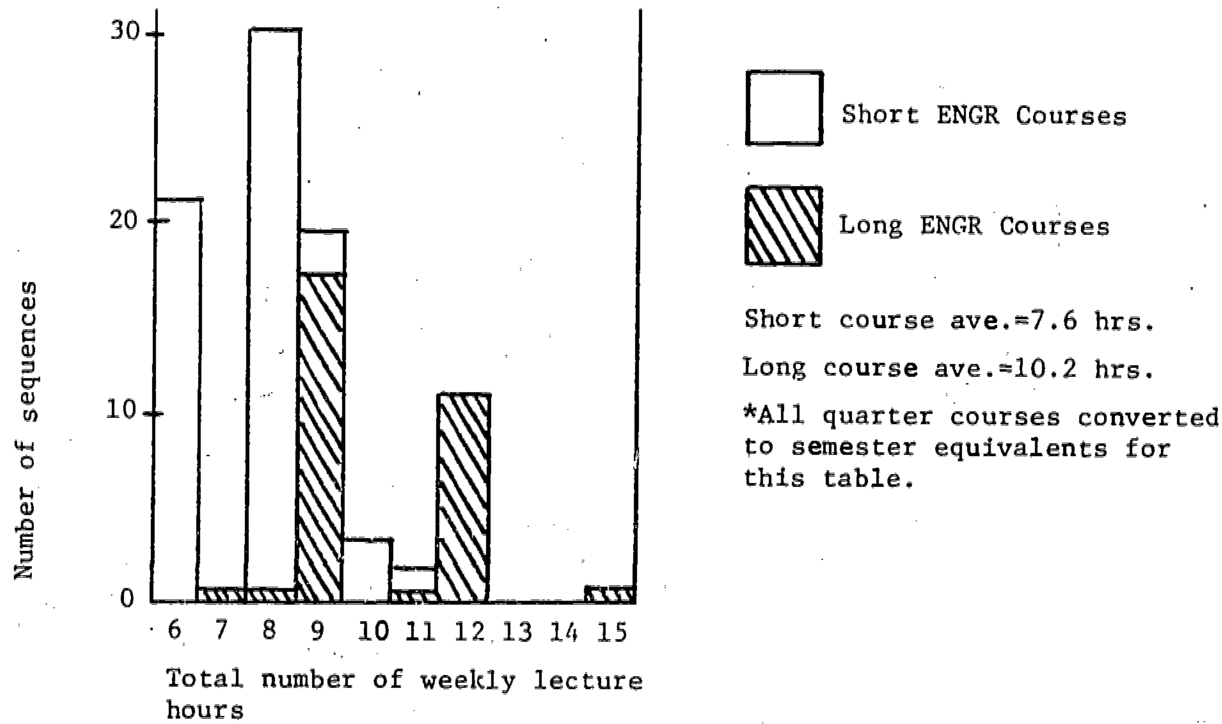
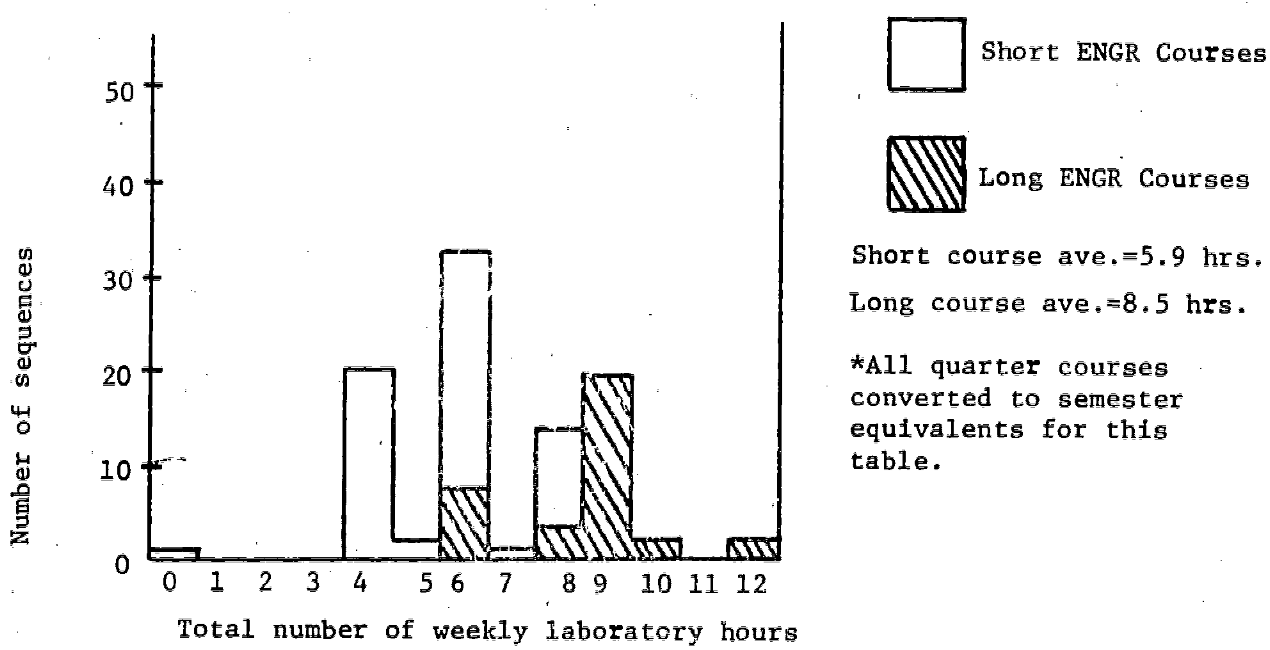


Table 21. Total Number of Semester Weekly Laboratory Hours* for Sequences, Engineering Physics--Calculus Based Courses (ENGR), Two-Year Colleges, 1977-78.

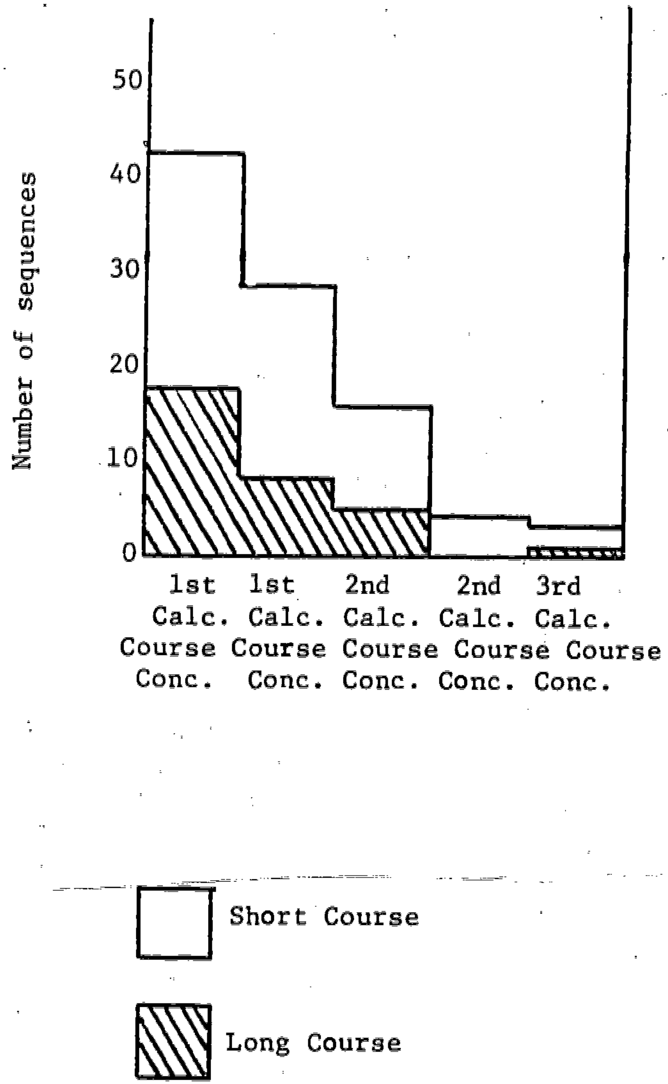


The average prerequisite for the short courses was the completion of the first course in calculus, whereas 53 percent of the long courses require only concurrent enrollment in the first calculus course (Table 22). The long courses average 12.8 semester units for the sequence (range 10-16) compared to a 9.4 average for the short courses (range 8-13) (Table 18). The long courses average nearly six weekly contact hours more than the short courses over the complete sequence, 18.7 compared to 13.0; this means an average of 6.2 hours per semester for three semesters compared to 6.5 for two terms (Table 19). The averages for total weekly lecture and laboratory hours both favored the long course, 10.2 to 7.6 and 8.5 to 5.9 respectively (Tables 20 and 21).

Colleges that devote the greatest effort to the calculus based course, those with the long course, are more apt to be found in the west (57%) or middle (43%) states than in the midwest (10%), northest (9%), mountain plains(5%) or south (2%); public (20%) rather than private (7%); and large (56%) rather than medium (18%) or small (4%). The short course was more apt to be found in the midwest (46%), south (43%) and mountain plains (41%) than in the middle (24%) states, western (14%) and northeast (none); in public (38%) than private (14%) colleges; and in medium (41%) and large (36%) and in small (25%) colleges.

A recent survey of physics requirements in undergraduate engineering education shows the mean number of credit hours in physics required for a B.S. in engineering ranges from 9.3 for the lowest department in the school to 11.2 for the highest, including 1.6 to 1.9 units of laboratory. Furthermore, in the last four years the hours required have been at a steady state. More than half of the colleges had the same physics requirement for all departments;

Table 22. Calculus Prerequisites for the First Course in the Engineering Physics Sequence (ENGR), Two-Year Colleges, 1977-78.



their mean was 10.35 units. This is nearly the same as the 10.6 unit per sequence average for the two-year colleges, a result which suggests that the physics requirements of engineering schools may be very influential in determining the structure of the calculus based physics courses in the two-year colleges.

Many of the innovations related to the engineering physics courses in two-year colleges have been concerned with the individualization of instruction (Emkey, 1978; Hess, 1977; and Kamm, 1978). Emkey made extensive use of video tapes, primarily for prelab instructions, to allow students the freedom to conduct their experiments any time (8am to 5pm) on Tuesdays or Thursdays. Self-instructional packets have been developed by Hess to replace the lecture laboratory approach, a move that has reduced scheduling problems and the equipment budget while increasing physics enrollment and student work with physical apparatus and phenomena. Kamm employed small personal computers as tutors for auxiliary learning to give students help for which the faculty does not have time. Erlichson (1975) correlated the textbook problems assigned students with the laboratory work. The problems are thus made more meaningful by comparing their solution with an actual laboratory situation.

Patterns of Courses

To properly serve the physics education needs of their heterogeneous student bodies, two-year colleges must offer several different physics sequences or separate courses. Many of them do so. In earlier sections of this monograph we discussed the subcategories of physics courses nationally; herein, we consider the physics programs of individual colleges.

Much of the resistance for offering a comprehensive curriculum in the various sciences comes from administrative and, sometimes, faculty opposition to "proliferating courses." Since the cost of including many low enrollment courses and faculty work load considerations dictate against offering a complete physics curriculum, it seemed appropriate to analyze the physics courses offered by each college to determine the extent of their programs. Table 23 reports the number of physics sequences or courses offered by colleges arranged by the size of college, type of control, emphasis of college and geographical region. Nationally, the average is 2.6 physics sequences of individual courses for colleges that offer physics under a physics department or science department listing. This does not include courses classified as physics but listed under some allied health, technology, developmental or other heading in the catalog and schedule; these averaged 0.4 sequences or courses per college. Adding these two figures, we find the average number of total physics sequences or courses per college is 3.0.

Large colleges showed the most variety in physics, 80 percent offer three or more sequences (one-third actually have five or more); whereas, two-thirds of the medium-sized group scheduled two or three; and 26 percent of the small colleges offer no physics.

Nearly one-half (46%) of the public colleges have three or more physics sequences; on the other hand, 61 percent of the private colleges have none. Comprehensive colleges parallel the public in physics offerings and liberal arts, the private; technical colleges are divided nearly evenly between two or more (55%) and one or more sequences (45%).

Geographically, the western colleges offer more variety in physics, more than two-thirds scheduled three or more courses as did nearly one-half of the middle states institutions. On the other hand, the northeast

Table 23

Number of Physics Courses or Sequences Offered by Two-Year Colleges Arranged by Size of College, Control and Emphasis 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	26	5	0	13
One	28	10	0	16
Two	32	35	20	31
Three	12	31	24	22
Four or More	2	19	56	17

By Control of College and Emphasis	Public Colleges (n=147)	Private Colleges (n=28)	Comprehen Colleges (n=142)	Lib Arts Colleges (n=15)	Tech Colleges (n=18)
None	4	61	8	53	17
One	17	11	15	13	28
Two	34	21	35	33	22
Three	25	7	25	0	22
Four or More	21	0	20	0	11

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	7	14	10	9	19	45
One	4	23	10	24	10	27
Two	21	45	44	30	24	9
Three	32	14	23	19	29	18
Four or More	36	5	13	19	19	0

has only 55 percent with any physics, and half of these with one sequence only. More than half of the southern colleges include only one or two sequences while two-thirds of the midwestern colleges included two or three sequences.

What pattern of physics sequences is predominant within each of the groups of colleges offering one, two, three or four or more sequences? An analysis of Table 24 reveals that for the one sequence group, 79 percent offer general physics and 11 percent technical physics as their single sequence. Eighteen percent also included physics courses in allied health, technology or general science programs.

Colleges offering two physics sequences favor (64%) the general physics (non-calculus) and engineering physics (calculus) combination with the general-non-science (11%) and general-technical (9%) combinations the next most popular. Table 24 shows the distribution of each type of sequence in these colleges.

The most popular combinations of three sequences were those involving general, engineering and non-science physics (36%); general, engineering and technical (21%); general, technical and non-science (10%); and general, engineering and allied health (8%). Table 24 also shows the distribution of the types of courses in these colleges including three sequences.

Colleges that offer four or more physics courses favor the non-calculus general physics (93%), calculus based physics (83%), technical physics (83%) and the non-science major course (67%). Indeed, half of these included each of these four among their offerings, while one-third included the combination of general, calculus based, technical and allied health. Forty percent of these colleges included physics courses in other areas.

Table 24

Distribution of Physics Courses by the Number of Sequences or Courses Offered, Two-Year Colleges, 1977-78

Type of Physics Sequence or Course	Number of Physics Sequences or Courses (Percent of Total Colleges in Group)			
	One (n=28)	Two (n=55)	Three (n=39)	Four or More (n=30)
Non-Science/Technology	4	16	54	67
Allied Health	4	5	10	37
Technical	11	16	49	83
Preparatory	0	0	13	20
General (Non-Calculus)	79	87	82	93
Other Non-Calculus	0	0	0	3
Engineering Gen (Calc)	4	67	77	83
Physics Courses Outside Physics	18	25	18	40

Small and medium-sized community colleges have experienced difficulty in meeting the physics requirements of the varied groups of students they serve. Because of normally small enrollments in all physics courses, it has been increasingly difficult for them to support any course. Several innovative approaches to overcoming this handicap have been reported (Cude, 1976; Fisher, 1978; Hubisz, 1973; Lea, 1978). Cude employed a three-unit calculus based course that physical science and engineering students completed after the non-calculus general physics sequence. Fisher used a multiple level lecture series featuring one set of lectures over each of the many physics topics each semester, with each lecture in the topic set becoming more mathematically sophisticated.

Students attended only those lectures that were commensurate with their mathematical ability. Fisher's program included the general physics (trigonometry based), general physics (introductory calculus based), and engineering physics (calculus based) courses with separately graded open laboratory courses, which also met simultaneously. The continuous registration, individualized, self-paced programmed (CRISP) physics approach of Hubisz included three introductory physics sequences (the non-science, general, and engineering) of two semesters each. These differ in entrance criteria. Lea used the PSI method and concurrent scheduling in a one-faculty member department to offer one-year sequences of general and engineering physics as well as a year physical science sequence and the physics of music and astronomy in alternate quarters.

PART II

THE INSTRUCTOR SURVEY

METHOD

The Sample

The same random sample of 175 colleges employed in the Curriculum Study was used in our 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 between February 20 and April 10, 1978, after the completion of the 1977 fall term to which the survey was confined. Due to death, retirement, leaves and dismissals, and other reasons, 114 surveys were not deliverable. 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 45 responses from physics faculty represented 3.5 percent of the returns compared to 160 (12.5%) from biologists and 82 (6.4%) from chemists. 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: physics 3.2 percent, biology 10.5 percent, and chemistry 5.1 percent.

The findings from this survey of most significance to physics are presented and discussed in the following sections. All tables include data for biology and chemistry as well as physics and the data for all twelve groups combined into an all science group; the reader is invited to make comparisons among these fields on these items.

RESULTS

Goals or Qualities Desired for Students

The abilities students are expected to demonstrate are a function of the goals the faculty member holds for the course. 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 25).

Table 25

Goals for Students

Response to Question: 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 ONE (One only selected)	Phys (n=45)	Biol (n=160)	Chem (n=82)	All Sci (n=1275)
Understand/appreciate interrelationships of science & technology with society.	16	48	22	27
Be able to understand scientific research literature.	0	1	0	2
Apply principles learned in course to solve qualitative and/or quantitative problems.	76	42	65	61
Develop proficiency in laboratory methods and techniques of the discipline.	9	7	10	8
SET TWO (One only selected)				
Relate knowledge acquired in class to real world systems and problems.	47	42	23	48
Understand the principles, concepts, and terminology of the discipline.	44	55	67	43
Develop appreciation/understanding of scientific method.	4	1	5	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.	24	40	31	33
Understand self.	0	9	1	9
Develop the ability to think critically.	67	48	55	47

Functions of Courses and Student Majors

Sixty percent of the physics faculty indicated that the course for 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 38 percent of the courses, allied health or natural resource majors in 27 percent, and nonscience majors, 24 percent. The total of these figures is greater than 60 percent because many introductory physics courses are multifunctional, serving two or more groups of students. Physics is lower than the all science group in sections that parallel lower division courses; it is also considerably lower than chemistry, biology, and the earth sciences or transfer courses for science and engineering majors. Only chemistry, agriculture, and engineering devoted a lower percentage of sections to transfer non-science majors.

Our faculty respondents reported that physics courses for the occupational groups strongly favored the engineering technologies (51%) over the allied health (20%) area, exceeded only by engineering and agriculture. Remedial courses in physics (2%) were much lower than mathematics (33%) or chemistry (13%). Physics was the lowest of all the sciences in sections described as being for further education or personal upgrading. Only engineering (6%) was lower than physics (7%) in sections designed for the general education of non-science and non-occupational students. These data suggest that physics faculty need to look for innovative courses or ways to interest the general student in their discipline.

Students

According to the Instructor Survey responses, physics enrolled an average of 24 students per lecture section, exceeding only engineering (23.5) of all the sciences.

And 88 percent of the physics students were reported as completing the course with a grade, a finding that was higher than all fields except for agriculture.*

Of the initial enrollments in physics, 74 percent were male and 26 percent female, suggesting a more male dominated field than any other except engineering. This is explainable because physics draws heavily from both the transfer and occupational engineering areas as well as the physical science programs, which are male dominated. Males also have a higher completion rate in physics (91%) than do females (81%).

Instructional Mode

Major contemporary issues in physics education include questions about the necessity of laboratory work in introductory courses and the need for the individualization of instruction. Our examination of catalogs and schedules provided a profile of the lecture and laboratory modes of instruction for each of the physics subcategories (Table 26); however, these resources were insufficient to reveal the extent to which the various schemes of individualized instruction were employed. Overall, the combined lecture-laboratory mode was used in more than four out of every five physics courses.** Only the preparatory and allied health categories have less than 50 percent lecture-laboratory.

The lower laboratory requirement in preparatory courses is accounted for by two factors: an emphasis on problem solving and the fundamentals of physics and

*These figures differ from other reported figures because the initial enrollment dates were not specified; further, these do not specify whether students receiving F and W grades were to be considered as completing the course with a grade since some colleges count these one way and others, another.

**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.

Table 26

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

Category of Course	Percent of Courses of Subcategory			
	Lec Lab[1]	Lec Only[2]	Lab Only[3]	Other or Unknown[4]
Non-Science (NSM)	63	33	4	0
Allied Health (AH)	48	45	5	2
Engineering Tech (TECH)	76	17	2	5
Preparatory (PREP)	45	50	0	0
General (Non-Calculus) (GEN)	92	5	3	0
Other Non-Calculus (MISC)	100	0	0	0
Engineering & General (Calculus Based) (ENGR GEN)	83	9	8	(<1)

[1] 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.

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

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

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

the use of personalized systems of instruction. The large group of lecture only courses for the allied health group is a consequence of their primary purpose, which is to communicate the physics information necessary for a given occupation.

Use of Class Time

The Instructor Survey also delved into the use of instructional techniques, asking the faculty about the percentage of class time devoted to certain activities (Table 27). The high use of lecture (93%) and examinations (82%) was expected, as was that of class discussion (73%) and laboratory experiments (87%). However, considering the nature of the subject and the availability of suitable materials, the utilization of lecture demonstration experiments (62%) and media (31%) are disappointing and should be of concern. The low utilization of practical examinations (16%) argues for research and development in this area.

Table 27

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

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

As expected, faculty lectures and student laboratory experiments account for nearly two-thirds of physics class time, with about one-eleventh of the time devoted to evaluation items. Table 27 compares the physics profile with the average classes in chemistry, biology or all the sciences.

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 physical phenomena. Additionally, since media materials are generally extensively involved in instructional innovation, we asked the faculty to indicate how often they used various materials. Only scientific instruments and lecture demonstration experiments were used frequently by more than half of the physicists; however, models, charts, overheads, films and film loops were used on occasion by half or more of the physics respondents. More than three-fourths of the physics faculty use textbooks, laboratory written materials and syllabi/handout materials. The responses are summarized in Tables 28 and 29 for media and printed materials, respectively, with data for chemistry, biology, physics and all sciences included.

Evaluation of Students

When queried about the abilities they expect their students to demonstrate on examinations and quizzes, most of the physics faculty rated "acquaintance with the concepts of the discipline" as the most important item. This was followed by about equal emphasis on "mastery of a skill", "understanding the significance of phenomena and experiments", and the "ability to synthesize course content" (Table 30).

Table 28

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)							
	Phys (n=45)		Biol (n=160)		Chem (n=82)		All Sci (n=1275)	
	Fr	Oc	Fr	Oc	Fr	Oc	Fr	Oc
Scientific instruments	64	31	42	34	51	35	18	21
Three dimensional models	7	49	34	42	42	50	10	27
Maps, charts, illustr, displays	22	36	35	45	42	33	20	36
Lecture/demonstr expts	51	38	18	36	38	44	10	17
Overhead proj transpar	13	40	45	28	31	35	20	27
Audiotape/film/combin	0	4	7	26	4	23	3	16
Films	0	51	16	59	2	52	9	40
Slides	0	16	26	49	1	28	8	22
Audiotapes/cassettes/records	2	11	6	21	2	21	3	17
Single concept film loops	7	47	4	38	2	17	1	12
Filmstrips	0	9	4	27	1	15	3	16
Videotapes	0	11	3	27	0	15	3	16
Natural or preserved specimens	0	0	56	28	2	5	9	7
TV	0	9	1	12	0	4	1	8
Other	7	0	2	2	1	1	6	2

Table 29

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)			
	Phys (n=45) PU-PG	Biol (n=160) PU-PG	Chem (n=82) PU-PG	All Sci (n=1275) PU-PG
Textbooks	91-154	96-340	98-312	94-308
Lab materials/workbooks	78- 34	80-112	84-107	44-101
Syllabi/handout materials	51- 18	74- 35	76- 40	62- 29
Problem books	20- 40	6- 75	38-117	10- 90
Reference books	18- 15	39- 90	33- 35	22-107
Journal/magazine articles	7- *	38- 13	23- 30	25- 23
Newspapers	2- *	11- 13	7- 30	11- 22
Collections of readings	7- 55	15- 76	6- 73	14-126
Other	4-170	7- 89	7- 52	8-121

*pages not reported.

Table 30

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

The physicists used several factors when determining a student's grade. They equally emphasized the results of objective tests and examinations (which can be scored quickly) and essay tests, followed by laboratory reports and problem sets or homework (Table 31).

Although only 80 percent of all the physicists used mathematical type problems where the work must be shown, it is the most widely used. This was followed by the construction of graphs, diagrams and equations. Multiple response and essay questions both are used less frequently in physics than in chemistry, biology or all the sciences (Table 32).

Nearly all of the physics faculty award ABCD grades, and over 90 percent also award F grades. These data reveal that the pass and fail or no credit system receives little attention from any of the sciences. References to Tables 30 through 32 show other factors related to evaluation of students by physicists 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 also asked to indicate their highest earned degree. Nearly one-third of the physics faculty (31%) hold earned doctorate degrees in physics or some other field; whereas, most of the remaining instructors (67%) have master's degrees in physics or another field. Doctorate attainment in chemistry (35%) and physics (31%) is higher than any other field.

Teaching Experience

In the fall of 1977 over 40 percent of the physics faculty had been teaching in two-year colleges for more than 10 years; in contrast, slightly more than one-quarter (27%) had less than four years experience. The physics

Table 31

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

(All other activities listed were less than 10% total for physics 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 32

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

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

Employment Status

There has been much concern 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; therefore, it may not reflect the contemporary scene as well as do our other data.

Nearly 80 percent of the physics sections were taught by full-time, non-administrative faculty, with one out of every nine sections handled by part-time instructors. Because c the factors mentioned above, part-time teaching in physics across the country today should be the subject of further detailed study to determine the effect it is having on the quality of instruction and student retention and performance. We found the physics curriculum to be more committed to full-time faculty than were biology or the all science group, and approximately the same as chemistry.

Assistance Available to Faculty

The 1969 Conference on Science in the Two-Year College (ACS, 1971) recommended that technical and secretarial assistance be provided for science faculty. We asked faculty about the types of assistance available to them and whether or not they had made use of this assistance. Clerical help, the most frequently available assistance, was available to 80 percent of the physicists and utilized by more than two-thirds. Laboratory or technical assistance, available only to 36 percent was utilized by 31 percent of the faculty (Table 33).

Table 33

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]		
	Phys	Biol	Chem	Phys	Biol	Chem	Phys	Biol	Chem
Technical (laboratory)	36	58	62	31	49	57	86	84	92
Tutors	44	56	61	31	38	54	70	68	89
Clerical Help	80	86	84	69	77	69	86	90	82
Paraprofessionals	16	24	26	7	19	20	44	79	77
Readers	11	11	16	7	4	11	64	36	69
Library-Bibliography	58	80	72	24	52	43	41	65	60
Media Production	60	76	76	29	54	40	48	71	53
Test Scoring	38	67	62	11	38	22	29	57	36
Other	2	3	5	2	3	5	100	100	100

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

[b] The % utilization = (% utilizing 1% available) 100.

These figures tell a different story if a need or usefulness index is calculated for the types of assistance included in the table. This index, defined as the percentage of faculty utilizing a given type of assistance, is reported in the third column of the table. Laboratory help and clerical help were rated equally in need or usefulness; both were used by 86 percent of the physicists to whom they were available. These indices argue strongly for the recommendations from the 1969 Conference.

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

The relatively high utilization index of tutors (70%) by physics faculty is a strong argument for those colleges that do not provide tutorial assistance to make it available. The control and location of physics tutors in the two-year colleges is controversial. Based on observations made during consultations and other on-site visitations, the author recommends they work in the physics area under the supervision of physics faculty to make more effective use of all possible resources (e.g., demonstration and laboratory equipment, references and faculty) and to minimize the negative effect of a tutor taking an entirely different approach than the instructor and thus compounding the student's conceptual and computational difficulties. Readers were utilized by nearly two-thirds of the physics faculty to whom they were available. Since they were provided by only 11 percent of the colleges, this area should also be studied as one way to relieve some of the burden on the faculty but still provide effective feedback to the student. Note also in the next section that one-quarter of the physicists call for additional help here.

Media production and library-bibliography services appear to be underutilized, a condition that suggests the need for additional study to determine ways of effecting improvements in physics 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 33 allows comparison of chemistry, physics, and biology on the provision and utilization of assistance.

Improvement of Instructional Effectiveness

Since faculty members have definite ideas for making their courses more effective, we sought their reactions to the effect of sixteen possible changes on their course. More than half of the physicists most desire students better prepared to handle course requirements (Table 34). This was the highest percentage response from the physics faculty as well as for chemistry, biology, and the all science group. Stricter prerequisites for admission to class were also rated high (40%) by physics respondents. The physicists (44%) also expessed the need for better laboratory facilities and more reader/paraprofessional aides (24%) as well as larger sized classes (22%). Reference to the table permits comparisons of the responses from the chemistry, biology, physics and all science groups on each of the items (Table 34).

Instructional Innovations

Several curriculum innovations were described in the discussion of the physics curriculum, and many of these also involved instructional innovations. Additionally, the literature contained references describing instructional innovations not associated with any specific course or in which the course reference appeared incidental. Among this group of references noted herein the following emanate from or should be of interest to two-year college faculty.

Table 34

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

Idea for Improvement	Percent of Total Faculty Respondents			
	Phys (n=45)	Biol (n=160)	Chem (n=82)	All Sci (n=1275)
Students better prepared to handle course requirements	56	54	63	53
Better laboratory facilities	44	31	37	21
Stricter prerequisites for admission to class	40	37	35	30
Instructor release time to develop course and/or material	38	42	49	38
More reader/paraprofessional aides	24	9	18	15
Larger class (more students)	22	4	10	8
Professional development opportunities for instructors	18	35	28	24
Availability of more media or instructional materials	18	48	26	36
More clerical assistance	18	18	20	17
More interaction with colleagues or administrators	18	18	18	18
Smaller class	16	27	23	29
Other	11	11	16	10
More freedom to choose materials	9	8	11	9
Less interference from colleagues or administrators	4	4	6	4
Different goals and objectives	2	5	5	4
Changed course description	0	5	7	6
Fewer or no prerequisites for admission to class	0	0	1	1

Three major trends in two-year college physics were described in a recent issue of CRPTYC: PSI (Schmitz, 1978); open laboratories (Mowery, 1978), and the place of Piaget in physics education (Campbell, 1978). Along with the Campbell article the discussion of homework problems from a Piagetian viewpoint (Lawson & Wollman, 1975) and the use of tutors in a Piagetian based personalized course (Campbell, 1977) deserve the attention of faculty members utilizing a Piagetian approach.

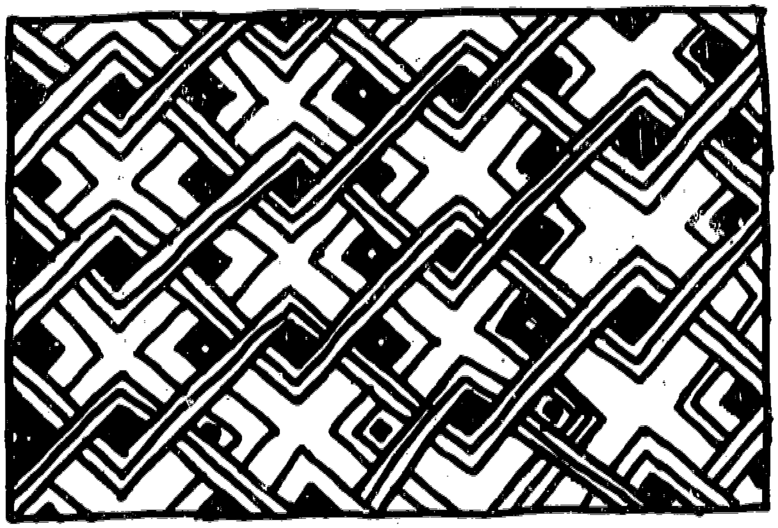
The use of media in teaching physics has concerned Dowling (1976), who asks why films are not used more, and Echols (1974), who describes how to make media match the topic and instructional system. Cise (1974) and Martin (1974) describe their use of student-made films and media-oriented student projects, respectively. Two-year colleges using open-laboratory and PSI programs should be able to make effective use of recently developed videotape materials of lecture-demonstrations and laboratory experiments (Resnick, 1976); laboratory instructions (Quarles et al., 1976); and optional lectures (Roper et al., 1976).

Computers and hand calculators appear to be here to stay in physics education in the two-year colleges. Peckham (1972, 1976) discusses use of each of these, and Feldker (1977) describes the generation of physics tests from a time-share terminal. Two-year college faculty interested in the reading level of their physics textbooks will find the work of Dukes and Kelley (1979) and Kennedy (1979) valuable.

The role and importance of the laboratory in physics instruction is the subject of two editorials (Swartz, 1979 a, b) as well as given a prominent place in the AAPT Task Force Report on high-quality instruction in the two-year colleges (Hitchingham, 1977). Many different techniques have been tried in preparing students for the laboratory: Hollinger and Hollinger (1976) have used workshops and Quarles et al. (1976) have prepared videotapes.

Problem-solving is one of the most important activities in two-year college physics courses. Innovations in this area include Carney's (1977) use of programmed instruction for problem-solving home assignments and Erlichson's (1975) correlation of textbook problems and laboratory experiments. Two-year college faculty will also find the physics homework course (Marsh & Dell, 1975) and the correlation of textbook problems with lecture demonstration experiments (Mitchell, 1975) of interest.

Some two-year college faculty have shown an interest in broader goals than just physics in their teaching. For example, Hewitt (1975) imparts social attitudes with distribution curves and Myer and Myer (1976) use value-clarification strategies in a non-science course. The use of multipurpose learning centers has been described by Prigo et al. (1975) and Hubisz (1973) in his CRISP physics program.



PART III

RECOMMENDATIONS

A major outcome of the Center's study has been to focus attention on what is needed for a high quality physics program in a two-year college. The elements of such a program have been called to our attention directly and indirectly through the literature review and the findings of the curriculum and instruction studies, as well as through discussions with faculty during college visitations or meetings of physics educators. In order to present a high quality, comprehensive physics program, the components described here 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 monograph, available through ERIC, we discuss obstacles to fulfilling these needs and cite references to programs that have shown progress in attaining the goals represented by these statements.

Ideally, the two-year college needs to provide:

1. A comprehensive non-calculus based physics curriculum that will properly and efficiently deal with the educational needs in physics of a student body that is widely heterogeneous in their backgrounds and abilities in the sciences, mathematics, and verbal and visualization areas, and that pursues a wide spectrum of educational goals.

2. A three- or four-semester program of caluclus based courses in classical and modern physics for students majoring in engineering and one of the physical sciences.

3. An efficient assessment and placement program to first characterize students desiring to enter the physics courses in terms of their goals as well as those abilities and achievements that correlate with success in physics; then, following the assessment, place the students in the proper physics course--e.g., the one intended for their program and in which they have the most reasonable chance for success.

4. A remediation program for dealing with students unprepared to enroll in certain physics sequences as well as those who are having conceptual and computational difficulties while enrolled in physics 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 physical phenomena, as well as to help students

better deal with physical topics at a concrete operational level. If necessary, colleges should plan or renovate their physics facilities to facilitate such lecture demonstration experiments.

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

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

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

9. Multiple instructional strategies to allow students a choice of methods and materials so that they may elect the ones 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 physics 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 BioCO-TIE (see Jordan et al., 1973).

10. 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 physics and its interactions with the other sciences and society as well as instructional concerns.

<u>In order to satisfy the curricular needs (1-4) and the instructional needs (5-10) the colleges need to provide</u>:

11. Suitable technical, secretarial, and tutorial assistance for the physics faculty.

12. Media-production and library bibliographic assistance that are conveniently available.

13. Opportunities for each of their physics faculty members to attend annual regional meetings of the American Association of Physics Teachers and for at least one member to attend a national meeting each year.

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

15. A student follow-up program offering feedback on the successes, problems and failures of former physics 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 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 students 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 physics faculty to design and perform new physics 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. Physics 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. Additionally the facilities should allow for the effective utilization of appropriate lecture-demonstration equipment and models; provide for appropriate faculty-student interaction; and make possible 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 physics faculty to effectively and efficiently deal with the physics 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, then provide a program to insure that their work is properly coordinated with that of the full-time staff and 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 our 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 physics program of the college. A separate group should be established for science and engineering technology if the college has that program and separate groups may be established for other portions of the physics curriculum or one group with subcommittees might be employed.

In order to carry out their responsibilities to the students, colleges and profession, the physics faculty must not only make effective use of what the college provides for their work (11-20) but they must also assume professional responsibilities, such as:

22. When responsible for courses intended for the allied health, engineering technology or any other specific group, work cooperatively with the faculty and professionals in the occupational fields to develop physics courses which are consistent with the educational needs of these 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 of physics 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 such as the American Association of Physics Teachers and the American Institute of Physics and the AACJC, the National Science Foundation and other governmental agencies, state community college agencies, private foundations and research centers, industry and other interested organizations should individually or cooperatively, as appropriate, develop:

24. A companion version of the document, Report of the AAPT Task Force on Teaching Responsibility for Four-Year Colleges (Fuller, 1979) for the two-year colleges. The corresponding AAPT Two-Year College Report (Hitchingham, 1977) is incomplete when compared to the Four-Year College Report and similar documents in chemistry (ACS, 1970, 1977). Preferably, the physics documents should be as inclusive as the chemistry.

25. Comprehensive programs for (A) presenting the Criteria document (24) to college administrators, science administrators, and physics faculty of the community colleges and for (B) assisting colleges in evaluating their programs in terms of the Criteria and other recommendations such as these, 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 Physics Education in the Two-Year Colleges which would stimulate and assist local college and groups of colleges in research projects designed to study the curriculum and instruction problems of the physics programs of the two-year colleges and to develop strategies and materials for dealing with these problems.

27. Create a national funding program for the sciences in the two-year colleges which 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 the level with soundly conceived innovations.

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

29. Strategies for relating physics 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, not specifically mentioned above, which pragmatically must be dealt with 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 physics program. They must understand the unique nature of physics as a discipline; the nature of the physics requirements of other disciplines within the curriculum; of the centrality of physics in a comprehensive community college program; of the economic requirements of a physics program; of the need to characterize the two-year college student with respect to the abilities required for success in physics and their implications for courses, assessments and instruction; and of the requirements of the physics faculty to develop programs to effectively and efficiently deal with these problems.

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

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** A number in parentheses, preceded by "ED," refers to an Educational Resources Information Center (ERIC) document available from the ERIC Document Reproduction Service, Box 190, Arlington, Virginia 22210, or viewed in any library that has the collection.

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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

APPENDIX A (continued)

Florida

Brevard
Edison
Florida
Palm Beach
Seminole
Valencia

Georgia

Atlanta
Bainbridge
Clayton
Floyd
Georgia Military
Middle Georgia
South Georgia

Kentucky

Southeast

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 Virginia
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

APPENDIX A (continued)

Michigan

Bay de Noc
Delta
Kalamazoo Valley
Kirtland
Monroe County
Oakland
Suomi

Minnesota

Austin
North Hennepin
Northland
Univ. 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.

Wisconsin

District One Tech.
Lakeshore Tech.
Milwaukee Area Tech.
Univ. 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
Saddeback
San Bernardino Valley
San Diego Mesa
Santa Rosa

Nevada

Clark County

Oregon

Chemeketa
Mt. Hood
Umpqua

Washington

Green River
Lower Columbia
Peninsula
South Seattle

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 activ ies.

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:

____________________ 11-13 ____________________
(Course) (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

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

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

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 workbooks	______ 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

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?

ABCDF	☐ 1	29
ABCD/No credit	☐ 2	
ABC/No credit	☐ 3	
Pass/Fail	☐ 4	
Pass/No credit	☐ 5	
No grades issued	☐ 6	
Other ________ *(please specify)*	☐ 7	

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?

Yes	☐ 1	41
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

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