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DIFFERENCES IN AIMS OF HIGH SCHOOL AND COLLEGE TEACHERS OF CHEMISTRY.

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AN INVESTIGATION WAS MADE OF THE ARTICULATION GAP WHICH RESULTS FROM THE LACK OF COMMUNICATION IN CHEMISTRY EDUCATION BETWEEN HIGH SCHOOL TEACHERS AND COLLEGE INSTRUCTORS OF FIRST-YEAR COURSES. AND FROM A LACK OF AGREEMENT ABOUT THE AIMS AND OBJECTIVES OF CHEMISTRY COURSES AT THE SECONDARY LEVEL. ELIMINATION OF THIS GAP WAS CONSIDERED BY THE INVESTIGATOR TO BE NECESSARY TO PROVIDE STUDENTS A SEQUENTIAL EDUCATION. TO DETERMINE THE EXTENT OF THE GAP AND THE FACTORS CONCERNED, 3,000 QUESTIONNAIRES WERE DISTRIBUTED NATIONWIDE TO THREE SEPARATE GROUPS--1,000 TO HIGH SCHOOL CHEMISTRY TEACHERS, 1,000 TO FIRST-YEAR COLLEGE CHEMISTRY PROFESSORS, AND 1,000 TO FIRST-YEAR COLLEGE CHEMISTRY STUDENTS. RESPONDENTS RATED NUMEROUS ASPECTS OF CHEMISTRY INSTRUCTION ON A THREE-POINT SCALE OF IMPORTANCE. THE AUTHOR THEN RANKED EACH ITEM IN ITS ORDER OF IMPORTANCE ACCORDING TO THE NUMBER OF RESPONDENTS IN EACH GROUP WHO HAD RANKED THAT ITEM AS "VERY IMPORTANT." THREE RESULTING LISTS WERE STATISTICALLY COMPARED, AND THE DIFFERENCES IN RESPONSE BETWEEN THE TWO GROUPS OF TEACHERS WERE TESTED AT THE .01 LEVEL. OF THE 10 AREAS IN WHICH THE TWO GROUPS DIFFERED MOST, SEVEN WERE SHOWN TO HAVE STATISTICALLY SIGNIFICANT DIFFERENCES. THE AUTHOR CONCLUDED THAT A SIGNIFICANT DISAGREEMENT EXISTS BETWEEN HIGH SCHOOL AND COLLEGE CHEMISTRY TEACHERS REGARDING OBJECTIVES AND CURRICULUM FOR HIGH SCHOOL CHEMISTRY CLASSES. (LB)

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DIFFERENCES IN AIMS OF HIGH SCHOOL AND COLLEGE TEACHERS OF CHEMISTRY

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Cooperative Research Project No. S-303

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Sponsoring Committee: Professor Elwood J. Winters, Chairman
Professor Louise E. Hock,
Professor William D. Wilkins

A STUDY OF THE ARTICULATION BETWEEN HIGH SCHOOL TEACHERS OF CHEMISTRY AND COLLEGE INSTRUCTORS OF FIRST-YEAR CHEMISTRY

BROTHER C. JOSEPH D'AGOSTINO, F.S.C.

Submitted in partial fulfillment of the
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The research reported herein was performed pursuant to a contract with the United States Department of Health, Education, and Welfare, Office of Education, under the provisions of the Cooperative Research Program.

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Date　　　　　Brother C. Joseph D'Agostino, F.S.C.

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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

General Statement of the Problem

The problem under investigation was to determine whether a lack of understanding exists between teachers of high school chemistry and instructors of first-year college chemistry with regard to the aims and objectives in teaching both levels of chemistry. The study examined the beliefs of the teachers at the high school level as well as those of the instructors and students at the college level in order to determine what factors might contribute to an articulation gap. As a result of this study, recommendations were formulated for teachers and students at both levels.

Related Sub-Problems

In order to investigate the general problem, the following five specific problems were recognized:

1. What do high school chemistry teachers believe are the aims, objectives, and prerequisites of a chemistry course at both high school and college levels?
2. What do first-year college chemistry instructors believe are the aims, objectives, and

prerequisites of a chemistry course at both high school and college levels?

3. How do first-year college chemistry students evaluate their transition from high school to first-year college chemistry in terms of aims, objectives, and prerequisites?

4. What do specialists in the American Chemical Society and the College Entrance Examination Board indicate are the important problems in articulation between high school chemistry teachers and first-year college chemistry instructors?

5. What do leaders in the new Chemical Bond Approach Curriculum and the CHEM Study Curriculum believe are the problems in articulation between high school chemistry teachers and first-year college chemistry instructors in those schools where these new curricula are offered?

Definition of Terms

The specific or technical terms which were used in this research are defined as follows:

Articulation between teachers and instructors is the communication that should exist between teachers of the same subject at the different levels of education. Ideally, this communication will result in the standardization of teaching at the various levels, so that both teachers and students are aware of their aims, objectives and roles in the articulation process. A student passing from one level to another, then, will have the benefit of a sequential education without gaps. A teacher at any level will know exactly what has already been accomplished in a pupil's education and what follows next in sequence.

The articulation gap may be considered from the point of view of the student as well as from that of the high school teacher and the college instructor. In the case of the student, the articulation gap is the lack of a smooth transition from one educational level to another. With regard to the high school teacher and the college instructor, the articulation gap is the lack of communication between the two and the lack of knowledge on the part of the one as to what is the concern of the other. Furthermore, the articulation gap between high school teachers and college instructors also means the lack of agreement about the aims and objectives of a course at the secondary level.

In this study, instructor is a general term used for all teachers at the college level, regardless of their professorial rank. Use of this term avoids confusion with the word teacher, which denotes all high school teachers.

First-year college chemistry means the first course offered in the college chemistry sequence. The term is used synonymously with general college chemistry and freshman chemistry.

The Chemical Bond Approach Project (known as CBA) is a high school chemistry course defined as a new approach to the presentation of chemical reactions and systems. CBA emphasizes operational and conceptual definitions, as well as how to deal with chemical reactions. This project is the outgrowth of a committee of the American Chemical Society and is being funded by the National Science Foundation. The headquarters are at Earlham College (Indiana), and the principal originator and present project director is Professor Laurence E. Strong.[1]

The Chemical Education Material Study (Known as the CHEM Study) is a high school chemistry course also recommended by a committee of the American Chemical Society in 1959 and likewise is funded by the National Science Foundation. The principal originators of this study were Glenn T. Seaborg (at that time Chancellor, University of California) and J. Arthur Campbell (Professor of Chemistry at Harvey Mudd College, California). Campbell served as the first project director and was succeeded by George C. Pimentel at the University of California, Berkeley. The specific purposes and objectives of CHEM Study are described as follows:

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[1]L. E. Strong, et al., Chemical Systems (New York: McGraw-Hill Book Company, 1964), p. vi.

> To diminish the current separation between scientists and teachers in the understanding of science; to stimulate and prepare those high school students whose purpose is to continue the study of chemistry in college as a profession; to further in those students who will not continue the study of chemistry after high school an understanding of the importance of science in current and future human activities; to encourage teachers to undertake further study of chemistry courses that are geared to keep pace with advancing scientific frontiers, and thereby improve their teaching methods; to eliminate from present materials those things which have proved relatively ineffective; and to extend the progress initiated so far.[2]

The American Chemical Society, a professional society, is a national body of men trained in chemistry who have banded together to exchange ideas and to discuss developments in the field of chemistry, including educational problems.

The College Entrance Examination Board was organized in 1900 by a group of colleges and universities to consider problems involved in the preparation and administration of college entrance examinations and to organize and conduct such examinations on a national basis.[3] The offices are in Princeton, New Jersey.

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[2] J. David Lockard (ed.), Third Report of the Information Clearinghouse on New Science and Mathematics Curricula, Joint Project (College Park, Maryland: American Association for the Advancement of Science and the Science Teaching Center, University of Maryland, 1965), p. 14.

[3] C. V. Good (ed.), Dictionary of Education (New York: McGraw-Hill Book Company, 1959), p. 109.

Curriculum is defined as the general overall plan of content or specific materials of instruction which a school should offer the student in order to qualify him for graduation or certification.[4]

The terms aims and objectives often are found together in educational literature. For purposes of this study aims and objectives are used interchangeably, or, when used singly, the one implies the other. Carter Good defines aim as a foreseen end that gives direction to an activity and motivates behavior.[5] Good also defines objective as the aim, end in view, or purpose of a course of action, or a belief; that which is anticipated as desirable in the early phase of an activity and serves to select, regulate, and direct later aspects of the act so that the total process is designed and integrated.[6]

The literature of science education offers further clarification of these terms:

> An aim of education that seems consistent with the postulations of modern philosophy is, Life Enrichment through Participation in a Democratic Social Order.[7]

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[4]*Ibid.*, p. 110.

[5]*Ibid.*, p. 23.

[6]*Ibid.*, p. 371.

[7]National Society for the Study of Education, "A Program for Teaching Science," *Thirty-First Yearbook, Part I* (Chicago, Illinois: University of Chicago Press, 1932), p. 42.

> The principles and generalizations that ramify most widely into human affairs may be stated as objectives of science education. The objective may be seen as differing from the aim of education chiefly in its scope.[8]

Delimitations of the Study

For the purposes of this study, the scope of investigation was confined to:

1. High school chemistry teachers in the seven selected states of California, Colorado, Illinois, New Hampshire, New Jersey, Oregon, and Tennessee. The study was delimited furthermore to those chemistry teachers listed in the registry of names maintained by the National Science Teachers Association.

2. Instructors of first-year college chemistry who teach in those colleges listed as approved by the American Chemical Society as well as those instructors who teach in the colleges listed in the Education Directory (Chicago).

3. First-year college chemistry students who study in the classes of those instructors who are included in the second delimitation and who volunteer to participate.

Basic Assumptions

For the purposes of this study, the following two assumptions were formulated and identified:

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[8] *Ibid.*, p. 43.

1. Chemistry is a science which can be taught at the secondary level.

2. Articulation between teaching levels is necessary for maximum efficiency of the educational system.

Basic Hypotheses

Two basic hypotheses were formulated at the beginning of this research project:

1. An articulation gap does exist between the beliefs of high school chemistry teachers and those of instructors of general college chemistry regarding the aims, objectives, and prerequisites of chemistry courses at both high school and college levels.

2. An articulation gap does exist between the beliefs of high school chemistry teachers and those of instructors of general college chemistry regarding the items that should be taught in a high school chemistry course.

The Significance of the Study

During the past four decades, at least forty studies have been reported which deal with the problems of articulation between high school and college chemistry. The researchers in science education have attempted to approach this problem from many directions. No investigator, however, has studied this problem from the point of view of a statistical analysis.

Recently, Heimler stated that "the exact relationship between high school and college chemistry is still unclear and continues to remain a topic of emotional, and sometimes heated, discussion and debate."[9]

As early as the 1920's, the National Education Association (NEA) became interested in the problem of articulation in all areas of the curriculum. A report in 1931 drew up an "Inarticulation Checklist" of 100 items.[10] In 1932, another NEA Bulletin listed the five greatest differences between high schools and colleges in this problem area of articulation:

1. Lack of cooperation from the secondary schools.
2. Intrenched opinion of the college faculty.
3. Influence brought to bear by standardizing agencies.
4. Lack of secondary school guidance of pupils into appropriate activities after graduation.
5. Lack of specific subject guidance in the secondary schools for pupils planning to enter

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[9]C. H. Heimler, "High School and College Chemistry Teaching: An Area of Needed Research," Science Education, Vol. 47, No. 1 (February, 1963), p. 99.

[10]J. A. Sexson, "Inarticulations in American Education," Ninth Yearbook (Washington, D. C.: National Education Association, Department of Superintendence, February, 1931), p. 394.

college.[11]

Certain college personnel have expressed their ideas about the problem of articulation. In a study by Downing,[12] Glenn Wakeham was quoted as follows: "As far as formal learning is concerned, the high school period could probably be dropped in toto without any serious effect upon the students' work in college."

In an early study by Foley,[13] several college professors were asked to comment on the articulation between high school and college physics teaching. Because of the close parallel, the word "chemistry" may be substituted here for the word "physics" in their remarks.

> Personally, I have not been able to see much difference in the grades of students who have had high school physics and those who have not. In many instances, the student who comes to the work without any previous study, works better than the others.
>
> In my opinion, the slight difference in the grades is a fair argument in favor of dropping the work in physics in the high school.

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[11]P. R. Brammell, "Practices and Problems in Improving Articulation of High Schools and Colleges," NEA Bulletin, No. 40 (Washington, D. C.: Department of Secondary School Principals, 1932), p. 170.

[12]E. R. Downing, "A New Interpretation of the Functions of High School Science," Journal of Higher Education, Vol. 4, No. 7 (October, 1933), p. 365.

[13]A. L. Foley, "The College Students' Knowledge of High School Physics," School Science and Mathematics, Vol. 22, Whole No. 189 (October, 1922), p. 601.

> Do students in high school learn anything except dancing and basketball?
>
> Benefit derived from high school physics is discouragingly small.
>
> It seems a better solution would be to require a far higher grade of preparation for those who are allowed to teach the subject.
>
> So far as knowledge of physics is concerned, many students who have had high school physics do no better work than those who have not had it. The personality and training of the high school teachers are factors which largely determine the amount of knowledge that the student acquires.

The high school teachers in turn have voiced their opinions about articulation.

> The secondary school teacher is only too willing and anxious to please. . . .
>
> Far too many people in the college field believe that the secondary school teacher dies, intellectually and chemically, when he receives his college diploma, that the reason people teach in high school is because they are not bright enough to teach in college. Most secondary teachers resent the attitude that their students are worse off then they would have been if they had had no high school chemistry at all.[14]

Several people have attempted to approach the articulation problem constructively. As early as 1948[15] Ehret of New York University suggested that in many cases there is

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[14] D. W. Gifford, "Correlation of High School and College Chemistry Courses," Journal of Chemical Education, Vol. 26, No. 1 (January, 1949), p. 50.

[15] W. F. Ehret, "Correlation of High School and College Chemistry Courses," Journal of Chemical Education, Vol. 25, No. 12 (December, 1948), p. 699.

much repetition of high school work in college classes. He advised that colleges should grant advanced standing to those students from high school who pass a qualifying examination. This system has been adopted by many colleges.

Albert E. Lawrence, formerly of Cornell University, also approached this problem with a great deal of understanding:

> The already befuddled freshman still frequently hears, "Forget your high school chemistry. This is college." Is such a charge justified? Is it meant to be taken literally? If the answers are in the affirmative, it is certainly high time that secondary school and college chemistry teachers get together more frequently to consider each other's contributions and aims.[16]

Lawrence's suggestion that high school and college personnel get together was acted upon. In 1958 a conference composed of fifteen high school teachers and eighteen college professors met at Reed College under the co-sponsorship of the American Chemical Society and the Crown Zellerbach Foundation.[17] Although the group was quite small, the meeting proved fruitful. Among the closing recommendations was a strong plea that more such conferences be planned throughout the country in order to bring high school and college

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[16] A. E. Lawrence, "Articulation of High School and College Chemistry Instruction," Journal of Chemical Education, Vol. 32, No. 1 (January, 1955), p. 25.

[17] "The Reed College Conference on the Teaching of Chemistry," Journal of Chemical Education, Vol. 35, No. 2 (February, 1958), p. 54.

personnel to a better understanding of their mutual problems.

The American Chemical Society has been quite active in attempting to close the articulation gap between the high school and college levels. In a letter dated February 8, 1963, Robert L. Silber, Educational Secretary of ACS, stated: "We are indeed interested in this area and realize in certain circumstances this might create a definite gap between the two endeavors."

In a more complete statement in a recent issue of the Journal of Chemical Education, Fuller made a stronger plea for articulation.

> In this time of rapid growth and change, we who teach chemistry must be concerned not only with our own pedagogical problems but also with the advance of chemical education on all fronts. . . . The teacher of first-year college chemistry must build on the chemical knowledge brought by his students from their secondary school studies of chemistry or he will lose the interest and enthusiasm of the better students. The high school chemistry teacher cannot be of maximum effectiveness unless he knows what science his pupils have had in junior high school. . . . The reflective teacher of chemistry realizes that, indeed, "no man is an island" and that his own professional effectiveness is inextricably bound up with the work of his fellow teachers in other universities, colleges and schools. . . . If a chemist is to grow in stature as a teacher, he needs to know what other teachers are doing . . . , to expand his knowledge of chemistry continually . . . , and to develop his skills in presenting chemistry to his students.[18]

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[18]E. C. Fuller, "From the Chairman (A.C.S.)--Objectives and Needs," Journal of Chemical Education, Vol. 40, No. 4 (April, 1963), p. 223.

After making an exhaustive and critical study of the literature on the articulation problem of high school and college chemistry teaching, Heimler concluded that four areas require immediate research:

1. Development of a valid testing instrument to predict college chemistry achievement.

2. The identification of those factors (course of study, teaching methodology, textbooks, exams, etc.) that are associated with high school chemistry courses that have proven successful in preparing students for college.

3. The study of ways and means of reducing the large number of drop-outs of failures in the first semester of college chemistry.

4. Development of an adequate pre-chemistry course for those students who need additional preparation before entering into regular college chemistry.[19]

In conclusion, this investigator prepared the present study along the lines of the second area mentioned in the above list. High school teachers were allowed to identify the strong areas of their chemistry courses, and these findings were compared with what the college instructors identified as the areas which should be included in high school chemistry.

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[19]Heimler, op. cit., p. 99

Incidence of the Problem

As a high school chemistry teacher with ten years of experience, this investigator frequently was told by members of the alumni, returning from college after a few weeks of exposure to college chemistry, that the opening remarks of instructors of first-year college chemistry invariably were aimed at belittling high school chemistry. When he mentioned this fact to colleagues, he found that many other high school chemistry teachers were having the same experience. Such charges were very frustrating to a high school teacher who had toiled with a class, or classes, for a full school year and had brought them to a point where they were able to take a comprehensive examination in chemistry.

The investigator decided, therefore, that this area of concentration would be most meaningful to himself, to his colleagues, and to the advancement of the teaching of high school chemistry.

The scope of the problem in which this investigator became interested fell within the lines of the following questions:

1. (To a college instructor) What do you believe should be taught in high school chemistry?
2. (To a high school teacher) What do you believe should be taught in high school chemistry?

3. (Of a college student) How was your teacher and your preparation in high school chemistry? How are you now getting along in general college chemistry? What items of high school chemistry have helped you in college chemistry?

It was considered that the answers to these questions would be valuable to the teaching profession. The purpose of the present investigation was to secure these answers.

CHAPTER II

RELATED LITERATURE

The research literature on the subject of articulation generally follows specific lines. The educational investigators have studied articulation largely in terms of courses--course content, course grades, course textbooks, and relationships between courses.

This researcher believes that the human factor--the people who are involved--is more significant than course material. For this reason, the sub-problems in this study deal with the teachers at the high school level, the teachers at the college level, the students who have spanned the gap of articulation and entered the general college chemistry course, and, finally, those people who are intimately involved in the formulation of both traditional and newer chemistry courses. An awareness of the "people" factor was kept constantly in mind by the investigator as he reviewed the literature.

It was found that articulation studies in science education could be divided into six main areas:

1. Investigations which found that courses in high school chemistry do help students in college chemistry.

2. Investigations which revealed no significant difference in students of college chemistry, whether or not they had taken high school chemistry.
3. Investigations which considered other factors, combined with high school chemistry, that may have contributed to success in college chemistry.
4. Investigations which used high school grades to predict success in college chemistry.
5. Investigations into the overlapping of high school and college chemistry course content.
6. Investigations which studied, incidentally, the teachers and students as factors in articulation.

Investigations Which Found That Courses in High School Chemistry Do Help Students in College Chemistry

In a doctoral study at Fordham University, Carlin[1]

[1]J. J. Carlin, "A Comparative Investigation of Grades in the First Semester of College Chemistry Attained by Students Who Had Had a Course in Chemistry at the High School Level and Those Who Had Not Had Such a Course," (unpublished Ph.D. dissertation, Fordham University, New York, 1955).

considered 800 college freshmen (400 with high school chemistry and 400 without high school chemistry). He concluded that those who had studied high school chemistry attained significantly higher grades in the first semester of college chemistry than those who had not.

In a much earlier study at Rutgers University, Garard and Gates[2] reached a similar conclusion. Their study group, composed of 216 students who had taken high school chemistry and 133 students who had not, attained course grade averages which favored those students who had taken high school chemistry (62.8 per cent, as compared to 53.8 per cent).

Steiner[3] conducted a study at Oberlin College with 328 students who had taken high school chemistry and 276 students who had not. Those with high school chemistry averaged 76.8 per cent, while those without this course averaged 69.2 per cent.

Officials at the United States Naval Academy at Annapolis, Maryland, were alarmed at the number of failures in first-year college chemistry. Thompson[4] carried out an investigation and found that the failure rate of those

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[2] I. D. Garard and T. B. Gates, "High School Chemistry and the Students' Record in College Chemistry," Journal of Chemical Education, Vol. 6, No. 3 (March, 1929), p. 514.

[3] L. E. Steiner, "Contributions of High School Chemistry Toward Success in the College Chemistry Course," Journal of Chemical Education, Vol. 9, No. 3 (March, 1932), p. 530.

[4] E. W. Thompson, "With or without Secondary School Chemistry," Journal of Chemical Education, Vol. 30, No. 7 (July, 1953), p. 353.

without high school chemistry was three times that of those with high school chemistry. In an attempt to investigate further, he sent out a questionnaire to several eastern colleges. Thompson's data revealed that in all cases studied, the rate of failure for those without high school chemistry was much greater than those with high school chemistry. He concluded that a definite relationship exists between a student's success in college chemistry and his previous preparation in the subject.

Williams and Lafferty[5] conducted a two-year study of freshmen taking college chemistry at East Texas State College. Their results showed a definite carry-over from high school to college chemistry.

Investigations Which Found No Significant Difference in Students of College Chemistry, Whether or Not They Had Taken High School Chemistry

In spite of the results of the preceding studies, a few investigations were found that indicated that high school chemistry had no impact on college chemistry.

At the University of Toledo, Hovey and Krohn[6] found no

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[5]B. Williams and H. M. Lafferty, "High School Chemistry--Asset or Liability in College," Journal of Educational Research, Vol. 46, No. 3 (November, 1952), p. 207.

[6]N. W. Hovey and A. Krohn, "Predicting Failures in General Chemistry," Journal of Chemical Education, Vol. 35, No. 10 (October, 1958), p. 507.

correlation between a student's rank in his high school graduation class and his success in college chemistry. Furthermore, they found that the high school chemistry grades were not a reliable indication of college chemistry performance.

A seven-year study of freshmen was undertaken by Wakeham at the University of Colorado.[7] He found that at the end of the first quarter's work, those students who had had high school chemistry made slightly higher grades, but the difference was so slight as to be hardly significant. These students also proved that high school physics and mathematics courses were as helpful in college chemistry as the regular high school chemistry course.

Investigations Which Considered Other Factors, Combined with High School Chemistry, That May Have Contributed to Success in College Chemistry

Brasted[8] studied 1,400 freshmen at the University of Minnesota as well as 1,100 freshmen at other nearby colleges. He confirmed the anticipated higher performance in college chemistry by those who had studied high school chemistry.

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[7]G. Wakeham, "High School and College Chemistry," *School and Society*, Vol. 32, No. 815 (August 9, 1930), p. 208.

[8]R. C. Brasted, "Achievement in First Year College Chemistry Related to High School Preparation," *Journal of Chemical Education*, Vol. 34, No. 11 (November, 1957), p. 562.

Brasted went further to isolate other factors. He found no significant difference in grades between students from small or large high schools. He did find, however, that students from parochial and private high schools performed much better than those from public schools.

In a study by Hadley, Scott, and Van Lente[9] at Southern Illinois University, 696 freshmen students were examined over a three-year period. Once again it was found that students with high school chemistry did much better than those without high school chemistry. Furthermore, the investigators found that those with high school chemistry, physics, and mathematics did far better work than those with chemistry alone. In discussing their results, these researchers asked the question: How much of the achievements of the freshmen students were the result of their high school scores and how much were due to other factors, such as I. Q., Personality, and so forth? The researchers implied that those students who elect high school chemistry probably are more gifted to start with than their high school classmates who avoid chemistry. To carry this point still further, those students who elect chemistry, physics, and mathematics in high school probably are much more talented than those students who do

[9] E. H. Hadley, R. A. Scott, and K. A. Van Lente, "Relation of High School Preparation to College Chemistry Grades," Journal of Chemical Education, Vol. 30, No. 6 (June, 1953), p. 311.

not elect these courses. Consequently, tests given in college to these two groups will probably show a bias.

A study made at the University of Wisconsin by McQuary, Williams, and Willard,[10] investigated students in two general chemistry courses who were not majoring in chemistry or engineering. The findings confirmed the results of the previous study, that is, students who elect high school chemistry average higher in general scholastic ability than those who do not. Two other conclusions also are pertinent here. The investigators found that students who had taken high school chemistry and those who had not did not differ significantly in nonintellectual characteristics such as sex, size of home community, and state residence. However, when the two groups were compared for their intellectual characteristics (rank in high school, standard tests), those students with high school chemistry scored higher than those without chemistry.

Investigations Which Used High School Grades to Predict Success in College Chemistry

Hines[11] conducted a research study over a twelve-year

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[10] J. P. McQuary, H. V. Williams, and J. E. Willard, "What Factors Determine Student Achievement in First-Year College Chemistry?" Journal of Chemical Education, Vol. 29, No. 9 (September, 1952), p. 460.

[11] M. A. Hines, "Of What Value Is the High School Course in Chemistry to Those Students Continuing the Subject in College," Journal of Chemical Education, Vol. 6, No. 4 (April, 1929), p. 697.

period at Northwestern University and found that 62 per cent of those who took high school chemistry passed college chemistry. He also found that 61 per cent of those who did not have high school chemistry also passed. These figures were based on results obtained in the first-year college chemistry course. If Hines had stopped at that point, he would have been forced to conclude that high school chemistry was ineffective in college. However, Hines did go further. In studying the results of students in chemistry courses beyond the freshman year, he found that those who had had high school chemistry took more advanced chemistry courses and made better grades in these courses than those who had not had high school chemistry.

In a three-year study at LaCrosse State Teachers College, Hoff[12] examined 340 college students and obtained the following data:

1. Students with high school chemistry achieve slightly better, but not significantly better, grades than their classmates without high school chemistry.
2. The high school chemistry group showed scholastic ability superior to that of the non-high school chemistry group.

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[12]A. G. Hoff, "The Effect of High School Chemistry upon Success in College Chemistry," Journal of Educational Research, Vol. 40, No. 7 (March, 1957), p. 539.

3. One-half the students achieved the same grade in college as they did in high school chemistry.

Hoff concluded the following:

1. The study of chemistry in high school has no significant beneficial effect on the grades achieved in college chemistry,
2. A student has a 50 per cent chance of achieving the same grade in college as he did in high school chemistry.

Investigations into the Overlapping of High School and College Chemistry Course Content

Hunt[13] conducted a study at George Washington University in the 1920's which compared the courses in several subjects (including chemistry) at the high school and college levels in Washington State. Hunt examined the courses of study, textbooks, grades, methods of teaching, and achievement on special tests. It was found that:

1. Considerable portions of the high school and college courses duplicated one another.
2. Most textbooks overlapped.
3. Students with high school science did better than those without, at least during the first year of college.

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[13]T. Hunt, "Overlapping in High School and College Again," Journal of Educational Research, Vol. 13, No. 3 (March, 1926), p. 197.

4. Grades in the second year of college s[illegible] [illegible] no advantage for those who had one year of high school science preparation.

Several decades ago, Koos[14] made a study of twenty-six secondary schools in six states and forty-one colleges in eleven states. He studied the teaching of chemistry by means of textbook and syllabus analysis. He found that the content of the high school chemistry course was similar to that of the college. Koos concluded at the time that high school and college chemistry are very much alike and that students repeat nearly all their high school chemistry in college.

About the same time Osbourn[15] repeated the Koos study in the area of physics. He found that:

1. Seventeen per cent of the high school textbook and 25 per cent of the high school laboratory manual is repeated in college.
2. Eleven per cent of the college textbook and 30 per cent of the college laboratory manual is a duplication of high school work.

I[illegible] interesting to note that the only recent study on overlapping was reported in a Russian journal.

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[14] L. V. Koos, "Overlapping in High School and College," Journal of Educational Research, Vol. 11, No. 5 (May, 1925), p. 322.

[15] W. J. Osbourn, Overlapping and Omissions in our Courses of Study (Bloomington, Illinois: Public School Publishing Company, 1928), p. 261.

Khomchenko[16] found the problem of overlapping in courses and textbooks to be a serious one in Soviet Russia.

Investigations Which Studied, Incidentally, the Teachers and Students as Factors in Articulation

In a survey of students failing first year chemistry at Purdue University, Martin[17] asked for the students' reactions to the practice of separating the students who had high school chemistry from those who did not. He found that several students objected to being penalized by being placed in a more difficult section merely because they had had high school chemistry.

Amon[18] passed out 800 questionnaires to the freshmen at Westminster College in Pennsylvania and received 398 replies. Of this number, 350 had taken high school biology, 302 had taken high school chemistry, and 202 had taken high school physics. Those who had taken a course in high school chemistry were asked to state their like or dislike for the

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16 G. P. Khomchenko, "Coordination of the Teaching of Chemistry in Secondary Schools and Higher Institutions," Soviet Education, Vol. 4, No. 10 (August, 1962), p. 26.

17 F. D. Martin, "A Diagnostic and Remedial Study of Failures in Freshman Chemistry," Journal of Chemical Education, Vol. 19, No. 6 (June, 1942), p. 274.

18 J. C. Amon, "A College Look at High School Science," The Science Teacher, Vol. 24, No. 2 (March, 1957), p. 69.

subject. Their answers were:

203	(67.2 per cent)	liked chemistry
31	(10.2 per cent)	disliked chemistry
68	(22.2 per cent)	tolerated chemistry

When asked to check off their reasons for disliking chemistry, they indicated their objections in the following numbers:

	Students
Poor teaching	12
Not interesting	6
Didn't understand	4
Too much memory	4
Too little lab	1
Mathematics	6

When asked to check off the aspects of chemistry they most liked, the students replied as follows:

	Students
Chemistry laboratory	49
Good Teaching	15
Interesting	11
Applications	7
Equations, problems	8

When asked to check off the aspects of chemistry they least liked, the students replied as follows:

	Students
Problems	11
Equations	8
Lack of equipment	7
Instructor	6
Didn't understand	6
Memory	4
Chemistry laboratory	5

Lawrence[19] made an extensive study of the articulation

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[19]Lawrence, op. cit., p. 25.

problem in his immediate area at Cornell University. He asked a panel of professors of physical science at Cornell to list what they most expected of high school teachers of science. Their replies, in the order of importance, were:

1. Interest in the field
2. Adequate mathematics preparation
3. Understanding of a few major principles and techniques
4. Ability to verbalize

Lawrence also listed what he believed to be the major problems in articulation:

1. Vertical articulation, or the need for an efficient interrelation of content, method, and objectives between high school and first-year college chemistry courses.
2. Decreasing physical science enrollment in our high schools.
3. The college's disregard for what is being taught in the high schools.
4. College professors who announce the first day that students should forget what they have learned in high school chemistry and go further to say that what these students have learned may be a distinct disadvantage.

Lawrence went on to state that research in the following areas would be very valuable.

1. Re-examination by both colleges and high schools in their course content, teaching

methods, and <u>motives</u>.

2. Study of the existing situation, past and present.
3. Study of the necessity of articulation.
4. Survey of the opinions of the accepted leaders and investigators in the field.
5. Survey of student attitudes.

In following through on the last two suggestions for areas of research, Lawrence conducted a study in 1954 of a random sampling of 1,000 freshmen science students at Cornell. They were asked to rate the importance of fifty-six items as they related to success in college chemistry. These fifty-six items involved subject matter, attitudes, skills, and concepts in high school chemistry, physics, and mathematics. Unfortunately, only sixty respondents replied. Lawrence compared the student responses with those from a similar questionnaire which he sent out to a group of scientists and science educators. A comparison of the first six student choices with the scientists' choices follows:

Relative Importance of Various Factors for Success in College Chemistry

Order of Students' Choices		Order of Scientists' Choices
1	Clarity in expression of ideas	4
2	Interest and enjoyment of science	1
3	Independent laboratory work	8
4	Content in Chemistry	5

Order of Students' Choices		Order of Scientists' Choices
5	Content in mathematics	2
6	Neatness in handwriting and spelling accuracy.	6

Finally, Lawrence asked the students to list the qualities they would like to find in a teacher. The qualities indicated were:

1. Clarity of explanation
2. Enthusiasm and interest
3. Mastery of the subject
4. Poise and control of classroom
5. Pleasant student-instructor relations
6. Definite interest in student's study habits
7. Tendency to give moderate assignments
8. Personal appeal

Summary of Related Literature

In conclusion, a total of nineteen studies were analyzed. One was a doctoral study, the rest were studies that were reported in professional journals.

The studies were broken down into six categories, all having to do with various factors in the articulation problem. Most of the studies concerned themselves with course content.

Interestingly enough, some studies showed that high school chemistry was a significant help to students in college chemistry, while still other studies supported the opposing views.

Some studies pointed up the fact that students who elect chemistry in high school are more gifted than their classmates and, hence, more should be expected of them in college.

It was also found that in many cases high school chemistry marks may be used to predict success in college chemistry.

No recent study was found on the overlapping of courses between high school and college chemistry. This might indicate an area where research is needed.

From the point of view of the investigator, the most interesting study was that by Lawrence. His work cannot be relied on too heavily, however, because of the extremely small size of his sample. Nevertheless, Lawrence laid the groundwork for a study that could be significant.

This investigator prepared his own research in the area of articulation outlined by Lawrence. No statistical study was found that dealt with the beliefs of teachers of high school chemistry, instructors of college chemistry, and first-year students. The present research was an attempt to add new data to this area in order to throw some light on the subject of articulation.

CHAPTER III

PROCEDURE IN COLLECTING AND TREATING THE DATA

In order to collect data to treat the first three specific problems, a questionnaire was devised. The instrument was constructed in such a way as to be applicable to all three categories with only minor changes. In the interest of avoiding any confusion, the instruments are identified as follows:

1. Form A: Questionnaire for Teachers of High School Chemistry
2. Form B: Questionnaire for Teachers of First-Year College Chemistry
3. Form C: Questionnaire for Students of First-Year College Chemistry who have Completed a High School Chemistry Course

The first three specific problems of this investigation are repeated here for the benefit of the reader.

1. What do high school chemistry teachers believe are the aims, objectives, prerequisites of a chemistry course at both the high school and college levels?
2. What do first-year college chemistry instructors believe are the aims, objectives, and prerequisites of a chemistry course at both high school and college levels?
3. How do first-year college chemistry students evaluate their transition from high school

to first-year college chemistry in terms of aims, objectives, and prerequisites?

Preparation of the Instrument

Since the articulation bridge has two supports and a span (high school chemistry courses, college chemistry courses, and the students who proceed from the first to the second), the purpose of the questionnaire instrument was to gather data from each of these three sources. The instrument was prepared to examine the beliefs of high school chemistry teachers, college chemistry instructors, and, the first-year college chemistry students who have spanned the gap between high school and college. (See Appendices A, B, C.)

In developing the questionnaire, the investigator utilized four guides:

1. His experience of ten years as a teacher of college preparatory chemistry using the New York State Syllabus.
2. The criteria for questionnaires that appear in Understanding Educational Research by Professor Deobold B. Van Dalen.
3. The recommendations of a jury of five men to whom the instrument was submitted for review.
4. The results of a pilot study.

The jury mentioned in the preceding paragraph was composed of the following:

1. A professor in a school of education with at least five years of experience.
2. A professor in a science education department with at least five years of experience.
3. A professor in a liberal arts college chemistry department with at least five years experience.
4. A chairman of a high school chemistry department with at least five years of experience in that position.
5. A classroom teacher of high school chemistry with at least five years of experience.

A listing of the five men composing this jury may be found in Appendix D.

The jury was asked to judge the validity of each item in the first draft of the questionnaire in order that the investigator might assume that the items would reveal the necessary data. The jury was given a rating sheet to score each item. Any question that was found to be not valid was given a score of zero. Any questionnaire item that was apparently valid was given a score of two. Any item about which the judge was undecided was given a score of one. Each item was then evaluated by totaling the scores of all the judges. The maximum total score which any item could receive was ten, while the minimum score was zero. It was decided that all items receiving total scores of seven or more would be included in the questionnaire. All items with scores below seven would be reworded to suit the demand of the jury. If this could not be done, the item was discarded.

The jury was also asked to comment on the format and clarity of the directions of the questionnaire.

From all the comments and scores supplied by the jury, a second draft of the questionnaire was prepared. This second draft was mimeographed and used in a pilot study in order to further refine the instrument. The questionnaires were distributed in the following manner:

1. Form A was administered to a selected group of ten high school chemistry teachers who were chosen from five high schools in the New York area. The teachers selected were all veterans of five years in secondary education.

2. Form B was administered to a selected group of ten college chemistry instructors with five years of teaching experience who were chosen from five colleges in the New York area.

3. Form C was administered to a selected group of fifty first-year college chemistry students who had completed high school chemistry. They were chosen from five colleges in the New York area.

The purposes of this pilot study were to ascertain the readability of the questionnaires, the accuracy of the directions, the time necessary to answer them, and the reliability of the instrument.

From the responses obtained in the above pilot study, the investigator was able to make the final revision of the instrument. It was found that certain multiple-choice questions did not offer a wide enough selection. Consequently, more choices were added. It was also pointed out that several syllabus items were overcrowded and it was necessary to itemize them still further so that choices could be made on each item in the breakdown. It was also suggested that a copy of the rating scale should be placed on each page of the questionnaire, so that the respondent would not be required to turn pages after reading each item. Most of the recommendations gathered from the pilot study were in the nature of format changes rather than revisions in the original content of the questionnaire items.

Rationale for the Specific Items Included in the Questionnaire

The investigator attempted to construct a questionnaire that would not exceed four printed pages. It was decided that brevity in the instrument might evoke a higher percentage of response. The panel of jurors agreed with the investigator in this decision. Therefore, the questionnaire was divided into three parts.

Part I of the questionnaire was concerned with general directions and background information about each respondent. This information was necessary in order to establish the experience of the respondents. The items in Part I also included questions on what the respondents believed to be important prerequisites for high school chemistry students.

The items included in Part I of the various forms of the questionnaire were identified as follows:

1. Form A: Items 1 through 12
2. Form B: Items 1 through 12
3. Form C: Items 1 through 11

Part II of the questionnaire was concerned with the beliefs of each group regarding the high school chemistry courses. These items were exactly the same in each version of the questionnaire. Included in this part were specific items questioning beliefs on aims, objectives, and course content.

The specific items on aims and objectives may be found in the Forty-Sixth Yearbook of the National Society for the Study of Education.[1] It was thought best to utilize these objectives because they were the summation of thought from many science educators. Their opinions covered all the major objectives for a high school chemistry course.

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[1]National Society for the Study of Education, "Science Education in the American Schools," Forty-Sixth Yearbook, Part I (Chicago, Illinois: University of Chicago Press, 1947), p. 142.

The second section of Part II was an outline of what a minimum course in college preparatory chemistry should include. The requirements were compiled by the New England Association of Chemistry Teachers.[2] This section was included to determine whether or not the high school and college personnel agree or disagree on what items should be taught in high school chemistry.

The items of Part II in the various forms of the questionnaire were identified as follows:

1. Form A: Items numbered 13 through 60
2. Form B: Items numbered 13 through 60
3. Form C: Items numbered 13 through 60

Part III of the questionnaire was concerned with the beliefs of the respondents regarding college chemistry. The first item (#61) asked each group to state what they considered the important prerequisites for students entering a college chemistry course.

The next two items (#62 and #63) asked whether or not the student in first-year college chemistry is helped by his high school chemistry course and whether or not the college instructor takes advantage of what is being taught in the high school chemistry course.

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[2]Report of the New England Association of Chemistry Teachers, "A Minimum Syllabus for a College Preparatory Course in Chemistry," Journal of Chemical Education, Vol. 34, No. 6 (June, 1957), p. 307.

The final scale items (#64 through #71) were the same in all versions of the questionnaire. These were nine items relating to the aims and objectives of college chemistry. The first five were taken from the Thirty-First Yearbook of the National Society for the Study of Education.[3] They represented an attempt to encompass all the needs of a college student. Since the investigator did not believe that the five were sufficient, additional items were obtained from prefaces of certain college textbooks. Two of these were obtained from a textbook used at Cornell University.[4] The last two were obtained from one of the textbooks used at New York University.[5] Items of Part III in each of the forms were identified as follows:

1. Form A: Items numbered 61 through 71
2. Form B: Items numbered 61 through 71
3. Form C: Items numbered 61 through 71

Completion of the Questionnaire

On September 15, 1965, the completed forms of the questionnaire were delivered to the New York University Office of Publications for printing and publication and mailing of the questionnaire together with the cover letter, direction

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[3]National Society for the Study of Education, "A Program for Teaching Science," Thirty-First Yearbook, Part I (Chicago, Illinois: University of Chicago Press, 1932), p. 311.

[4]M. J. Sienko and R. A. Plane, Chemistry (New York: McGraw-Hill Book Company, 1957), p. v.

[5]D. C. Gregg, College Chemistry, (Boston: Allyn and Bacon, Inc., 1961), p. vi.

sheet, and return envelope. (See Appendices A, B, and C.)

Size and Distribution of the Sample

The size and distribution of the sample differed with each form that was used. Therefore, they will be discussed separately.

Form A

The National Science Teachers Association maintains the U. S. Registry of Junior and Senior High School Science and Mathematics Teaching Personnel. All science teachers in the secondary level of instruction are listed by name, address, and the discipline they instruct.

This registry lists over 21,000 chemistry teachers in the United States. Since this registry supplies names in blocks by states, it was impossible to obtain a random sampling as originally planned.

First plans called for a survey of 1,000 secondary chemistry teachers. However, it was decided to choose teachers from several states using the following criteria:

1. The states should be geographically situated to represent the several sections of the United States.
2. The states should be selected to include respondents from large rural areas as well as large urban areas.

The states selected were California, Colorado, Illinois, New Hampshire, New Jersey, Oregon and Tennessee. These seven states represented a total of 3,874 high school chemistry teachers. Questionnaires were sent out to all these teachers on November 1, 1965, with the request that they be returned within ten days after the arrival of the questionnaire.

The cut-off date for accepting responses in this study was set for January 27, 1966. By that date, the number of responses returned was 1,993, or 51 per cent. (See Appendix E for the national distribution of the response.)

Form B

In the course of obtaining a listing of the instructors of first-year college chemistry, another problem was encountered. No directory or mailing list service carries a special listing of chemistry instructors according to the level of chemistry which they teach. Estimates on the number of college chemistry instructors range from 11,000 to 20,000. It was difficult to estimate what per cent teach first-year chemistry.

It was decided that a listing would be obtained from The Educational Directory, a division of the American University Press Services, which maintains the names of all of the chemistry department heads in the nation. This listing had a total of 723 names.

However, in comparing this list against the one published by the American Chemical Society of all of the

ACS-approved chemistry departments in the country, a few more colleges had to be added to the mailing list.

The mailing list for Form B finally totaled 775 department heads. It was decided that in addition to a letter of explanation to each department head, the envelope would include five copies of the Form B questionnaire together with a request that they be passed on to the instructors of first-year college chemistry for completion.

The 3,880 Form B questionnaires were mailed out on November 1, 1965. (See Appendix B.) It would be unsafe to assume, however, that each of these questionnaires finally did reach the hands of a first-year college chemistry instructor. From the many questionnaires that were conscientiously returned unopened, it was apparent that a large number of colleges have fewer than five members teaching first-year college chemistry.

The probable number of questionnaires that actually did reach the first-year chemistry instructors would be about 2,400.

At the cut-off date of January 27, 1966, a total of 1,245 responses to Form B was received. Assuming the 2,400 figure to be accurate, this would amount to a 52 per cent response. (See Appendix E for the national distribution of the response.)

Form C

In order to obtain a large enough sample, Item 73 was added to Form B. This item requested permission of the college instructor to allow Form C of the questionnaire to be distributed in his class. It was expected that a population as large as 2,000 might be obtained in this way. These instructors were also requested to submit an estimate of the number of questionnaires they would like to have distributed.

When the requests for Form C questionnaires were totaled, 600 instructors had requested over 30,000 questionnaires. This number was much too large to handle. It was decided that only five Form C questionnaires would be sent to each instructor requesting copies. Included with these was a letter explaining the reason for limiting the number of questionnaires sent.

On December 5, 1965, a total of 3,000 Form C questionnaires were mailed with cover letters and direction sheets. (See Appendix C .)

On the cut-off date of January 27, 1966, a total of 1,650 responses had been returned. This amounted to a 55 per cent response. (See Appendix E for the national distribution of this sample.)

Design for the Treatment of the Data

Specific Problems 1, 2, and 3

The design for the treatment of the data derived from the three questionnaire forms was divided into three steps. Because of the large population, a computer was used to analyze the data. The procedure was as follows:

First Step: Tabulation of the responses on each of the three forms and the computation of the percentage of the response at each level of the scale.

Second Step: A factor analysis of the scale items referring to the aims and objectives of high school chemistry. These items were numbered 13 to 60 inclusive in the questionnaire. Only the responses to Forms A and B were used in this factor analysis, since the main purpose of this study was to test the differences between the high school and college chemistry teachers.

A computer program was used for the factor analysis of forty-eight variables using a Principle Components Technique. The unrotated factor matrix was rotated to a normalized solution using Kaiser's Varimax Solution. The program selected factors on the basis of lambda being greater than one (1).

Third Step: The factors derived from the Second Step then were studied as they related to the beliefs of the high school and college instructors. A "t-test" of significance was used to prove whether or not the difference between high school and college instructors was statistically significant or due to chance.

Specific Problems 4 and 5

The design for obtaining data for Specific Problems 4 and 5 used one or more of the following methods:

1. A personal interview with the specialist.
2. A telephone interview with the specialist.
3. An exchange of correspondence with the specialist.

Specific Problems 4 and 5 are repeated here for the benefit of the reader:

4. What do specialists in the American Chemical Society and the College Entrance Examination Board indicate are the important problems in articulation between high school chemistry teachers and first-year college chemistry instructors?

5. What do leaders in the new Chemical Bond Approach Curriculum and the CHEM Study Curriculum believe are the problems in articulation between high school chemistry teachers and first-year college chemistry instructors in those schools where these new curricula are offered?

CHAPTER IV

ANALYSIS OF THE DATA

The first step in the data analysis was to tabulate the responses to each of the three forms of the questionnaire and compute the percentages of responses at each level of the scale. This chapter will present the tabulations for each item and for all the possible responses within the item. Chapter V then will summarize the profiles and composite answers which the writer has compiled from the raw data.

The material will be offered as a tabulation of items, total numbers of responses, and their corresponding percentages. In order to interpret correctly the percentages which follow, the reader should keep three points in mind:

1. All per cents given are percentages of the total sample.
2. Where the totals shown do not equal 100 per cent, this discrepancy is due to invalid responses. A response is invalid when the respondent checks off two or three scale values under the same item, or does not check any scale value at all.
3. Where the totals exceed 100 per cent, these items have multiple responses, so that an individual may have checked off more than one choice for a particular item.

Background Information on Respondents

Since each of the three forms of the questionnaire had a distinct opening section on background information, each section will be reported separately (see Tables I, II, and III).

Results of Similar Items on the Three Forms of the Questionnaire

Most of the remaining items on the three forms of the instrument were similar. Therefore, in reporting the results of these items, they will be presented together in tables so that comparisons may be drawn.

In order to keep these tabulations legible and as simple as possible, the raw scores for each of the scale items are not listed. Only the per cents are recorded. The numbers listed under "Scale" refer to the value of the response for each questionnaire item. The values were assigned according to the following code:

Scale	
1	The item is very important
2	The item is mildly important
3	The item is unimportant

Tables IV, V, and VI deal with the responses according to three general areas of interest: the major objectives of science teaching in high school (Items 13-20), major items to be included in high school chemistry courses (Items 21-60), and the aims and objectives of first-year college chemistry courses (Items 64-71).

TABLE I

PROFILE OF HIGH SCHOOL CHEMISTRY TEACHERS
(FORM A: TOTAL RESPONSES, 1,993)

Characteristic	Number	Per Cent
Sex:		
Male	1,574	79.0
Female	411	20.6
Size of school:		
Under 500 students	600	30.1
500 to 1,000 students	391	19.6
Over 1,000 students	945	47.4
Number of years in teaching:		
Under 5 years	519	26.0
5 to 9 years	515	25.8
10 to 19 years	601	30.2
20 years and over	343	17.2
Number of years teaching chemistry:		
Under 5 years	754	37.8
5 to 9 years	576	28.9
10 to 19 years	462	23.2
20 years and over	185	9.3
Degrees held:		
B.A.	732	36.7
B.S.	1,015	50.9
Total bachelor's degrees	1,747	87.6
M.A.	439	22.0
M.S.	559	28.0
Total master's degrees	998	50.0
Ed.D.	10	.5
Ph.D.	12	.6
Total doctorates	22	1.1
Teachers have taken in-services courses since 1960:		
Yes	1,361	68.3
No	632	31.7
Membership in professional organizations:		
National Science Teachers Association	753	37.7

TABLE I (Cont.)

Characteristic	Number	Per Cent
American Chemical Society	347	17.4
National Education Association	915	45.9
Types of chemistry taught at respondents' schools:		
Traditional college preparatory	1,436	72.0
Terminal course	248	12.3
Advanced chemistry	347	17.4
CBA chemistry	145	8.9
CHEM Study chemistry	817	40.9
Number of chemistry credits taken in college by respondent:		
Under 15	165	8.3
16-20	233	11.7
21-24	233	11.7
Over 24	1,342	67.1

TABLE II

PROFILE OF FIRST-YEAR COLLEGE CHEMISTRY INSTRUCTORS
(FORM B: TOTAL RESPONSES, 1,245)

Characteristic	Number	Per Cent
Sex:		
Male	1,099	88.3
Female	132	10.6
Size of college:		
Under 1,000	174	13.9
1,000 to 5,000	600	48.2
Over 5,000	444	35.6
Number of years in teaching:		
Under 5 years	370	29.7
5 to 9 years	288	23.1
10 to 19 years	320	25.7
20 years and over	265	21.3
Degrees held:		
B.A.	380	30.5
B.S.	677	54.3
Total bachelor's degrees	1,057	84.8
M.A.	173	13.9
M.S.	577	46.3
Total master's degrees	750	60.2
Ed.D.	9	.7
Ph.D.	1,004	80.6
Total doctorates	1,013	81.3
Instructors have taken in-service courses since 1960:		
Yes	320	25.7
No	919	73.8
Membership in professional organizations:		
American Chemical Society	1,123	90.0
National Education Association	30	2.4
American Association of University Professors	583	46.9
National Science Teachers Association	46	3.7

TABLE II (Cont.)

Characteristic	Number	Per Cent
High school chemistry required of first-year chemistry students:		
Yes	225	18.0
No	1,005	80.7
Do respondents' colleges differentiate between students with and without high school chemistry?		
Separate courses	258	16.3
Same course for both groups	775	49.0
Advanced standing for those with high school chemistry	148	9.3
Time spent by respondents in first-year chemistry instruction:		
100 per cent	143	11.5
About 75 per cent	248	19.9
About 50 per cent	443	35.4
About 25 per cent	397	31.8

TABLE III

PROFILE OF FIRST-YEAR COLLEGE CHEMISTRY STUDENTS WHO HAVE HAD A HIGH SCHOOL CHEMISTRY COURSE (FORM C: TOTAL RESPONSES, 1,650)

Characteristic	Number	Per Cent
Sex:		
Male	1,062	64.4
Female	566	34.3
Semester of college chemistry completed by respondent:		
First semester	1,325	80.3
Second semester	199	12.1
What science and mathematics courses were taken in high school by respondents?		
Earth science	147	8.8
General science	997	60.4
Biology	1,507	91.3
Physics	1,241	75.2
Math, 1 year	312	18.8
Math, 2 years	365	22.1
Math, 3 years	526	31.8
Math, 4 years	1,222	74.0
College prep chemistry	1,136	68.8
Advanced placement chemistry	68	4.1
Honors chemistry	85	5.1
CBA chemistry	45	2.7
CHEM Study chemistry	164	9.9
Number of periods per week spent in high school chemistry:		
In the classroom		
3 periods	255	15.4
4 periods	421	25.5
5 periods	903	54.7
6 periods	26	1.5
In the chemistry laboratory		
1 period	660	40.0
2 periods	595	36.0
3 periods	38	2.3

TABLE III (Cont.)

Characteristic	Number	Per Cent
Duration of these chemistry classes:		
30 to 39 minutes	28	1.7
40 to 49 minutes	502	30.4
50 to 60 minutes	1,038	62.9
Approximate final grade of respondents in high school chemistry:		
A (90-100)	791	48.0
B (80-89)	612	37.1
C (70-79)	200	12.1
D (60-69)	22	1.3
How respondents classify their high school chemistry courses:		
Poor	105	6.4
Fair	361	21.9
Good	529	32.0
Very good	522	31.6
Exceptional	110	6.9
How respondents classify their high school chemistry teachers:		
Poor	143	8.7
Fair	298	18.1
Good	377	22.8
Very good	537	32.5
Exceptional	266	16.1
Year in which respondents took high school chemistry:		
10th grade	133	8.0
11th grade	1,043	63.2
12th grade	424	25.0

TABLE IV

MAJOR OBJECTIVES OF SCIENCE TEACHING IN HIGH SCHOOL AS PROPOSED BY LEADING EDUCATORS (ITEMS 13-20)

Item		Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
13.	Provide opportunities for growth in the functional understanding of facts.	1	56.4	55.7	62.5
		2	36.1	31.3	30.8
		3	5.4	7.3	5.8
14.	Provide for development of fu··:ional concepts.	1	78.2	66.3	69.1
		2	16.9	22.5	24.5
		3	2.6	4.7	5.7
15.	Provide for growth in the functional understanding of principles.	1	83.8	79.3	77.0
		2	11.4	12.3	16.5
		3	2.8	3.3	5.7
16.	Provide for growth in basic instrument skill.	1	28.7	11.6	29.5
		2	59.8	49.4	57.7
		3	9.7	35.7	12.0
17.	Provide opportunity for growth of skill in the use of elements of the scientific method.	1	59.9	49.2	45.5
		2	32.8	37.1	45.0
		3	5.3	8.5	8.2
18.	Provide for growth in development of scientific attitudes.	1	71.9	63.8	49.7
		2	22.6	25.5	40.8
		3	4.0	6.4	8.7
19.	Provide for growth in development of scientific appreciations.	1	54.0	45.7	36.8
		2	38.5	39.1	49.1
		3	6.2	9.5	13.0
20.	Provide for growth in development of interests in science.	1	53.3	53.2	47.6
		2	40.1	36.5	39.9
		3	5.0	6.7	11.6

TABLE V

MAJOR ITEMS TO BE INCLUDED IN HIGH SCHOOL CHEMISTRY COURSES (ITEMS 21-60)

Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
21. Chemistry of nonmetals and their compounds (e.g., oxygen, hydrogen, nitrogen, sulfur, carbon, halogens).	1	55.9	57.0	75.7
	2	36.9	36.8	17.8
	3	5.6	4.4	5.7
22. Composition of air.	1	15.9	15.2	21.6
	2	53.7	49.4	53.1
	3	29.0	32.9	24.8
23. Water and its properties.	1	54.9	54.4	64.4
	2	38.7	39.5	29.2
	3	5.3	4.3	5.9
24. Properties of metals in general.	1	57.0	55.1	61.7
	2	35.8	38.0	32.5
	3	5.8	5.1	5.3
25. Chemistry of sodium, aluminum, iron.	1	15.8	20.0	29.5
	2	63.1	58.9	59.4
	3	19.3	18.2	10.3
26. Industrial processes (e.g., Haber, Ostwald, Contact).	1	6.9	7.6	12.3
	2	47.1	42.0	52.8
	3	44.3	48.3	33.8
27. Kinetic-molecular theory.	1	90.2	73.2	73.4
	2	6.4	21.0	20.2
	3	2.8	4.5	5.9
28. Properties of solids and liquids.	1	67.4	58.8	63.5
	2	28.2	36.4	31.8
	3	3.1	3.2	4.4
29. Properties of gases.	1	72.4	72.1	71.7
	2	23.9	24.3	23.3
	3	2.7	2.1	4.7

TABLE V (Cont.)

	Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
30.	Quantitative treatment of the gas laws.	1	58.1	58.3	55.1
		2	36.7	34.8	38.9
		3	4.1	5.4	5.3
31.	Elements, mixtures, compounds.	1	63.3	67.1	58.6
		2	31.0	27.4	34.6
		3	4.7	4.3	6.3
32.	Nature of a chemical change.	1	86.5	79.1	63.2
		2	9.0	16.1	30.9
		3	3.6	3.5	5.5
33.	Types of chemical reactions.	1	66.1	56.9	61.8
		2	27.8	33.7	32.3
		3	4.5	8.0	5.7
34.	Balancing of chemical equations.	1	74.9	74.5	64.6
		2	21.0	21.0	28.4
		3	3.1	3.5	6.7
35.	Problems based on chemical equations (e.g., weight, volume).	1	76.8	80.1	64.1
		2	19.7	16.2	29.5
		3	2.6	2.6	5.9
36.	Mole and molar solutions.	1	80.0	77.9	63.1
		2	16.3	18.1	30.2
		3	3.1	2.8	6.3
37.	Use of atomic structure to show compound formation.	1	80.7	69.8	52.6
		2	15.6	24.7	38.4
		3	2.6	3.9	8.5
38.	Explaining reactions in terms of electron transfer.	1	79.7	60.9	61.5
		2	15.8	30.9	31.6
		3	3.5	6.7	6.5
39.	Electrovalence and ionic nature of salts.	1	72.2	71.0	46.0
		2	23.8	24.9	45.7
		3	3.1	3.1	7.8

TABLE V (Cont.)

	Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
40.	Covalence in simple molecules.	1	72.3	72.6	47.3
		2	23.6	23.1	44.3
		3	3.0	3.1	7.9
41.	Definition of concentrated and dilute solutions.	1	37.3	37.3	31.2
		2	47.9	41.5	51.9
		3	13.8	19.2	16.5
42.	Electrolytes (e.g., acids, bases, salts).	1	68.7	66.5	54.5
		2	27.1	28.4	38.7
		3	3.0	3.5	6.2
43.	Arrhenius concept of acids and bases.	1	34.1	39.1	22.6
		2	54.4	44.8	55.6
		3	10.0	14.4	16.2
44.	Bronsted-Lowry concept of acids and bases.	1	54.1	47.4	33.8
		2	37.4	39.9	49.2
		3	6.5	11.5	11.5
45.	Hydrolysis of salts.	1	32.2	29.4	27.4
		2	58.6	50.2	60.0
		3	7.3	18.6	11.3
46.	Reasons why some reactions go to completion.	1	62.6	55.1	48.6
		2	32.3	34.3	41.7
		3	4.1	8.4	9.4
47.	Electrolysis of aqueous solutions and fused salts.	1	30.8	29.6	26.2
		2	57.3	52.6	58.4
		3	10.6	15.7	13.8
48.	Definition of atom and molecule.	1	67.9	78.0	69.7
		2	23.7	14.9	21.2
		3	7.1	5.3	8.8
49.	Nuclear charge and the distribution of electrons.	1	80.1	69.1	68.1
		2	15.6	24.3	24.7
		3	3.1	5.1	6.4

TABLE V (Cont.)

Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
50. Periodic law and its relation to atomic structure.	1	87.6	81.4	73.3
	2	8.5	14.4	19.6
	3	3.0	2.8	6.5
51. Discussion of radio-chemistry and isotopes.	1	27.2	16.2	24.1
	2	58.7	59.2	57.1
	3	12.9	23.1	18.1
52. Nuclear fission and fusion.	1	25.0	11.1	28.2
	2	55.8	51.2	52.3
	3	17.7	36.3	18.9
53. Organic chemistry (e.g., hydrocarbons, alcohols, esters, aldehydes, ketones).	1	40.2	14.5	47.6
	2	50.6	49.8	40.6
	3	7.9	33.9	10.8
54. LeChatelier's principle and the law of mass action.	1	56.4	63.8	39.6
	2	35.4	28.4	42.8
	3	7.0	6.5	12.6
55. Determination of molecular weight by depression of freezing point and elevation of boiling point.	1	24.1	19.4	32.2
	2	57.6	55.8	51.1
	3	17.1	22.9	15.6
56. Equivalent weights and normal solutions.	1	48.8	48.7	56.5
	2	36.1	32.9	35.8
	3	14.0	17.2	6.9
57. Oxidation-reduction reactions.	1	79.7	64.2	77.4
	2	16.6	30.5	16.8
	3	3.0	3.9	5.5
58. Balancing equations by means of the electron transfer method.	1	62.6	47.5	57.4
	2	31.2	38.4	34.7
	3	5.1	12.2	7.1

TABLE V (Cont.)

	Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
59.	Chemistry of plastics, rubber, glass, cement.	1	4.5	4.0	13.3
		2	40.6	25.7	47.5
		3	53.8	68.7	38.2
60.	Chemistry of textiles and food.	1	4.7	3.4	14.2
		2	37.0	25.5	40.4
		3	57.2	69.5	44.6

TABLE VI

AIMS AND OBJECTIVES OF FIRST-YEAR COLLEGE CHEMISTRY COURSES (ITEMS 64-71)

Item	Scale	Form A (1,993) %	Form B (1,245) %	Form C (1,650) %
64. Scientific information.	1 2 3	54.7 34.6 6.0	58.0 32.7 5.6	62.0 30.2 5.7
65. Development of an interest in science.	1 2 3	40.6 44.1 12.1	51.3 38.8 7.6	41.7 42.6 14.8
66. Understanding the relationship of science to everyday life (applications).	1 2 3	31.6 48.5 16.4	29.8 52.5 15.7	44.2 42.3 12.8
67. Understanding the relationship of chemistry to the other sciences.	1 2 3	52.8 39.8 5.0	37.6 52.3 8.1	41.1 48.5 9.8
68. The assumption of no previous knowledge of chemistry.	1 2 3	12.4 40.9 38.3	18.8 37.9 33.6	27.1 40.8 30.3
69. A greater emphasis on the principles of chemistry at the expense of descriptive details.	1 2 3	68.3 22.9 5.4	65.9 25.4 6.1	48.4 36.4 14.5
70. A certain degree of freedom so that instructor may formulate his own syllabus.	1 2 3	42.9 42.5 10.7	53.6 35.2 8.4	41.7 43.5 13.9
71. Assistance to the student in proper use of chemical facts, theories, principles, and concepts.	1 2 3	84.9 10.1 2.6	88.4 7.7 2.2	85.5 8.2 5.8

Analysis of Items 12, 61, 62, and 63

The four items presented in Table VII were designed to discover the opinions of high school teachers and college instructors about the desirable prerequisites to a high school chemistry course and the value of these prerequisites to the student when he enters a first-year college chemistry course. The reader should note that the numbers and percentages given for the groups represented in Forms A and B pertain to the opinions and evaluations of instructors and teachers. Those given for Form C reflect the actual courses taken by students in high school. They are not opinions, but are figures which are included in this tabulation for the sake of comparison with the evaluations enumerated in Forms A and B.

Second Step in Analysis of Questionnaire Data

The second step in the analysis of the questionnaire data was the factor analysis of Items 13 through 60. The computer analysis generated nine factors with a lambda greater than one (1). The tenth factor had a variance of less than one (1).

Only those items with a factor loading of .4000 or better were considered meaningful. The nine factors that emerged and their factor loadings are given in Table VIII.

TABLE VII

DESIRABLE PREREQUISITES FOR CHEMISTRY COURSE AND THEIR VALUE TO THE FIRST-YEAR COLLEGE STUDENT

Item	Form A (1,993) No.	%	Form B (1,245) No.	%	Form C* (1,650) No.	%
12. Students entering a course in high school chemistry should have the following prerequisites:						
Earth science	258	12.9	93	7.5	147	8.8
General science	1,260	63.2	695	55.8	997	60.4
Biology	807	40.4	197	15.8	1,507	91.3
Physics	385	19.3	549	44.1	1,241	75.2
Math. 1 year	482	24.1	241	19.4	312	18.8
Math. 2 years	1,358	68.1	723	58.1	365	22.1
Math. 3 years	413	20.7	327	26.3	526	31.8
Math. 4 years	43	2.1	101	8.1	1,222	74.0
61. Students entering first-year college chemistry should have the following prerequisites:						
Earth science	213	10.6	83	6.7	130	7.5
General science	861	43.2	542	43.5	931	56.4
Biology	974	48.8	217	17.4	547	33.2
Physics	1,418	71.1	926	74.3	1,103	66.8
Math. 1 year	253	[illegible]	[illegible]	9.4	241	14.6
Math. 2 years	611	30.6	366	29.4	485	29.4
Math. 3 years	1,026	51.4	541	43.4	784	47.5
Math. 4 years	587	29.4	454	36.4	618	37.4
62. A student entering a first-year college chemistry course is helped by his high school chemistry course:						
Very much	1,343	67.3	304	24.4	1,082	65.5
Some	550	27.6	816	65.5	511	31.0

TABLE VII (Cont.)

Item	Form A (1,993) No.	%	Form B (1,245) No.	%	Form C* (1,650) No.	%
Not at all	3	.2	14	1.1	25	1.5
Undecided	37	1.9	57	4.6	22	1.3
63. College chemistry instructors make use of the knowledge that a student brings from his high school chemistry course:						
Very much	265	13.3	119	9.6	525	31.8
Some	1,377	69.1	938	73.3	953	57.8
Not at all	120	6.0	101	8.1	114	6.9
Undecided	153	7.7	51	4.1	43	2.6

* Represents actual courses taken

TABLE VIII

FACTOR ANALYSIS OF ITEMS 13-60

Factor	Item No.	Loading
1. Electron theory--atomic structure		
Use of atomic structure to show compound formation	37	.71430
Explaining reactions in terms of electron transfer	38	.68311
Nuclear charge and the distribution of electrons	49	.68256
Periodic law and its relation to atomic structure	50	.63264
Covalence in simple molecules	40	.62429
Electrovalence and ionic nature of salts	39	.59996
Kinetic-molecular theory	27	.58500
Oxidation-reduction reactions	57	.41786
Nature of a chemical change	32	.41539
2. Descriptive chemistry		
Chemistry of plastics, rubber, glass, cement	59	.78352
Chemistry of textiles and food	60	.77026
Nuclear fission and fusion	52	.74353
Discussion of radiochemistry and isotopes	51	.68671
Organic chemistry (e.g., hydrocarbons, alcohols, esters, aldehydes, ketones)	53	.55537
Industrial processes (e.g., Haber, Ostwald, Contact)	26	.49021
3. Nature of chemistry and chemical properties		
Chemistry of nonmetals and their compounds (e.g., oxygen, hydrogen, nitrogen, sulfur, carbon, halogens)	21	.75771
Properties of metals in general	24	.68512
Water and its properties	23	.67180
Chemistry of sodium, aluminum, iron	25	.63972
Composition of air	22	.50519

TABLE VIII (Cont.)

Factor	Item No.	Loading
4. Scientific attitudes		
Providing for growth in the development of scientific appreciations	19	.80637
Providing for growth in the development of scientific attitudes	18	.71968
Providing for growth in the development of interests in science	20	.69978
Providing opportunity for growth of skill in the use of elements of the scientific method	17	.57709
5. States of matter		
Properties of gases	29	.78918
Properties of solids and liquids	28	.77217
Quantitative treatment of the gas laws	30	.41595
6. Chemical Definitions		
Elements, mixtures, compounds	31	.68747
Definition of atom and molecule	48	.67314
Definition of concentrated and dilute solutions	41	.54954
Types of chemical reactions	33	.54287
Nature of a chemical change	32	.51591
Balancing of chemical equations	34	.43950
7. Ionization Theory		
Hydrolysis of salts	45	.60417
Electrolysis of aqueous solutions and fused salts	47	.58197
Arrhenius concept of acids and bases	43	.50181
Bronsted-Lowry concept of acids and bases	44	.47458
Determination of molecular weight by depression of the freezing point and elevation of the boiling point	55	.45099
Electrolytes (e.g., acids, bases, salts)	42	.43577

TABLE VIII (Cont.)

Factor	Item No.	Loading
Electrovalence and ionic nature of salts	39	.42899
Definition of concentrated and dilute solutions	41	.42379
Covalence in simple molecules	40	.40591
8. Concepts and Principles		
Providing for development of functional concepts	14	.74173
Providing for opportunities for growth in the functional understanding of facts	13	.69341
Providing for growth in the functional understanding of principles	15	.66136
Providing for growth in basic instrument skill	16	.43692
9. Chemical mathematics		
Balancing equations by means of the electron transfer method	58	.65491
Oxidation-reduction reactions	57	.63495
Equivalent weights and normal solutions	56	.57698
Problems based on chemical equations (e.g., weight, volume)	35	.57167
Balancing of chemical equations	34	.50690
Mole and molar solutions	36	.48913
Elements, mixtures, compounds	31	.46514
Determination of molecular weight by depression of the freezing point and elevation of the boiling point	55	.40247

Third Step in Analysis of Questionnaire Data

The third step in the analysis of the data obtained from the questionnaires was to determine by means of the "t-test" whether or not the differences between the high school teachers and the college instructors with regard to these nine factors were statistically significant. Table IX presents the results of the statistical data prepared with the aid of a computer.

A discussion of the conclusions to be drawn from the analysis of the questionnaire data will be found in Chapters V and VI.

Sub-Problems 4 and 5

The American Chemical Society

Dr. Robert L. Silber, Educational Secretary of the American Chemical Society, stated in a letter that the society was both interested in the area of articulation and aware of a possible gap in articulation between high school and college chemistry teachers.[1]

The letter stated further that several groups have been working in this area and have accomplished a great deal toward closing this gap. The groups mentioned were: the National Science Foundation which is the sponsoring agent

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[1]Private correspondence, headquarters of the American Chemical Society, Washington, D. C., February 8, 1963.

TABLE IX

ANALYSIS SCORES OF NINE FACTORS OF SYLLABUS OF HIGH SCHOOL CHEMISTRY

Factor	Level	Mean	S.D.	"T"	D.F.	"P"
1	High school teachers	48.82	9.36	8.38	2374	.000*
	College instructors	51.92	10.72			
2	High school teachers	47.82	9.30	16.11	2476	.000*
	College instructors	53.51	10.10			
3	High school teachers	50.84	9.78	6.01	2557	.000*
	College instructors	48.66	10.20			
4	High school teachers	49.76	9.21	1.68	2267	.094
	College instructors	50.40	11.18			
5	High school teachers	49.98	9.68	.11	2474	.911**
	College instructors	50.02	10.53			
6	High school teachers	50.43	9.72	3.04	2503	.002
	College instructors	49.32	10.41			
7	High school teachers	49.40	9.91	4.41	2607	.000*
	College instructors	50.99	10.07			
8	High school teachers	50.14	8.68	.93	2077	.359**
	College instructors	49.78	11.80			
9	High school teachers	50.62	9.35	4.36	2343	.000*
	College instructors	48.99	10.89			

* Less than .0001
** Not statistically significant

for Summer Institutes, Academic Year Institutes, and In-Service Institutes; the various national chemistry curriculum studies on the secondary level; the ACS-sponsored Advisory Council on College Chemistry. Although these programs have not solved the problem completely, the fear was expressed that the possible cessation of these projects would revert the situation back to its previous status.

The College Entrance Examination Board

On February 23, 1966, the writer visited the Princeton headquarters of the Educational Testing Services, the home of the College Entrance Examination Board. A personal interview was conducted with Dr. Frank Fornoff, Director of the Sciences Division.

It was established that although the administrators of the CEEB program are engaged in the area of high school and college relations, they are not interested in the problem of articulation as such. The CEEB testing program is designed to test the aptitudes and achievement of students at the secondary level and to turn these scores over to college personnel as an aid in admissions to their freshmen classes.

In the case of the achievement tests, the CEEB administrators actually are engaging in the articulation process, since all these tests are the responsibility of a committee of examiners composed of both college and secondary school teachers. These committee members are chosen for their reputations in their subject-matter field and for their knowledge of current teaching practice in the subject.[2] This committee participates with specialists from the ETS in

[2]College Entrance Examination Board, "A Description of the College Board Achievement Tests" (Princeton, New Jersey: Educational Testing Service, 1965), p. 5.

creating tests that will reflect what students have learned in secondary schools and how well they are prepared for the course work they will take in college.

The objective of a CEEB Committee is to produce a test that will measure not only a student's knowledge of the facts about a subject but also his ability to utilize the facts in order to solve problems.[3] These tests also are constructed so that they are capable of being administered to students from a wide variety of schools.

In the case of the science achievement tests, these have been constructed to measure: (a) the ability to demonstrate an understanding of basic scientific principles and concepts; (b) the ability to apply these principles and concepts to familiar and unfamiliar situations; (c) the ability to handle quantitative relationships in science; (d) the ability to interpret cause-and-effect relationships; (e) the ability to interpret experimental data; and (f) the ability to apply laboratory procedures to problems arising in each field.[4]

The committee responsible for the construction of the chemistry achievement test has listed a series of items which they consider proper subject matter for their tests. It is presumed that these items were agreed to by both the

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[3] _Ibid._, p. 6.

[4] _Ibid._, p. 91.

secondary and college members of the committee. They include: kinetic-molecular theory, and the three states of matter; atomic structure and the periodic table; quantitative relations as applied to chemical formulas and equations; chemical bonding and molecular structure, and their relations to properties; the nature of chemical reactions, including acid-base reactions, oxidation-reduction reactions, ionic reactions, and other chemical changes occurring in solution; energy changes accompanying chemical reactions; interpretation of chemical equilibria and reaction rates; solution phenomena; electro-chemistry, nuclear chemistry, and radiochemistry; physical and chemical properties of the more familiar metals, transition elements, and nonmetals, and of the more familiar compounds; understanding and interpretation of laboratory procedures and observations.[5]

The Chemical Bond Approach Curricular Project

The Acting Director of the CBA Project for the academic year 1965-1966 was Professor Theodore Benfey of Earlham College in Richmond, Indiana. Benfey assumed this role in the absence of Professor Laurence Strong. In a telephone interview with Benfey on May 13, 1966, he was asked to comment on the articulation of high school and college teachers of chemistry in terms of his work with and knowledge of the CBA Project.

Benfey remarked that no real studies have been made with regard to complete articulation between high school

[5]*Ibid.*, p. 102.

and college. He feels, however, that most of the articulation appears to be on the side of the high school. The high school personnel are laboring to upgrade their courses and refine their teaching techniques. There does not seem to be a comparable effort on the college level. The colleges seem unwilling to make use of the advances that are being made in the teaching of secondary chemistry by programs such as CBA.

If this trend develops further and the colleges still are slow to adapt their courses, Benfey feels that the current wave of really able students who are defecting to the fields of biology and physics will increase considerably. It is up to the college chemistry instructors to prevent greater losses of their chemistry students.[6]

The Chemical Education Material Study

Correspondence was initiated in 1963 with the then Director of the CHEM Study Project, Prof. J. Arthur Campbell of Harvey Mudd College, Claremont, California.

In a letter expressing his views on articulation Campbell stated that for the past twenty years the syllabi for both high school and college chemistry have been identical. Colleges have tended to repeat the material already covered in the high school. This tendency may have reflected the rather poor retention of high school material by those

[6]Private telephone interview, May 13, 1966.

going on to college chemistry. Campbell believes, however, that there may have been a misapprehension at both levels. On the one hand, high school texts were being written by people who were unfamiliar with developments in the colleges, and, on the other hand, college people made very few attempts to learn the course content of the high school chemistry classes.

Campbell's next remark reinforced the purpose of the present study:

> As you can gather from the above, it is my opinion that articulation has been rather poor between high school and college largely because of an almost complete lack of communication between the teachers and authors of the two levels.[7]

He continued the letter by saying that one of the aims of the CHEM Study was to develop a course for both the terminal high school chemistry student and the student who expects to continue chemistry training in college.

> It is our hope that the colleges will be able to build on this course in designing their own first-year work. This hope is based on the fact that the ideas in the CHEM Study high school course are presented and used sufficiently that the student may really become master of a fair number of them, and that it will not be necessary to repeat a great deal of this when the student gets to college. Rather it will be possible to build on these ideas and, thus, to go considerably farther both in coverage and in depth.[8]

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[7] Private correspondence, headquarters of the Chemical Education Material Study, Harvey Mudd College, Claremont, California, June 3, 1963.

[8] Ibid.

One of the greatest contributions of the CHEM Study Project, in Campbell's estimation, is the opportunity to bring together large groups of college and high school teachers so that they may become acquainted with each others' problems and capabilities. In the light of this experience, the degree of articulation should sharply increase in the future.

Campbell also was aware of the problems of transition as the first CHEM Study students enter the college domain.

> We do anticipate a period of time during which many students will enter college with backgrounds quite different than those the college is used to handling. This will result in some disappointment, both on the part of the colleges, and on the part of the students. There is some sign that this period of mis-match may not extend very long in time, because of the awareness of the colleges as to what is going on and their feeling that it is desirable to change their own work somewhat. The study has made considerable efforts to keep the colleges aware of the changes, as well as to let the high schools know the kind of information which would be helpful to the colleges in planning such changes.[9]

Another exchange of correspondence took place in 1966 with the present Director of the CHEM Study, Professor George C. Pimentel at the University of California at Berkeley. Pimentel reported that sufficient data had been collected to indicate that, by and large, CHEM Study students enjoy a significant advantage in freshman chemistry over traditional students.

[9] *Ibid.*

> There are one or two exceptions, but generally the CHEM Study students average a few tenths of a grade point higher in the first semester. We have carefully verified that the CHEM Study students are not a select and intrinsically unrepresentative group. Furthermore, at the other end of the spectrum, the CHEM Study students are showing greater persistence, in that a far smaller percentage left the course (voluntarily or through failure).[10]

A discussion of the findings for Specific Questions 4 and 5 will be found in the Chapter VI.

[10] Private correspondence, headquarters of the Chemical Education Material Study, Lawrence Hall of Science, University of California, Berkeley, California, February 21, 1966.

CHAPTER V

SUMMARY AND DISCUSSION

Profiles of the Respondent Groups

The data obtained from the questionnaire forms can be summarized to yield profiles of the three groups who responded to the various forms of the questionnaire. These profiles are presented in Tables X, XI, and XII. The percentage of response listed next to each characteristic indicates the highest percentage of the several choices allowed in that category. If two or more represent nearly identical choices, all scores are given.

Analysis of Responses to Questionnaire Data

Using Tables X, XI, and XII as guides to the three types of respondents, the discussion will proceed to the first step, the analysis of the responses to the items dealing with the aims, objectives, and course content of high school chemistry. These areas are covered by Items 13 through 60 in the questionnaires. The first points to be considered are the aims and objectives enumerated in Items 13 through 20.

For purposes of discussion, the responses to these items were listed in the following manner:

1. All items were recorded in descending order

TABLE X

THE TYPICAL HIGH SCHOOL CHEMISTRY TEACHER
(FORM A: TOTAL RESPONSES, 1,993)

Characteristic	Response	Per Cent
Sex	Male	79.0
Size of respondent's school	Over 1,000 students	47.4
Number of years in teaching	10 to 19 years	30.2
Number of years teaching chemistry	Under 5 years	37.8
Degrees held	Bachelor	87.6
	Master	50.0
Teachers have taken in-service courses	Yes	68.3
Professional organizations	NEA	45.9
	NSTA	37.7
Type of chemistry taught in respondent's school	Traditional	72.0
	CHEM Study	40.9
Number of credits in chemistry	Over 24 credits	67.1

of importance according to the per cent response in Scale 1 (very important).

2. No items were discussed which received responses lower than 50 per cent.

The listing, therefore, is a popularity rating of the specific items selected by the respondents for each of the three forms. The ratings are given in Table XIII.

Although there were varying percentages of support, the respondents all agreed on the popularity of the first two items:

Item 15. Providing for growth in the functional understanding of principles.

TABLE XI

THE TYPICAL FIRST-YEAR COLLEGE CHEMISTRY INSTRUCTOR
(FORM B: TOTAL RESPONSES, 1,245)

Characteristic	Response	Per Cent
Sex	Male	88.3
Size of respondent's college	1,000 to 5,000 students	48.2
Number of years in teaching	Under 5 years	29.7
Degrees held	Ph.D.	81.3
Instructors have taken in-service courses	No	73.8
Professional organizations	ACS	90.0
	AAUP	46.9
Colleges require high school chemistry of students in first-year college chemistry	No	80.7
Colleges differentiate between students with and without high school chemistry	Same course for both	49.0
Time spent teaching first-year chemistry students	About 50 per cent	35.4
	About 25 per cent	31.8

Item 14. Providing for development of functional concepts.

It is quite clear that both high school and college instructors agreed that the key words principles and concepts occupy a prominent position in the aims and objectives of a high school chemistry course. The first-year chemistry students in college also were in agreement on this point.

Item 18 (Providing for growth in the development of scientific attitudes) also is an objective which appears on the lists of both high school and college instructors.

TABLE XII

THE TYPICAL FIRST-YEAR COLLEGE CHEMISTRY STUDENT
(FORM C: TOTAL RESPONSES, 1,650)

Characteristic	Response	Per Cent
Sex	Male	64.4
College semester	First semester	80.3
Science courses taken	General science	60.4
	Biology	91.3
	Physics	75.2
Math Courses taken	3 years	31.8
	4 years	74.0
Type of high school chemistry	Traditional	68.8
Periods per week in high school chemistry class	5 periods	54.7
Periods per week in high school chemistry lab.	1 period	40.0
	2 periods	36.0
Duration of high school chemistry classes	50-60 minutes	62.9
Approximate final grade in high school chemistry	A (90-100)	48.0
	B (80-89)	37.1
Would classify high school chemistry as:	Good	32.0
	Very good	31.6
Would classify high school chemistry teacher as:	Very good	32.5
Year when chemistry was taken	11th grade	63.2

Scientific attitudes are important for a student in high school science. However, while "scientific attitude" is ranked third by the high school and college instructors, the first-year students do not share this feeling. Item 13 (Providing for opportunities for growth in the functional understanding of facts) occupies the third position on their list and is the last item to receive a vote of over 50 per

TABLE XIII

RESPONSES TO ITEMS 13-20 IN DESCENDING ORDER OF IMPORTANCE

Form A (1,993)		Form B (1,245)		Form C (1,650)	
Item	Per Cent	Item	Per Cent	Item	Per Cent
15	83.8	15	79.3	15	77.0
14	78.2	14	66.3	14	69.1
18	71.9	18	63.8	13	62.5
17	59.9	13	55.7	18	49.7
13	56.4	20	53.2	20	47.6
19	54.0	17	49.2	17	45.5
20	53.3	19	45.7	19	36.8
16	28.7	16	11.6	16	29.5

cent. Perhaps this is evidence of the serious concern of students with the problem of grades. It is possible that many students feel that the absorption of large quantities of facts will help them to score higher on their examination. It is interesting to note that the college instructors ranked Item 13 as fourth on their listing with response of 55.7 per cent, while the high school teachers ranked this same item fifth on their listing with a response of 56.4 per cent.

In fourth place on the listing of the high school teachers is Item 17 (Providing opportunity for growth of skill in the use of elements of the scientific method.) This item fails to appear on the lists of either the college instructors or the first-year students. Several comments were written into the questionnaire by college instructors.

They expressed concern over the use of the term "THE scientific method." They remarked that there is no one way to define or outline the scientific method. Perhaps this feeling was rather widespread and accounted for the small support of this item.

Item 20 (Providing for growth in the development of interests in science) appeared fifth and last on the listing of the college instructors. The item was seventh and last on the listing of the high school teachers. Apparently college instructors would like the students to develop an interest and curiosity in science and the subject with which science is associated.

The sixth item on the listing of the high school teachers does not appear on the listing of the college instructors. This is Item 19 (Providing for growth in the development of scientific appreciations).

Next to be considered are items 21 through 60, which refer to the content of a high school chemistry course. These items will be analyzed in a manner similar to the foregoing. Table XIV presents a rank order chart, arranged in descending order, showing the percentage of response to each item in each of the forms.

Study of the preceding table indicates that the high school teachers (Form A) rated twenty-six items as being very important. These were chosen by over 50 per cent of the sample. Only twenty-four items were indicated by 50 per cent or more of the college instructors to be very important.

TABLE XIV

RESPONSES TO SYLLABUS ITEMS ON ALL QUESTIONNAIRE FORMS IN DESCENDING ORDER OF CHOICE

Order of Choice	Form A (1,993) Item	Form A (1,993) Per Cent	Form B (1,245) Item	Form B (1,245) Per Cent	Form C (1,650) Item	Form C (1,650) Per Cent
1.	27	90.2	50	81.4	57	77.4
2.	50	87.6	35	80.1	21	75.7
3.	32	86.5	32	79.1	27	73.4
4.	37	80.7	48	78.0	50	73.3
5.	49	80.1	36	77.9	29	71.7
6.	36	80.0	34	74.5	[illegible]	69.7
7.	38	79.7	27	73.2	49	68.1
8.	57	79.7	40	72.6	34	64.6
9.	35	76.8	29	72.1	23	64.4
10.	34	74.9	39	71.0	35	64.1
11.	29	72.4	37	69.8	28	63.5
12.	40	72.3	49	69.1	32	63.2
13.	39	72.2	31	67.1	36	63.1
14.	42	68.7	42	66.5	33	61.8
15.	48	67.9	57	64.2	24	61.7
16.	28	67.4	54	63.8	38	61.5
17.	33	66.1	38	60.9	31	58.6
18.	31	63.3	28	58.8	58	57.4
19.	46	62.6	30	58.3	56	56.5
20.	58	62.6	21	57.0	30	55.1
21.	30	58.1	33	56.9	42	54.5
22.	24	57.0	24	55.1	37	52.6
23.	54	56.4	46	55.1	46	48.6
24.	21	55.9	23	54.4	53	47.6
25.	23	54.9	56	48.7	40	47.3
26.	44	54.1	58	47.5	39	46.0
27.	56	48.8	44	47.4	54	39.6
28.	53	40.2	43	39.1	44	33.8
29.	41	37.3	41	37.3	55	32.2
30.	43	34.1	47	29.6	41	31.2
31.	45	32.2	45	29.4	25	29.5
32.	47	30.8	25	20.0	52	28.2
33.	51	27.2	55	19.4	45	27.4
34.	52	25.0	51	16.2	47	26.2
35.	55	24.1	22	15.2	51	24.1
36.	22	15.9	53	14.5	43	22.6
37.	25	15.8	52	11.1	22	21.6
38.	26	6.9	26	7.6	60	14.2
39.	60	4.7	59	4.0	59	13.3
40.	59	4.5	60	3.4	26	12.3

Only twenty-two items were selected as very important by over 50 per cent of the sample of college freshmen.

A study of the top ten items selected by the respondents to each of the three forms indicates those areas of high school chemistry which were considered very important and which should aid the student as he proceeds from high school chemistry to first-year college chemistry.

With regard to the Form A group, Item 27 (Kinetic-molecular theory) was chosen by more than 90 per cent of the 1,933 respondents as very important. This same item was indicated by the first-year students as third in importance. It is surprising, however, to note that the college instructors selected this item as seventh on their listing.

The second in popularity with the high school teachers (Form A) was Item 50 (Periodic law and its relation to atomic structure). The college instructors also viewed this concept as very important and ranked it first in their listing. The first-year students also considered the item very important and rated it fourth on their listing.

Item 32 (Nature of a chemical change) ranked third among the high school teacher respondents. This principle, which is basic to an understanding of chemistry, was ranked in third place by the college instructors as well. The first-year students, however, did not consider this principle so important as others and ranked it twelfth on their listing.

The high school teachers selected Item 37 (Use of atomic structure to show compound formation) as the fourth most popular item on the syllabus. The college instructors selected this item as eleventh on their listing, while the first-year students relegated this item to the twenty-second place on their listing.

Fifth in popularity among the high school teachers was Item 49 (Nuclear charge and the distribution of electrons). The college instructors ranked this as number twelve on their listing, while the first-year students rated it in ninth position.

Item 36 (Mole and molar solutions) was chosen for the sixth position among high school teachers. This item rated fifth among college instructors and thirteenth among first-year students.

Item 38 (Explaining reactions in terms of electron transfer) occupied the seventh place with high school teachers. This item was chosen seventeenth among college instructors. The first-year students selected it as sixteenth in importance.

Eighth place on the listing of high school teachers was accorded to Item 57 (Oxidation-reduction reactions). College instructors rated this fifteenth, while first-year students scored it as first choice in their selections.

Ninth place on the listing by the high school teachers was given to Item 35 (Problems based on chemical equations). This item was rated higher by the college instructors, who placed it in second position on their listing. The first-year students rated it tenth.

Tenth place was given by high school teachers to Item 34 (Balancing of chemical equations). This was rated slightly higher by the college instructors, who placed it in the sixth position. The item ranked eighth by the first-year students.

Four items which were selected by the college instructors among their first ten choices did not appear among the first ten chosen by the high school teachers. These were:

Item 48 (Definition of atom and molecule).

Item 40 (Covalence in simple molecules).

Item 29 (Properties of gases).

Item 39 (Electrovalence and ionic nature of salts).

Two items which were selected by first-year students among their first ten choices did not appear on either the high school teachers' listing or on the college instructors' listing. These were:

Item 21 (Chemistry of nonmetals and their compounds, e.g., oxygen, hydrogen, nitrogen, sulfur, halogens).

Item 23 (Water and its properties).

As for those items of high school chemistry which were classified as least in descending order of importance, it is interesting to note the last ten items on the listing of high school teachers. They follow:

31 Item 45 (Hydrolysis of salts).

32 Item 47 (Electrolysis of aqueous solutions and fused salts).

33 Item 51 (Discussion of radiochemistry and isotopes).

34 Item 52 (Nuclear fission and fusion).

35 Item 55 (Determination of molecular weight by depression of the freezing point and elevation of the boiling point).

36 Item 22 (Composition of air).

37 Item 25 (Chemistry of sodium, Aluminum, iron).

38 Item 26 (Industrial processes, e.g., Haber, Ostwald, Contact).

39 Item 60 (Chemistry of textiles and food).

40 Item 59 (Chemistry of plastics, rubber, glass, cement).

Among the last ten items chosen by the college instructors were several that compared with the listing of the high school people. In order, they were Items 45, 25, 55, 51, 22, 52, 26, 59, 60. One item on the college list did not appear on the high school listing:

36 Item 53 (Organic chemistry, e.g., hydrocarbons, alcohols, esters, aldehydes, ketones).

Nine of the last ten items chosen by the first-year college students corresponded to the items listed by the high school and college personnel. These were Items 25, 52, 45, 47, 51, 22, 60, 59, 26. One item was listed only by the students:

36 Item 43 (Arrhenius concept of acids and bases).

Items 64 through 71 refer to the aims and objectives of a college chemistry course. Table XV presents these items in descending rank of choice as shown on all three forms of the questionnaire.

TABLE XV

RESPONSE TO ITEMS 64-71 ON ALL QUESTIONNAIRE FORMS IN DESCENDING ORDER OF CHOICE

Order of Choice	Form A (1,993) Item	Per Cent	Form B (1,245) Item	Per Cent	Form C (1,650) Item	Per Cent
1	71	84.9	71	88.4	71	85.5
2	69	68.3	69	65.9	64	62.0
3	64	54.7	64	58.0	69	48.4
4	67	52.8	70	53.6	66	44.2
5	70	42.9	65	51.3	65	41.7
6	65	40.6	67	37.6	70	41.7
7	66	31.6	66	29.8	67	41.1
8	68	12.4	68	18.8	68	27.1

An analysis of the above list indicates a degree of similarity with but few exceptions. Item 71 (Assistance to the student in the proper use of chemical facts, theories, principles, and concepts) ranked first on all three lists. However, the first-year college instructors gave this item the highest amount of agreement (88.4 per cent).

Item 69 (A greater emphasis on the principles of chemistry at the expense of descriptive details) placed second on the listing of high school teachers as well as on that of the college instructors. The first-year students placed the item in third position. Second place among the first-year students was given to Item 64 (Scientific information), which was ranked third by both the high school teachers and college instructors.

The fourth choice of the high school teachers was Item 67 (Understanding the relationships of chemistry to the other sciences). This was rated sixth by the college instructors and seventh by the first-year students.

Two other items which were chosen by over 50 per cent of the college instructors as very important received less than a 50 per cent response from both the high school teachers and the first-year college students. These items were:

Item 70. A certain degree of freedom so that the instructor may formulate his own syllabus.

Item 65. Development of an interest in science.

The four remaining questionnaire items are 12, 61, 62, and 63. Discussion of these topics follows. (See Table VII, page 63.)

Item 12 (Students entering a course in high school chemistry should have the following prerequisites) was designed to indicate the degree of feeling for a particular subject in high school on the part of both the high school teachers and the college instructors. Both groups chose general science as the most important prerequisite for high school chemistry (Form A, 63.2 per cent; Form B, 55.8 per cent). Neither group selected earth science with any degree of consistency (Form A, 12.9 per cent: Form B, 7.5 per cent).

The importance of biology and physics as prerequisites for high school chemistry showed wide disagreement between the high school teachers and the college instructors. The high school teachers indicated that biology was more important (biology, 40.4 per cent; physics, 15.8 per cent), while the college instructors considered physics the more important subject (biology, 19.3 per cent; physics, 44.1 per cent).

Inspection of the list of courses taken by the first-year students indicated that all subjects were considered important and were included in their programs, but biology was most popular (general science 60.4 per cent; biology, 91.3 per cent; physics, 75.2 per cent). All these figures were much higher than those indicated by the high school teachers and college instructors.

With regard to the amount of mathematics considered necessary for a high school chemistry course, both the high school teachers and the college instructors agreed that two years of mathematics are sufficient. However, the per cents of first-year students who had completed three and four years of mathematics were very significant. Two years of mathematics were considered sufficient by 68.1 per cent of high school teachers, 58.1 per cent of college instructors, and 22.1 per cent of first-year students. However, 31.8 per cent of the students preferred three years in the subject, and 74.0 per cent preferred four years.

Item 61 (Students entering first-year college chemistry courses should have the following prerequisites) allowed the high school teachers and college instructors to express their feelings about the course background which they felt desirable for first-year students to have. Both the high school teachers and college instructors agreed on the importance of physics and general science, but they disagreed on the importance of biology. Their ratings of the subjects are given in Table XVI.

TABLE XVI

COMPARATIVE RATINGS OF PHYSICS, GENERAL SCIENCE, AND BIOLOGY AS PREREQUISITES FOR COLLEGE CHEMISTRY

Group	No. of Responses	Physics %	General Science %	Biology %
High school teachers	1,993	71.1	43.2	48.8
College instructors	1,245	74.3	43.5	17.4
First-year college instructors	1,650	66.8	56.4	33.2

Table XVII shows that all three groups agreed that three years of mathematics is a necessary prerequisite for college chemistry.

With regard to Item 62 (A student entering a course in first-year college chemistry is helped by his high school chemistry course), the groups varied in their opinions about the usefulness of high school chemistry. Their responses are given in Table XVIII.

Item 63 (College chemistry instructors make use of the knowledge of chemistry that a student brings from his high school chemistry course) is closely related to the preceding

TABLE XVII

COMPARISON OF PREFERENCES FOR THREE OR FOUR YEARS OF MATHEMATICS AS PREREQUISITES FOR COLLEGE CHEMISTRY

Group	No. of Responses	Math, 3 years %	Math, 4 years %
High school teachers	1,993	51.4	29.4
College instructors	1,245	43.4	36.4
First-year college students	1,650	47.5	37.4

TABLE XVIII

COMPARISON OF OPINIONS CONCERNING THE EXTENT TO WHICH THE FIRST-YEAR COLLEGE STUDENT IS HELPED BY HIGH SCHOOL CHEMISTRY

Group	No. of Responses	Helped Very Much %	Helped Some %
High school teachers	1,993	67.3	27.6
College instructors	1,245	24.4	65.6
First-year college students	1,650	65.6	31.0

item. It is significant that the first-year college students disagreed markedly with the college instructors (see Table XIX).

Factor Analysis of Questionnaire Data

The second step in the study of the questionnaire data

TABLE XIX

COMPARISON OF OPINIONS CONCERNING THE EXTENT TO WHICH THE COLLEGE INSTRUCTOR MAKES USE OF THE STUDENT'S KNOWLEDGE OF HIGH SCHOOL CHEMISTRY

Group	No. of Responses	Very Much %	Some %	Not at All %	Undecided %
High school teachers	1,993	13.3	69.1	6.0	7.7
College instructors	1,245	9.6	73.3	8.1	4.1
First-year college students	1,650	31.8	57.8	6.9	2.6

was the factor analysis. The discussion of these factors will indicate the differences in the beliefs between the high school teachers and college instructors with regard to what should be taught in the high school.

The factors are repeated here:

Factor 1. Electron theory-atomic structure
Factor 2. Descriptive chemistry
Factor 3. Nature of chemistry and chemical properties
Factor 4. Scientific attitudes
Factor 5. States of matter
Factor 6. Chemical definitions
Factor 7. Ionization theory
Factor 8. Concepts and principles
Factor 9. Chemical mathematics

A discussion of these factors would not be complete without introducing the results of the third step in the analysis. This third step was the use of the "t-test" to determine the significance of the differences between the high school and college personnel regarding these nine factors.

The results of the "t-test" indicated that seven of the nine results were significant at the following levels:

Factor 1. Greater than the .01 level
Factor 2. Greater than the .01 level
Factor 3. Greater than the .01 level
Factor 4. Greater than the .10 level
Factor 6. Greater than the .01 level
Factor 7. Greater than the .01 level
Factor 9. Greater than the .01 level

Two factors showed no significant difference:

Factor 5. States of matter
Factor 8. Concepts and principles

The results shown above indicate that for seven of the nine factors there was a significant difference between the means of the high school and the college instructors. This finding, then, is the statistical support for the second hypothesis, which states that there is an articulation gap between the high school teachers of chemistry and the college instructors of first-year chemistry.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

By means of a questionnaire and interview survey, answers were found to the specific questions considered basic to the general problem of articulation between high school teachers of chemistry and college instructors of first-year chemistry. The results of the study supported, in many instances, the hypotheses upon which this investigation was based.

Although many articles were found in the literature which discussed an articulation gap between high school and college chemistry and many opinions were offered by veterans in the field, no statistical study was found to provide basic information for the solution of this problem. It was the purpose of this investigation, then, to study this problem of articulation and to statistically establish that a gap was indeed present. Several ways of approaching the problem of articulation became apparent, such as course content, textbook analysis, and comparison of grades. This investigator decided, however, to aim this research in the direction of the people involved in the articulation process: the high school teachers, the college instructors, and the first-year college chemistry students.

First Hypothesis

The first hypothesis (see page 8) states that an articulation gap does exist between the beliefs of high school teachers and college instructors in relation to the aims and objectives as well as the prerequisites of chemistry courses at both high school and college levels. The investigation supported this hypothesis in several of its findings.

An inspection of the items in the questionnaire dealing with aims and objectives at the high school level indicates that there are differences of opinion.

(For purposes of discussion the results of the items in the questionnaire are recapitulated here in a simpler form. Tables XX to XXIV list the various items in the questionnaire with the responses of both the high school teachers (Form A) and the college instructors (Form B). However, the responses listed in these tables are limited to the responses of both groups to Scale 1 of the three scale values allowed for each questionnaire item. Scale 1 is the value checked for all items which are considered very important by the respondent.)

The percentages of responses to Scale 1 (the item is very important) for ... ms 13 through 20 on the questionnaire are presented in Table XX. (Table XX is a summary of Table IV, page 55, and Table XIII, page 81.)

In order to interpret Table XX, as well as Tables XXI, XXII, XXIII, and XXIV, an explanation is included here. The last column of these Tables (Difference - %) is evaluated in

TABLE XX

AIMS AND OBJECTIVES AT THE HIGH SCHOOL LEVEL
(FORM A: TOTAL RESPONSES, 1,993;
FORM B: TOTAL RESPONSES, 1,245)

Item	Form A %	Form B %	Difference %
13	56.4	55.7	.7
14	78.2	66.3	11.9
15	83.8	79.3	4.5
16	28.7	11.6	17.1
17-18	59.9	49.2	10.7
18	71.9	63.8	8.1
19	54.0	45.7	8.3
20	53.3	53.2	.1

terms of a statistical analysis employing the difference between the proportions in two independent populations and the "t-test" of significance.[1] The results of this statistical analysis indicated that any difference between the two populations that was greater than 3.5 per cent was significant beyond the .01 level. However, although this difference of 3.5 per cent between high school and college personnel is significant, it was decided that, in order to recognize the existence of a gap between high school teachers and college instructors, a difference of 10 per cent would be considered a minimum difference of percentage.

An examination of Table XX shows that in the results of three of the eight items there is a difference of over 10 per

[1]See Appendix F.

cent, indicating a gap between the opinions of the high school teachers and the college instructors. These three items are:

14. Providing for the development of functional concepts.

16. Providing for growth in basic instrument skill.

17. Providing for growth of skill in the use of elements of the scientific method.

For all of these items, there was a higher degree of acceptance on the part of the high school teacher. From this it is inferred that the typical high school chemistry teacher's philosophy regarding aims and objectives of high school chemistry includes a greater interest in functional concepts, basic instrumental skills, and the use of elements of the scientific method.

Item 17 includes the specific objective of "problem-solving" which has become so much a part of the newer science curricula. Educators and curricular advisers in science have introduced this process in the newer curriculas in several ways and have identified this as a means of making classroom science more like laboratory science. It is important to observe that this objective is a part of the articulation gap; also that it received a greater support from the high school teacher.

In contrast to this, the college instructor whose philosophy of chemical education is oriented more toward the broader understanding of principles rated Items 14, 16, and 17 somewhat lower than the high school teacher.

However, with regard to more than half of the items in this category, the teachers at both levels were in agreement:

13. Providing for growth in the functional understanding of facts.
15. Providing for growth in the functional understanding of principles.
18. Providing for growth in the development of scientific attitudes.
19. Providing for growth in the development of scientific appreciations.
20. Providing for growth in the development of interests in science.

There is no gap, therefore, between the two levels of teaching regarding chemical facts, principles, attitudes, appreciations, and interests.

A study of the aims and objectives at the college level shows a degree of difference in the responses of both groups to those items which were checked as very important on the scale of values. The differences are presented in Table XXI. (Table XXI is a summary of Table VI, page 61, and Table XV, page 88.)

An examination of Table XXI indicates that a difference of over 10 per cent, or a gap, exists between high school teachers and college instructors regarding the aims and objectives of chemistry at the college level in three of the

TABLE XXI

AIMS AND OBJECTIVES AT THE COLLEGE LEVEL
(FORM A: TOTAL RESPONSES, 1,993;
FORM B: TOTAL RESPONSES, 1,245)

Item	Form A %	Form B %	Difference %
64	54.7	58.0	4.7
65	40.6	51.3	10.7
66	31.6	29.8	1.8
67	52.8	37.6	15.2
68	12.4	18.8	6.4
69	68.3	65.9	2.4
70	42.9	53.6	10.7
71	84.9	88.4	3.5

eight items.

The three items that show this degree of difference are:

65. Development of an interest in science.

67. Understanding the relationships of chemistry to the other sciences.

70. A certain degree of freedom so that the instructor may formulate his own syllabus.

The results of questionnaire Item 65 are interesting because they show the college instructor as one who is more interested in the broader aspects of science rather than tied down to specific facts, which are the constant concern of the high school teacher who must cover a prescribed syllabus in the course of one year.

The response to Item 67 indicates that the college teachers do not view their college chemistry course as one that must be related to the other sciences. The majority of the high school teachers feel that chemistry should be related to other sciences.

The high response of college teachers to Item 70 indicates their concern over the freedom necessary in the structuring of their subject. The high school teachers, however, in differing with the college instructors, reveal the strictures of their background.

There were five items in Table XXI which showed a difference of less than 10 per cent and in these items there was no evidence of a gap.

64. Scientific information.

66. Understanding the relationship of science to the environment of everyday life (applications).

68. The assumption of no previous knowledge of chemistry.

69. A greater emphasis on the principles of chemistry at the expense of descriptive details.

71. Assistance to the students in the proper use of chemical facts, theories, principles, and concepts.

An analysis of the responses of the high school teachers and college chemistry instructors indicates a difference of opinion regarding the prerequisites of a student entering a high school chemistry course. Table XXII is a summary of th percentages of responses to Scale 1 (the item is very important). (Table XXII is a summary of a portion of Table VII, page 63.)

TABLE XXII

PREREQUISITES FOR A HIGH SCHOOL CHEMISTRY COURSE
(FORM A: TOTAL RESPONSES, 1,993;
FORM B: TOTAL RESPONSES, 1,245)

Prerequisite	Form A %	Form B %	Difference %
Earth science	12.9	7.5	5.4
General science	63.2	55.8	7.4
Biology	40.4	15.8	24.6
Physics	19.[illegible]	44.1	24.8
Math, 1 year	24.1	19.4	4.7
Math, 2 years	68.1	58.1	10.0
Math, 3 years	20.7	26.3	5.6
Math, 4 years	2.1	8.1	6.0

An examination of Table XXII indicates that in three of the eight subjects offered as prerequisites for high school chemistry, there is a gap in the opinions of the high school teachers and the college instructors.

The high school teachers favored biology and two years of mathematics as prerequisites. The college instructors selected physics as a major prerequisite to high school chemistry. The possible explanation why so few high school teachers selected physics as a prerequisite is that in a number of high schools chemistry is offered in the eleventh grade while physics is offered in the twelfth grade.

However, both levels of teachers were in substantial agreement regarding the merits of earth science, general science, and mathematics: 1, 3, and 4 years.

An analysis of the responses of the high school teachers and college chemistry instructors regarding the prerequisites of a student entering a course in college chemistry also indicates differences of opinion. Table XXIII shows the differences of percentages of responses to Scale 1 (the item is very important). (Table XXIII is a summary of a portion of

TABLE XXIII

PREREQUISITES FOR A COLLEGE CHEMISTRY COURSE
(FORM A: TOTAL RESPONSES, 1,993;
FORM B: TOTAL RESPONSES, 1,245)

Prerequisite	Form A %	Form B %	Difference %
Earth science	10.6	6.7	3.9
General science	43.2	43.5	.3
Biology	48.8	17.4	31.4
Physics	71.1	74.3	3.2
Math, 1 year	12.6	9.4	3.2
Math, 2 years	30.6	29.4	1.2
Math, 3 years	51.4	43.4	8.0
Math, 4 years	29.4	36.4	7.0

Table VII, page 63, Table XVI, page 91, and Table XVII, page 92.)

An examination of Table XXIII indicates that there is only one subject that causes a difference in opinion between the teachers at the two levels. The subject is biology and the difference in percentages is 31.4 per cent. Although 48.8 per cent of the high school teachers chose biology as a prerequisite for college chemistry, only 17.4 per cent of the college instructors thought it was important. Since biology, or biological science, is a required subject in most high schools, the high school teachers were inclined to give it more emphasis than the college instructors.

However, concerning all the other prerequisites, there was no difference of opinion between the teachers at both levels.

Although they are not specifically included in the statement of the first hypothesis, the responses to the following items lend weight to its support:

Item 62. A student entering a course in first-year college chemistry is helped by his high school chemistry course.

Item 63. College chemistry instructors make use of the knowledge of chemistry that a student brings from his high school chemistry course.

Table XXIV compares the responses of the two groups to both items.

The conclusions drawn from the responses to Item 62 indicate that the typical high school chemistry teacher believes that his chemistry course is able to prepare a student sufficiently to bridge the gap between high school and college chemistry. This is shown by a response of 67.3 per cent of the high school teachers who indicated that a student is helped "very much" by his high school chemistry course. The college instructors' responses differed from the high school by 42.9 per cent. However, the college instructors indicated that the high school student is helped "some" by his high

TABLE XXIV

COMPARISON OF RESPONSES TO ITEMS 62 AND 63
(FORM A: TOTAL RESPONSES, 1,993;
FORM B: TOTAL RESPONSES, 1,245)

Response	Form A %	Form B %	Difference %
Item 62			
Very much	67.3	24.4	42.9
Some	27.6	65.5	38.0
Not at all	.2	1.1	.9
Undecided	1.9	4.6	2.7
Item 63			
Very much	13.3	9.6	3.7
Some	69.1	73.3	4.2
Not at all	6.0	8.1	2.1
Undecided	7.7	4.1	3.6

school chemistry course (65.5 per cent).

The large gap noted here may be due in some measure to the student who is prepared sufficiently in June to take a comprehensive examination in chemistry but who, by September, is incapable of remembering much of the basic information on chemistry. Since the teacher must cover a required list of topics that is usually lengthy, the student must absorb these before the final examinations. This type of studying is not conducive to retention. Hence, over the summer the student loses some of his chemical knowledge.

As noted earlier, however, when students in their first semester of college chemistry were asked whether or not they were helped by their high school chemistry, 65.5 per cent responded that they were helped "very much" by their high school course. (See Table VII, page 63.)

Item 63 reveals no difference of opinion between the high school and college teachers. Both agree that the college chemistry instructor makes "some" use of the knowledge of chemistry that a student brings from his high school chemistry course.

Second Hypothesis

The second hypothesis states that an articulation gap does exist between the beliefs of high school chemistry teachers and instructors of first-year college chemistry with regard to the items that should be taught in a high school chemistry course.

Support was given to this hypothesis by the factor analysis and "t-test" which were used to analyze the forty items of the high school syllabus included in the questionnaire. These forty items were analyzed and classified under seven of the nine factors, or general areas of chemistry. (See Table VIII, page 65.)

When the responses of both high school and college personnel were studied in terms of these seven factors, six were found to be statistically significant. This revealed a significant difference between the means of the high school and college personnel in six out of the seven factors. It is apparent that the high school teachers and the college instructors disagree about the importance of items that should be taught at the high school level. The analysis of the responses also offers statistical proof that an articulation gap does exist between the two levels of teachers in this respect. (See Table IX, page 69. Also see pages 92-94.)

The following factors showed a significant difference between high school teachers and college instructors and, therefore, contribute to the articulation gap:

Factor 1. Electron theory-atomic structure
Factor 2. Descriptive chemistry
Factor 3. Nature of chemistry and chemical properties
Factor 6. Chemical definitions
Factor 7. Ionization theory
Factor 9. Chemical mathematics

The following factor showed no significant difference and, therefore, in this area there is agreement by the personnel at both levels of teaching:

Factor 5. States of matter

Supporting the preceding analysis of the content of the chemistry syllabus, two factors evolved from the eight aims and objectives of a high school chemistry course. These factors were: (1) scientific attitudes, and (2) concepts and principles. (See Table VIII, page 65.) When these factors were subjected to the "t-test," the first factor showed a difference at the .10 level between the means of the high school teachers and the college instructors. The second factor was also given the "t-test" and no significant difference was found between the teachers at the two levels. From this it may be inferred that the college instructors and the high school instructors agree in their opinions regarding the concepts and principles that should be included in a high school chemistry course. However, there is a degree of difference between the two levels regarding scientific attitudes. But, this difference was not as great as the difference between the two levels concerning the items that should be included in a high school syllabus.

The discussion of the two hypotheses concludes with the statement that both hypotheses were supported by different sections of this statistical study. Of the forty items on the questionnaire dealing with Hypothesis I (Aims, Objectives, and Prerequisites of high school and college chemistry), it was found that in 12 there was a gap between the opinions of the high school and college instructors. The gap was marked by a difference in percentage of response from 10 to 38 per cent. However, the study also showed that there was no difference of opinion in 32 categories.

Of the 48 items on the questionnaire dealing with Hypothesis II (High school chemistry syllabus), a factor analysis disclosed seven major factors which were easier to manipulate statistically than the 40 separate items. A "t-test" was employed with these seven factors and it was found that in six factors there was a significant difference between the opinions of high school teachers of chemistry and college instructors of chemistry.

Discussion of Sub-Problems 4 and 5

4. What do specialists in the American Chemical Society and the College Entrance Examination Board indicate are the important problems in articulation between high school chemistry teachers and first-year college chemistry instructors?

5. What do leaders of the new Chemical Bond Approach Curriculum and the CHEM Study Curriculum believe are the problems in articulation between high school chemistry teachers and first-year college chemistry instructors in those schools where these new curricula are offered?

Sub-problems 4 and 5 were concerned with the views and opinions of experts in the field of chemistry and chemical education. Although the number of experts interviewed was small and their responses did not lend themselves to a statistical study, their replies added weight to the statistical results described in this study.

A summary of the interviews with the leaders of the ACS, CEEB, CBA, and CHEMS (see pages 68-76) indicates that there is concern among these leaders that the articulation problem is grave and steps must be taken to overcome this gap.

Their replies indicate that although several attempts are being made to help solve the problem, more time and serious effort should be devoted to this problem. Some of the college personnel also remarked that most of the efforts at articulation seem to originate at the high school level and they would like to see this complemented by more action at the college level. They realize that this articulation gap will become smaller as communication concerning mutual problems becomes closer between more college and high school personnel.

The data gathered from sub-problems 4 and 5, therefore, reinforce the conclusions of the first three sub-problems that there is a significant gap between the high school teachers and college instructors of chemistry.

Interpretations and Implications of the Data

The implications of these findings involve the backgrounds, levels of achievement, and goals of the high school teachers, the college instructors, and the first-year college students.

Differences in Background

The background of the typical high school chemistry teacher, as shown in this study, indicates these teachers have more than a minimum of chemistry credits. (See Table I, page 49.) It appears that the average high school chemistry teacher is capable of handling the concepts that a modern course in chemistry includes. In many cases, in the experience of this investigator, the high school chemistry teacher is fully prepared to teach at the college level. However, there are still relatively few, who are either converted chemistry teachers or part-time chemistry teachers, whose backgrounds are not adequate for teaching the type of chemistry course that is desirable today.

In contrast to the high school situation, the instructors at the college level are adequately prepared and completely oriented to the field of chemistry, a conclusion which is attested to by the high percentages of instructors with Ph.D. degrees shown in this study. (See Table II, page 51.)

One difference emerges between the thinking of high school teachers and college instructors. Among the college instructors there is a singleness of purpose regarding the research in and the teaching of chemistry. Among the high school teachers there is a wide divergence in background which is reflected in their statements of opinion.

Differences in Levels of Achievement

The level of achievement of the high school teacher is restricted to undergraduate work in chemistry and a few graduate credits in chemistry, supplemented by the offerings of in-service courses which touch upon recent advances in chemistry. In a sense, this is sufficient for the high school teacher, since the content that is covered in the high school course does not require a great deal of sophistication.

At the college level, however, the instructor usually is involved in research. His research, together with technical discussions with fellow faculty members, keeps him abreast with the advances in chemistry research. Since many colleges encourage or require their professors to publish, there is constant pressure to keep up with the latest literature. Furthermore, the first-year college chemistry instructor is also given assignments in chemistry in more advanced courses and thus must keep informed of newer developments in these areas.

The level of achievement, therefore, is a second area where differences of opinion may occur between high school and college teachers of chemistry. Whereas the high school teacher is prepared for the immediate needs of a high school student, the college instructor must anticipate the future needs of the secondary student. Thus, the responses of the two groups as to which items are important at the high school level would be expected to differ on many counts.

Differences in Goals

A third area of difference between the high school teachers and college instructors involves their goals. The high school chemistry teacher has the responsibility of preparing a student with little or no background in chemistry, to take a comprehensive examination during the course of one school year, embracing the theory of inorganic and organic chemistry. This puts the high school teacher under severe pressure from school administrators, parents, and the pupils themselves to follow the chemistry syllabus religiously and to present it diligently and forcefully. This syllabus represents not only a single document but also the combination of several. It may include the local syllabus, as well as those of the state, the Regents, the College Entrance Examination Board, and any of the newer curricula. All these requirements add to the stress of teaching chemistry at the high school level.

In contrast, the syllabus of the instructor of first-year college chemistry may have been developed by his departmental chairman or, if he has been teaching a few years, it may be of his own choosing. The syllabus may be broad in scope, allowing the instructor a great deal of latitude. The administration may exert no pressure to show results in the form of passing grades. There may be an absence of pressure from the instructors at the next level who require a certain level of competence on the part of students entering their classes. For many of these first-year students, the course in general chemistry will be their terminal course in science. Those who plan to major in science and who intend to prepare for graduate school may experience very little pressure during the first year of college in their courses.

Thus, the great amount of pressure on the high school teachers and the minimum amount of pressure on the first-year college instructors may result in certain differences in their opinions as to what should be taught in high school.

Differences in Methods of Instruction

Still another area of difference between high school teachers and college instructors is the method of instruction. The high school teacher uses every means to develop the student's sense of motivation in the subject. He attempts to instill in his students an interest in chemistry and an awareness of its importance to the modern world as well as its usefulness in explaining the nature of the world about us. The good teacher tries to present his subject attractively and to keep his students alert by means of frequent questionings during the class period and use of blackboard and audio-visual aids, such as films, slides, and television. He evaluates his students constantly by means of frequent quizzes and recitations, as well as regular full-period examinations which require not only a certain degree of recall but also the ability to formulate broader generalizations.

On the other hand, the college instructor is generally pictured as the lecturing type. Most of the pressure is placed on the student, who is expected to garner as much information as possible from the lecture and to broaden his knowledge of the subject by textbook and related library readings. Although a number of first-year instructors make good use of audio-visual aids, the majority adhere to the straight lecture method and evaluate their students by means of a biweekly or weekly quiz, as well as the final semester examination. This is not to criticize instruction at the college level, however; it is an indication of the differences in the philosophy of education and the method of teaching at the two levels. The colleges expect their students to be more mature and to do more independent work. This attitude is not as prevalent in the high schools, where the immaturity of the students does require a different philosophy of education.

Attitudes of Students

The third part of the questionnaire study related to the attitudes of the first-year college chemistry students. These students are directly affected by the problem of articulation, and they have contributed to the gap.

During their high school days, these students frequently study and cram in anticipation of questions which they expect on examinations. Study of this sort, however, does not contribute to an understanding of a subject. Consequently, they may retain only a little of what they have learned. When these students appear in the college chemistry classes, they already have forgotten a good deal of their high school chemistry. College instructors, however, should not condemn the high school teachers for this lack of knowledge on the part of the student but consider it merely a result of high school pressures.

Recommendations

The recommendations resulting from this investigation are divided into the following categories: (1) recommendations for high school teachers of chemistry; (2) recommendations for college instructors of first-year chemistry; (3) recommendations for chemistry students; (4) recommendations for educational leaders and textbook authors; (5) recommendations for further study of the problem.

Recommendations for High School Chemistry Teachers

The results of this study indicate that teachers of high school chemistry have completed over twenty-four credits in chemistry courses. It is recommended, therefore, that chemistry teachers strive to master as many courses in chemistry as possible at both undergraduate and graduate levels. In view of the increasing sophistication of high school chemistry courses and the pressures of college requirements, a chemistry teacher would do well to amass a total of thirty credits in chemistry, approximately one-third to be taken at the graduate level.

Another recommendation is that the high school teacher maintain an interest in chemistry content and in the techniques of teaching chemistry by enrolling in in-service and refresher courses every few years. An important finding of this investigation is that over 68 per cent of the chemistry teachers who responded are interested in this type of self-improvement. (See Table I, page 49.)

It is recommended that teachers take advantage of in-service courses in order to exchange ideas and to seek out what is good and successful in other parts of the country. Membership in the professional societies, such as the National Science Teachers Association and the American Chemical Society also inform a teacher about ideas and activities of experienced personnel from other systems. Local organizations and locally sponsored symposia are designed to bring together scientists and teachers of one area. If these dialogues take place between the high school and college personnel, then the high school teacher should make every effort to participate and to cultivate a health articulation between the levels. It is the duty of the high school teacher to find out what is going on in the classroom of the first-year college chemistry student. This knowledge will help the teacher to orient his lesson plan to the needs of his student.

Recommendations for First-Year College Chemistry Instructors

This investigation points out the need for college instructors to participate in in-service courses. (See Table II, page 51.) It is recommended that colleges and universities devise a program that will allow instructors to take refresher courses in their field even after the Ph.D. has been completed. Refresher courses in the area of teaching techniques might also be desirable. If it imposes a hardship on some college instructors to take a course in methods of college teaching, then a system of observed teaching might be substituted. Instructors should be observed by recognized experts, and they should be given the opportunity to observe other teachers in the classroom.

Another recommendation is that the college instructors attempt to learn the background of their chemistry students by pre-testing. A knowledge of the students' readiness for chemistry would aid the instructor in preparing the opening lessons in first-year chemistry and might result in the elimination of one or several lectures dealing with items already covered by the students in high school. (It is interesting to note here that although 65 per cent of the students responded that they were helped very much by their high school chemistry course, only 24 per cent of the college instructors shared this opinion. See Table VII, page 63.)

There are further implications evolving from this study. The college instructor should make an effort to find out what is being taught at the high school level, particularly in the high schools of those students who make up a large percentage of the attendance of their college. This knowledge could be obtained by visiting those schools that are sending students to the college. Questionnaire surveys could be conducted in these schools, or college sponsored symposia could be planned at which the local high school chemistry teachers would participate in all-day sessions with the college chemistry teachers.[1] It is much easier for college personnel to sponsor these sumposia: the high school teachers would appreciate the opportunity to discuss topics of mutual interest in chemistry. At these symposia the

[1]The New England Association of Chemistry Teachers has done a great deal in this field. Also, Professor James A. Goldman at the Polytechnic Institute of Brooklyn has been a pioneer in this area.

college teachers should not hesitate to clearly state what they expect of a typical freshman who has taken a course in high school chemistry. This kind of communication and articulation among teachers will benefit the most interested person--the student involved in the process of articulation.

Recommendations for Chemistry Students

According to the results of the questionnaire survey, a student who plans to take college chemistry should study three sciences in high school: general science, biology, and physics. The student should also plan to take four years of mathematics. (See Table VII, page 63.)

In their comments, a number of college and high school teachers recommended one additional course above all others. This course is English: grammar, writing, and reading comprehension. Apparently, the ability to write clearly and to understand is a deficiency among college students which warrants particular attention.

Recommendations for Educational Leaders and Textbook Authors

Judging from the results of this survey, it is apparent that the problem of articulation is national in scope. Therefore, although recommendations have been made for individual teachers and college instructors, these recommendations would affect only a small number of reforms. In order to coordinate reforms on a broader scale, it is necessary to engage the services and resources of educational leaders at the higher levels.

It is recommended, therefore, that those who are entrusted with educational policy at the municipal, state and national level make every effort to inform themselves of the problems of articulation. Since the training of educated citizens is a national concern, the efforts to eliminate an articulation gap should also be implemented from the top of educational circles. It is recommended that those educational leaders who are responsible for the designing of city or state syllabi for high school subjects should be made aware of the needs of college personnel before completing these documents. Incorporating the suggestions and opinions of the college authorities into the high school syllabus is an important means of narrowing the articulation gap.

Although a national syllabus in any one discipline may not be desirable to many people at this time, it is recommended that the U. S. Office of Education, working in conjunction with national professional organizations, devise guidelines for the content of high school syllabi that would meet the needs of the high school, the college and the student. As far as syllabi in science are concerned, an organization such as the National Science Teachers Association, with membership drawn from the elementary, the secondary and the college levels, would be in an excellent position to advise on problems of articulation.

It is recommended, also, that the various textbook authors, who exert so much influence in course content, should make themselves aware of the problems of high school and college articulation when gathering material for the content of the high school textbooks. A textbook with a presentation that is properly prepared should contribute to the diminution of the articulation gap.

Recommendations for Further Study

Similar studies in the field of physics, biology, and mathematics are recommended in order to establish whether or not there is a corresponding lack of articulation between the teachers of these disciplines at the two levels of instruction--high school and college. Perhaps, since the results of this study in chemistry proved to be statistically significant, similar studies would be useful in other subjects, such as English, foreign languages, and history.

It is recommended that specific curricula in chemistry be studied in greater detail than has been covered in this investigation. A more comprehensive study of the CBA approach and the CHEM Study approach would provide sufficient material for several studies. As more school systems turn to these curricula, their effectiveness in reducing the articulation gap should be studied.

Although this investigation was a cross-sectional study embracing a large sample of students, it might be advisable to design a longitudinal study of several hundred high school chemistry students and follow them throughout their college careers as far as their courses in science are concerned.

One result of this study is the listing of items pertaining to high school chemistry courses which indicates those considered most important by the high school teachers, the college instructors, and the first-year students, respectively. (See Table XIV, page 83.) The writer recommends that these topics be arranged by an author or a publisher in order to form a high school textbook. This textbook would be acceptable to both levels of teachers and would attempt to bridge the gap between the levels.

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APPENDICES

APPENDIX A

FORM A (QUESTIONNAIRE FOR TEACHERS OF HIGH SCHOOL CHEMISTRY) AND ACCOMPANYING MATERIAL

NEW YORK UNIVERSITY
School of Education
WASHINGTON SQUARE, NEW YORK, N.Y. 10003
AREA 212 777-2000

Department of Science and Mathematics Education

Press Building - Room 23 Ext. 226

November 1, 1965

Dear High School Teacher of Chemistry:

As one of the 21,000 high school teachers of chemistry in this country, you probably have given some thought to the problem of the articulation between high school chemistry and college chemistry. This problem affects the teachers at both levels as well as the students who must bridge the gap between high school and college.

The U.S. Office of Education has authorized a grant of money to support a widespread study of this problem of articulation. The study will consist of a questionnaire survey. The questionnaire instrument has been devised to survey the beliefs of a cross section of people involved in this articulation problem. The American Chemical Society and the National Science Teachers Association have expressed an interest in studying the results of this study.

The questionnaire has been developed over a one year period. It has been validated by a jury of five qualified men and it has been used on a limited basis for a three month pilot study. The questionnaire will be sent across the nation to:

Form A - 1,000 high school teachers of chemistry,
Form B - 1,000 college instructors of first year chemistry,
Form C - 1,000 students of first year college chemistry.

In any questionnaire survey, the percentage of the response will influence the significance of the results. The questionnaire has been structured so that the respondent may easily fill out all of the items in less than twenty minutes.

Your name has been selected as one of the 1,000 high school teachers of chemistry to be surveyed. May we ask your cooperation in taking a few minutes of your time to fill in this questionnaire. Your efforts in this regard are sincerely appreciated.

Yours truly,

Joseph D'Agostino, F.S.C.

Joseph D'Agostino, F.S.C.
Project Director

DIRECTIONS TO RESPONDENTS

Form A - High School Teachers of Chemistry

(1)This questionnaire has eliminated most questions that involve lengthy answers. For the most part, items may be answered with a check or a circle.

(2)Pen or pencil may be used. It is requested that the mark next to an item be very clear and distinct. This will help the key-punch operator who will transfer the information to data processing cards.

(3)You are under no obligation to answer open-ended questions. Where you feel strongly about some item and would like to comment, feel free to write in remarks. Each questionnaire will be inspected for these comments.

(4)A business reply envelope is supplied to facilitate the rapid return of the questionnaire. No postage is required.

(5)May we ask you to return the questionnaire within ten days of its arrival. This will be appreciated.

(6)This study will be completed by September, 1966. Should you be interested in the results, merely drop a note to this effect in the envelope with the returning questionnaire. An abstract of the results of the study will be mailed to you.

New York University, School of Education
United States Office of Education
Project S-303

Questionnaire for Teachers of High School Chemistry

1. Name of teacher .... Male........ Female........
   (Please note that all information concerning the name of the respondent, as well as the name of the participating school, will be kept confidential.)

2. Name of school .... Size of school: Under 500 ....
3. Address of school .... 500—1,000 ....
   .... Over 1,000 ....

4. Number of years teaching: (Check one)
   Under 5 years....................
   5—9 years......................
   10—19 years......................
   20 years and over..............

5. Number of years teaching chemistry: (Check one)
   Under 5 years...........
   5—9 years ....
   10—19 years.............
   20 years and over........

6. Check degrees held: *a*) A.B......... *b*) B.S.......... *c*) A.M......... *d*) M.S.......... *e*) Ed.D......... *f*) Ph.D......... *g*) Specify others: ....

7. Check if you have taken an in-service course since 1960 ....

8. Check any professional organization in which you are currently enrolled:
   a) N.S.T.A......... *b*) A.C.S......... *c*) N.E.A......... *d*) Specify others: ....

9. Name any professional journals you have read in the last six months. (If none, please write "none.")

10. Check all of the following types of chemistry courses taught at your high school:
    a) .... traditional college preparatory
    b) .... separate course for noncollege-bound students
    c) .... advanced chemistry
    d) .... C.B.A. chemistry
    e) .... CHEM study chemistry
    f) .... Specify any others: ....

11. Check the number of credits in chemistry taken by you in college:
    a) .... under 15 credits
    b) .... 16 — 20 credits
    c) .... 20 — 24 credits
    d) .... over 24 credits

12. Do you believe that a student entering a course in high school chemistry should have:
    (Check the ones that apply)
    a) .... earth science
    b) .... general science
    c) .... biology
    d) .... physics
    e) .... mathematics 1 year
    f) .... mathematics 2 years
    g) .... mathematics 3 years
    h) .... mathematics 4 years
    i) .... Specify others:
    ....
    ....
    ....

(Below is a listing of the major objectives of science teaching as proposed by leading educators.

Circle 1 if you believe that this objective is *very important;*
circle 2 if you believe that this objective is *mildly important;*
circle 3 if you believe that this objective is *unimportant.*)

A high school chemistry course is effective when it is:

13. Providing for opportunities for growth in the functional understanding of facts.	1	2	3	(13)
14. Providing for development of functional concepts.	1	2	3	(14)
15. Providing for growth in the functional understanding of principles.	1	2	3	(15)
16. Providing for growth in basic instrument skill.	1	2	3	(16)
17. Providing opportunity for growth of skill in the use of elements of the scientific method.	1	2	3	(17)
18. Providing for growth in the development of scientific attitudes.	1	2	3	(18)
19. Providing for growth in the development of scientific appreciations.	1	2	3	(19)
20. Providing for growth in the development of interests in science.	1	2	3	(20)

(The following is described as a minimum syllabus for a college preparatory course in chemistry.

Circle 1 if you believe that this item is *very important;*
circle 2 if you believe that this item is *mildly important;*
circle 3 if you believe that this item is *unimportant.*)

PART I: DESCRIPTIVE CHEMISTRY

21. Chemistry of nonmetals and their compounds (e.g., oxygen, hydrogen, nitrogen, sulfur, carbon, halogens)	1	2	3	(21)
22. Composition of air.	1	2	3	(22)
23. Water and its properties.	1	2	3	(23)
24. Properties of metals in general.	1	2	3	(24)
25. Chemistry of sodium, aluminum, iron.	1	2	3	(25)
26. Industrial processes (e.g., Haber, Ostwald, Contact).	1	2	3	(26)

PART II: GENERAL CHEMISTRY

27. Kinetic-molecular theory.	1	2	3	(27)
28. Properties of solids and liquids.	1	2	3	(28)
29. Properties of gases.	1	2	3	(29)
30. Quantitative treatment of the gas laws.	1	2	3	(30)
31. Elements, mixtures, compounds.	1	2	3	(31)
32. Nature of a chemical change.	1	2	3	(32)
33. Types of chemical reactions.	1	2	3	([illegible])
34. Balancing of chemical equations.	1	2	3	(34)

35. Problems based on chemical equations (e.g., weight, volume).	1	2	3	(35)
36. Mole and molar solutions.	1	2	3	(36)
37. Use of atomic structure to show compound formation.	1	2	3	(37)
38. Explaining reactions in terms of electron transfer.	1	2	3	(38)
39. Electrovalence and ionic nature of salts.	1	2	3	(39)
40. Covalence in simple molecules.	1	2	3	(40)
41. Definition of concentrated and dilute solutions.	1	2	3	(41)
42. Electrolytes (e.g., acids, bases, salts).	1	2	3	(42)
43. Arrhenius concept of acids and bases.	1	2	3	(43)
44. Bronsted-Lowry concept of acids and bases.	1	2	3	(44)
45. Hydrolysis of salts.	1	2	3	(45)
46. Reasons why some reactions go to completion.	1	2	3	(46)
47. Electrolysis of aqueous solutions and fused salts.	1	2	3	(47)
48. Definition of atom and molecule.	1	2	3	(48)
49. Nuclear charge and the distribution of electrons.	1	2	3	(49)
50. Periodic law and its relation to atomic structure.	1	2	3	(50)
51. Discussion of radiochemistry and isotopes.	1	2	3	(51)
52. Nuclear fission and fusion.	1	2	3	(52)

(Reference:

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

PART III: ADDITIONAL TOPICS

53. Organic chemistry (e.g., hydrocarbons, alcohols, esters, aldehydes, ketones).	1	2	3	(53)
54. LeChatelier's Principle and the Law of Mass Action.	1	2	3	(54)
55. Determination of molecular weight by depression of the freezing point and elevation of the boiling point.	1	2	3	(55)
56. Equivalent weights and normal solutions.	1	2	3	(56)
57. Oxidation-reduction reactions.	1	2	3	(57)
58. Balancing equations by means of the electron transfer method.	1	2	3	(58)
59. Chemistry of plastics, rubber, glass, cement.	1	2	3	(59)
60. Chemistry of textiles and food.	1	2	3	(60)

QUESTIONS CONCERNING COLLEGE CHEMISTRY

61. Which of the following high school courses do you believe should be prerequisites for a student entering a course in first year college chemistry? (Check all those that apply.)

a) .... earth science
b) .... general science
c) .... biology
d) .... physics
e) .... mathematics 1 year
f) .... mathematics 2 years
g) .... mathematics 3 years
h) .... mathematics 4 years
i) .... Specify others: ....

62. Do you believe that a student entering a course in first year college chemistry is helped by the high school chemistry course? (Check below)

.... Very much .... Some .... Not at all .... Undecided

63. Do you believe that college chemistry instructors make use of the knowledge of chemistry that a student brings from his high school chemistry course? (Check below)

.... Very much .... Some .... Not at all .... Undecided

Additional comments, if necessary: ....

(Certain educators have indicated the following as aims and objectives of the first year college chemistry course.

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

A first year college chemistry course should probably include:

64. Scientific information.	1	2	3	(64)
65. Development of an interest in science.	1	2	3	(65)
66. Understanding the relationship of science to the environment of every day life (applications)	1	2	3	(66)
67. Understanding the relationships of chemistry to the other sciences.	1	2	3	(67)
68. The assumption of no previous knowledge of chemistry.	1	2	3	(68)
69. A greater emphasis on the principles of chemistry at the expense of descriptive details.	1	2	3	(69)
70. A certain degree of freedom so that the instructor may formulate his own syllabus.	1	2	3	(70)
71. Assistance to the student in the proper use of chemical facts, theories, principles, and concepts.	1	2	3	(71)

72. Any comments or suggestions to add to this questionnaire will be gratefully received.

APPENDIX B

FORM B (QUESTIONNAIRE FOR INSTRUCTORS OF FIRST-YEAR COLLEGE CHEMISTRY) AND ACCOMPANYING MATERIALS

NEW YORK UNIVERSITY
School of Education
WASHINGTON SQUARE, NEW YORK, N.Y. 10003
AREA 212 777-2000

Department of Science and Mathematics Education

Press Building - Room 23 Ext. 226

November 1, 1965

TO THE CHAIRMAN OF THE CHEMISTRY DEPARTMENT:

Dear Professor,

During this Fall Semester, a national study is being conducted under the auspices of the New York University School of Education and supported by the United States Office of Education. The purpose of this study is to study the articulation between high school teachers of chemistry and college instructors of chemistry.

Since it is impossible to obtain a complete listing of the individual college instructors of chemistry, this material is being sent to your office with the request that it be distributed to the members of your Chemistry Department who teach First Year College Chemistry.

We are sending copies of this questionnaire to Chairmen of Chemistry in all of the 780 colleges and Universities listed in The Education Directory. We would very much like to obtain a high response from this population. Any effort on your part to encourage returns will be deeply appreciated. The questionnaire has been devised so that it may be answered in a minimum of time. Return envelopes have been provided so that each respondent may easily return their reply.

Many thanks for any consideration you give to this project.

Sincerely,

Joseph D'Agostino, F.S.C.

Joseph D'Agostino, F.S.C.
Project Director

NEW YORK UNIVERSITY
School of Education
WASHINGTON SQUARE, NEW YORK, N.Y. 10003
AREA 212 777-2000

Department of Scie ıce and Mathematics Education

Press Building - Room 23 Ext. 226

November 1, 1965

Dear College Instructor of Chemistry:

As one of the approximately 20,000 college instructors of chemistry in this country, you probably have given some thought to the problem of the articulation between high school chemistry and college chemistry. This problem affects the teachers at both levels as well as the students who must bridge the gap between high school and college.

The U.S. Office of Education has authorized a grant of money to support a widespread study of this problem of articulation. The study will consist of a questionnaire survey. A questionnaire instrument has been devised to survey the beliefs of a cross section of people involved in this articulation problem. The American Chemical Society and the National Science Teachers Association have expressed an interest in studying the results of this study.

The questionnaire has been developed over a one year period. It has been validated by a jury of five qualified men and it has been used on a limited basis for a three month pilot study. This questionnaire will be sent across the nation to:

Form A - 1,000 high school teachers of chemistry,
Form B - 1,000 college instructors of first year chemistry,
Form C - 1,000 students of first year college chemistry.

In any questionnaire survey, the percentage of the response will influence the significance of the results. The questionnaire has been structured so that the respondent may easily fill out all of the items in less than twenty minutes.

Your name has been selected as one of the 1,000 college instructors of chemistry to be surveyed. May we ask your cooperation in taking some of your time to fill in this questionnaire. Your efforts in this regard are sincerely appreciated.

Yours truly,

Joseph D'Agostino, F.S.C.

Joseph D'Agostino, F.S.C.
Project Director

DIRECTIONS TO RESPONDENTS

Form B - Instructors of First Year College Chemistry

(1)
This questionnaire has eliminated most questions involving lengthy answers. For the most part, items may be answered with a check or circle.

(2)
Pen or pencil may be used. It is only requested that the mark next to an item be very clear and distinct. This will be a help to the key-punch operator who will transfer this information to data processing cards.

(3)
You are under no obligation to answer the open-ended questions. Where you feel strongly about some item and would like to comment, feel free to write in remarks. Each questionnaire will be inspected for these comments.

(4)
A business reply envelope is supplied to facilitate the rapid return of the questionnaire. No postage is required.

(5)
May we ask you to return the questionnaire within ten days of its arrival. This will be appreciated.

(6)
This study will be completed by September, 1966. Should you be interested in the results, merely drop a note to this effect in the envelope with the returning questionnaire. An abstract of the results will be mailed to you.

(7)
Please note the final item on the questionnaire. Since we will need 1,000 first year college chemistry students, your affirmative answer to this question will help us achieve this population. The questionnaires and instructions will be structured so that a minimum of time will be taken from the classroom hour.

....

New York University, School of Education
United States Office of Education
Project S-303

Questionnaire for Instructors of First-Year College Chemistry

1. Name of instructor .... Male........ Female........
   (Please note that all information concerning the name of the respondent, as well as the name of the participating institution, will be kept confidential.)

2. Name of college .... Size of college: Under 1,000........

3. Address of college .... 1,000 — 5,000........
   .... Over 5,000........

4. Number of years teaching: (Check one)
   Under 5 years....................
   5—9 years ....
   10—19 years.....................
   20 years and over..............

5. Check degrees held: *a*) A.B......... *c*) A.M......... *e*) Ed.D......... *g*) Specify others:
   b) B.S......... *d*) M.S......... *f*) Ph.D......... ....

6. Check if you have taken an in-service course since 1960 ....

7. Check any professional organization in which you are currently enrolled:
   a) A.C.S......... *b*) N.E.A......... *c*) A.A.U.P......... *d*) N.S.T.A........
   e) Specify others: ....

8. Name any professional journals you read regularly: ....

9. Does your college require high school chemistry of students taking first year college chemistry?
   (Check one) ....Yes ....No

10. Does your college have courses that differentiate between those students who have had and those who have not had high school chemistry?
    (Check the ones that apply)
    a) .... separate courses for those with and those without chemistry
    b) .... the same course offered to those with and those without chemistry
    c) .... advanced standing to those with high school chemistry
    d) .... any other program (please specify): ....

11. Approximately how much time of your week's schedule is spent with first year college chemistry instruction?
    (Check one)
    a) .... 100 percent
    b) .... about 75 percent
    c) .... about 50 percent
    d) .... about 25 percent

QUESTIONS ON HIGH SCHOOL CHEMISTRY

12. Do you believe that a student entering a course in high school chemistry should have:
    (Check the ones that apply)
    a) .... earth science
    b) .... general science
    c) .... biology
    d) .... physics
    e) .... mathematics 1 year
    f) .... mathematics 2 years
    g) .... mathematics 3 years
    h) .... mathematics 4 years
    i) .... Specify others:
    ....
    ....
    ....

(Below is a listing of the major objectives of science teaching as proposed by leading educators.

Circle 1 if you believe that this objective is *very important;*
circle 2 if you believe that this objective is *mildly important;*
circle 3 if you believe that this objective is *unimportant.*)

A high school chemistry course is effective when it is:				
13. Providing for opportunities for growth in the functional understanding of facts.	1	2	3	(13)
14. Providing for development of functional concepts.	1	2	3	(14)
15. Providing for growth in the functional understanding of principles.	1	2	3	(15)
16. Providing for growth in basic instrument skill.	1	2	3	(16)
17. Providing opportunity for growth of skill in the use of elements of the scientific method.	1	2	3	(17)
18. Providing for growth in the development of scientific attitudes.	1	2	3	(18)
19. Providing for growth in the development of scientific appreciations.	1	2	3	(19)
20. Providing for growth in the development of interests in science.	1	2	3	(20)

(The following is described as a minimum syllabus for a college preparatory course in chemistry.

Circle 1 if you believe that this item is *very important;*
circle 2 if you believe that this item is *mildly important;*
circle 3 if you believe that this item is *unimportant.*)

PART I: DESCRIPTIVE CHEMISTRY

21. Chemistry of nonmetals and their compounds (e.g., oxygen, hydrogen, nitrogen, sulfur, carbon, halogens)	1	2	3	(21)
22. Composition of air.	1	2	3	(22)
23. Water and its properties.	1	2	3	(23)
24. Properties of metals in general.	1	2	3	(24)
25. Chemistry of sodium, aluminium, iron.	1	2	3	(25)
26. Industrial processes (e.g., Haber, Ostwald, Contact).	1	2	3	(26)

PART II: GENERAL CHEMISTRY

27. Kinetic-molecular theory.	1	2	3	(27)
28. Properties of solids and liquids.	1	2	3	(28)
29. Properties of gases.	1	2	3	(29)
30. Quantitative treatment of the gas laws.	1	2	3	(30)
31. Elements, mixtures, compounds.	1	2	3	(31)
32. Nature of a chemical change.	1	2	3	(32)
33. Types of chemical reactions.	1	2	3	(33)
34. Balancing of chemical equations.	1	2	3	(34)

35. Problems based on chemical equations (e.g., weight, volume).	1	2	3	(35)
36. Mole and molar solutions.	1	2	3	(36)
37. Use of atomic structure to show compound formation.	1	2	3	(37)
38. Explaining reactions in terms of electron transfer.	1	2	3	(38)
39. Electrovalence and ionic nature of salts.	1	2	3	(39)
40. Covalence in simple molecules.	1	2	3	(40)
41. Definition of concentrated and dilute solutions.	1	2	3	(41)
42. Electrolytes (e.g., acids, bases, salts).	1	2	3	(42)
43. Arrhenius concept of acids and bases.	1	2	3	(43)
44. Bronsted-Lowry concept of acids and bases.	1	2	3	(44)
45. Hydrolysis of salts.	1	2	3	(45)
46. Reasons why some reactions go to completion.	1	2	3	(46)
47. Electrolysis of aqueous solutions and fused salts.	1	2	3	(47)
48. Definition of atom and molecule.	1	2	3	(48)
49. Nuclear charge and the distribution of electrons.	1	2	3	(49)
50. Periodic law and its relation to atomic structure.	1	2	3	(50)
51. Discussion of radiochemistry and isotopes.	1	2	3	(51)
52. Nuclear fission and fusion.	1	2	3	(52)

(Reference:

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

PART III: ADDITIONAL TOPICS

53. Organic chemistry (e.g., hydrocarbons, alcohols, esters, aldehydes, ketones).	1	2	3	(53)
54. LeChatelier's Principle and the Law of Mass Action.	1	2	3	(54)
55. Determination of molecular weight by depression of the freezing point and elevation of the boiling point.	1	2	3	(55)
56. Equivalent weights and normal solutions.	1	2	3	(56)
57. Oxidation-reduction reactions.	1	2	3	(57)
58. Balancing equations by means of the electron transfer method.	1	2	3	(58)
59. Chemistry of plastics, rubber, glass, cement.	1	2	3	(59)
60. Chemistry of textiles and food.	1	2	3	(60)

QUESTIONS CONCERNING COLLEGE CHEMISTRY

61. Which of the following high school courses do you believe should be prerequisites for a student entering a course in first year college chemistry? (Check all those that apply.)

a) .... earth science
b) .... general science
c) .... biology
d) .... physics
e) .... mathematics 1 year
f) .... mathematics 2 years
g) .... mathematics 3 years
h) .... mathematics 4 years
i) .... Specify others: ....

62. Do you believe that a student entering a course in first year college chemistry is helped by the high school chemistry course? (Check below)

.... Very much .... Some .... Not at all .... Undecided

63. Do you believe that college chemistry instructors make use of the knowledge of chemistry that a student brings from his high school chemistry course? (Check below)

.... Very much .... Some .... Not at all .... Undecided

Additional comments, if necessary: ....

(Certain educators have indicated the following as aims and objectives of the first year college chemistry course.

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

A first year college chemistry course should probably include:

64. Scientific information.	1	2	3	(64)
65. Development of an interest in science.	1	2	3	(65)
66. Understanding the relationship of science to the environment of every day life (applications)	1	2	3	(66)
67. Understanding the relationships of chemistry to the other sciences.	1	2	3	(67)
68. The assumption of no previous knowledge of chemistry.	1	2	3	(68)
69. A greater emphasis on the principles of chemistry at the expense of descriptive details.	1	2	3	(69)
70. A certain degree of freedom so that the instructor may formulate his own syllabus.	1	2	3	(70)
71. Assistance to the student in the proper use of chemical facts, theories, principles, and concepts.	1	2	3	(71)

72. Any comments or suggestions to add to this questionnaire will be gratefully received.

73. May we have your permission to send you a set of similar questionnaires to be administered to your first year college chemistry students. (The questionnaire should take less than 20 minutes.) .... Yes .... No

If *yes*, how many copies of the questionnaire would you like us to send. ....

APPENDIX C

FORM C (QUESTIONNAIRE FOR STUDENTS OF FIRST-YEAR COLLEGE CHEMISTRY WHO HAVE COMPLETED A HIGH SCHOOL CHEMISTRY COURSE

MEMO FROM THE DIRECTOR OF PROJECT S-303

Dear Professor:

The request for questionnaires for Students of First Year Chemistry (FORM C) totaled over 30,000 from nearly 600 different professors throughout the nation.

We have decided to send five questionnaires to each professor who sent in a request for copies of FORM C. This should give us a profile of the college students of chemistry from nearly every state. We expect this response to be much larger than the 1,000 originally estimated. We are very sorry, however, that we could not completely fill every request sent in to us.

We earnestly recommend that you give these questionnaires to:-

a) willing volunteers
b) students who have taken high school chemistry.

Once again, many thanks for your interest and assistance.

Joseph D'Agostino, F.S.C.
Project Director

NEW YORK UNIVERSITY
School of Education
WASHINGTON SQUARE, NEW YORK, N.Y. 10003
AREA 212 777-2000

Department of Science and Mathematics Education

TO THE FIRST YEAR COLLEGE CHEMISTRY INSTRUCTORS :

RE : FORM C Questionnaire -
Students of First Year College Chemistry

Dear Professor,

First of all, I wish to thank you for indicating on your returned questionnaire that you would allow us to survey your first year chemistry class. Your positive response is deeply appreciated.

Enclosed in this envelope are the number of questionnaires you requested for your first year chemistry students. Each questionnaire is complete with directions, a cover letter, and a business reply envelope.

You may administer the questionnaire in either of two ways. You may allow the students about twenty minutes or less of class time to fill in the questionnaire and seal them in the reply envelopes. If you prefer, you may allow the students to take the questionnaire with them and allow them to fill in the questionnaire at their leisure time. (However it is safe to assume that the former method will have a higher percentage of response than the latter.)

Again, many thanks for the time and help you have given to the successful completion of this project.

Sincerely,

Joseph D'Agostino, F.S.C.

Joseph D'Agostino, F.S.C.
Project Director

NEW YORK UNIVERSITY
School of Education
WASHINGTON SQUARE, NEW YORK, N.Y. 10003
AREA 212 777-2000

Department of Science and Mathematics Education

December 1, 1965

Dear Student of First Year College Chemistry :

The U.S. Office of Education has authorized a grant of money to support a widespread study of the problem of articulation between high school chemistry and college chemistry. This study will be completed under the auspices of New York University. The American Chemical Society and the National Science Teachers Association have expressed an interest in studying the results of this study.

A questionnaire instrument has been devised to survey the beliefs of a cross section of people involved in this articulation problem. This questionnaire has been developed over a one year period and has been validated by a jury of five qualified men in the field. It also has been used on a limited basis for a three month pilot study. The questionnaire will be sent across the country as follows:-

Form A - 1,000 high school teachers of chemistry
Form B - 1,000 college instructors of first year chemistry
Form C - 1,000 students of first year college chemistry

In any questionnaire survey, the percentage of the response will influence the significance of the results. This questionnaire has been structured so that the respondent may easily fill out all of the items in less than twenty minutes.

You have been selected as one of the 1,000 first year college chemistry students to be surveyed. May we ask your cooperation in taking a few minutes of your time to fill in this questionnaire. Your efforts in this regard are sincerely appreciated.

Yours truly,

Joseph D'Agostino, F.S.C.

Joseph D'Agostino, F.S.C.
Project Director

DIRECTIONS TO RESPONDENTS

Form C - Students of First Year College Chemistry

(1)
This questionnaire has eliminated most questions involving lengthy answers. For the most part, items may be answered with a check or circle.

(2)
Pen or pencil may be used. It is only requested that the mark next to an item be made very clear and distinct. This will be a help to the key-punch operator who will transfer this information to data processing cards.

(3)
You are under no obligation to answer the open-ended questions. Where you feel strongly about some item and would like to comment, feel free to write in remarks. Each questionnaire will be inspected for these comments.

(4)
A business reply envelope is supplied to facilitate the rapid return of the questionnaire. No postage is required.

(5)
May we ask you to return the questionnaire within ten days of its arrival. This will be appreciated.

(6)
Please note that Question Number One (Name of Respondent) is optional.

New York University, School of Education
United States Office of Education
Project S-303

Questionnaire for Students of First-Year College Chemistry Who Have Completed a High School Chemistry Course

1. Name of student .... Male........ Female........
   (OPTIONAL)
   (Please note that all information concerning the name of the respondent, as well as the participating institution, will be held confidential.)
2. Name of college ....
3. Address of college ....
   ....
4. How many semesters of college chemistry have you completed? (Check one)
   a) .... now in my first semester
   b) .... now in my second semester
   c) .... any other, please specify:
5. Have you had the following courses in high school? (Check all that apply)
   a) .... earth science
   b) .... general science
   c) .... biology
   d) .... physics
   e) .... mathematics 1 year
   f) .... mathematics 2 years
   g) .... mathematics 3 years
   h) .... mathematics 4 years
   i) .... college preparatory chemistry
   j) .... advanced placement chemistry
   k) .... honors chemistry
   l) .... C.B.A. chemistry
   m) .... CHEM study chemistry
6. How many periods a week did you have high school chemistry?
   In the classroom:
   a) .... 3 periods
   b) .... 4 periods
   c) .... 5 periods
   d) .... 6 periods
   e) Any others: ....
   In the laboratory:
   f) .... 1 period
   g) .... 2 periods
   h) .... 3 periods
   i) Any others: ....
7. Of what duration were your high school chemistry classes?
   a) .... 30 — 39 minutes
   b) .... 40 — 49 minutes
   c) .... 50 — 60 minutes
   d) .... any others, please specify:..........................
8. What, approximately, was your final grade in high school chemistry?
   a) .... A (90–100) *b*) .... B (80–89) *c*) .... C (70–79) *d*) .... D (60–69)
9. How would you classify your high school chemistry course?
   a) ...... poor *b*) ...... fair *c*) ...... good *d*) ...... very good *e*) ...... exceptional
10. How would you classify your high school chemistry teacher?
    a) ...... poor *b*) ...... fair *c*) ...... good *d*) ...... very good *e*) ...... exceptional
11. In what year did you take high school chemistry?
    a) .... 10th grade
    b) .... 11th grade
    c) .... 12th grade
    d) .... any other, please specify: ....

FORM C (Page 2)

(Below is a listing of the major objectives of science teaching as proposed by leading educators.

Circle 1 if you believe that this objective is *very important;*
circle 2 if you believe that this objective is *mildly important;*
circle 3 if you believe that this objective is *unimportant.*)

A high school chemistry course is effective when it is:

13. Providing for opportunities for growth in the functional understanding of facts.	1	2	3	(13)
14. Providing for development of functional concepts.	1	2	3	(14)
15. Providing for growth in the functional understanding of principles.	1	2	3	(15)
16. Providing for growth in basic instrument skill.	1	2	3	(16)
17. Providing opportunity for growth of skill in the use of elements of the scientific method.	1	2	3	(17)
18. Providing for growth in the development of scientific attitudes.	1	2	3	(18)
19. Providing for growth in the development of scientific appreciations.	1	2	3	(19)
20. Providing for growth in the development of interests in science.	1	2	3	(20)

(The following is described as a minimum syllabus for a college preparatory course in chemistry.

Circle 1 if you believe that this item is *very important;*
circle 2 if you believe that this item is *mildly important;*
circle 3 if you believe that this item is *unimportant.*)

PART I: DESCRIPTIVE CHEMISTRY

21. Chemistry of nonmetals and their compounds (e.g., oxygen, hydrogen, nitrogen, sulfur, carbon, halogens)	1	2	3	(21)
22. Composition of air.	1	2	3	(22)
23. Water and its properties.	1	2	3	(23)
24. Properties of metals in general.	1	2	3	(24)
25. Chemistry of sodium, aluminum, iron.	1	2	3	(25)
26. Industrial processes (e.g., Haber, Ostwald, Contact).	1	2	3	(26)

PART II: GENERAL CHEMISTRY

27. Kinetic-molecular theory.	1	2	3	(27)
28. Properties of solids and liquids.	1	2	3	(28)
29. Properties of gases.	1	2	3	(29)
30. Quantitative treatment of the gas laws.	1	2	3	(30)
31. Elements, mixtures, compounds.	1	2	3	(31)
32. Nature of a chemical change.	1	2	3	(32)
33. Types of chemical reactions.	1	2	3	(33)
34. Balancing of chemical equations.	1	2	3	(34)

35. Problems based on chemical equations (e.g., weight, volume).	1	2	3	(35)
36. Mole and molar solutions.	1	2	3	(36)
37. Use of atomic structure to show compound formation.	1	2	3	(37)
38. Explaining reactions in terms of electron transfer.	1	2	3	(38)
39. Electrovalence and ionic nature of salts.	1	2	3	(39)
40. Covalence in simple molecules.	1	2	3	(40)
41. Definition of concentrated and dilute solutions.	1	2	3	(41)
42. Electrolytes (e.g., acids, bases, salts).	1	2	3	(42)
43. Arrhenius concept of acids and bases.	1	2	3	(43)
44. Bronsted-Lowry concept of acids and bases.	1	2	3	(44)
45. Hydrolysis of salts.	1	2	3	(45)
46. Reasons why some reactions go to completion.	1	2	3	(46)
47. Electrolysis of aqueous solutions and fused salts.	1	2	3	(47)
48. Definition of atom and molecule.	1	2	3	(48)
49. Nuclear charge and the distribution of electrons.	1	2	3	(49)
50. Periodic law and its relation to atomic structure.	1	2	3	(50)
51. Discussion of radiochemistry and isotopes.	1	2	3	(51)
52. Nuclear fission and fusion.	1	2	3	(52)

(Reference:

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

PART III: ADDITIONAL TOPICS

53. Organic chemistry (e.g., hydrocarbons, alcohols, esters, aldehydes, ketones).	1	2	3	(53)
54. LeChatelier's Principle and the Law of Mass Action.	1	2	3	(54)
55. Determination of molecular weight by depression of the freezing point and elevation of the boiling point.	1	2	3	(55)
56. Equivalent weights and normal solutions.	1	2	3	(56)
57. Oxidation-reduction reactions.	1	2	3	(57)
58. Balancing equations by means of the electron transfer method.	1	2	3	(58)
59. Chemistry of plastics, rubber, glass, cement.	1	2	3	(59)
60. Chemistry of textiles and food.	1	2	3	(60)

QUESTIONS CONCERNING COLLEGE CHEMISTRY

61. Which of the following high school courses do you believe should be prerequisites for a student entering a course in first year college chemistry? (Check all those that apply.)

   a) .... earth science
   b) .... general science
   c) .... biology
   d) .... physics
   e) .... mathematics 1 year
   f) .... mathematics 2 years
   g) .... mathematics 3 years
   h) .... mathematics 4 years
   i) .... Specify others:

   ....

62. Do you believe that a student entering a course in first year college chemistry is helped by the high school chemistry course? (Check below)

   .... Very much .... Some .... Not at all .... Undecided

63. Do you believe that college chemistry instructors make use of the knowledge of chemistry that a student brings from his high school chemistry course? (Check below)

   .... Very much .... Some .... Not at all .... Undecided

   Additional comments, if necessary: ....

(Certain educators have indicated the following as aims and objectives of the first year college chemistry course.

Circle 1 if you believe the item is *very important;*
circle 2 if you believe the item is *mildly important;*
circle 3 if you believe the item is *unimportant.*)

A first year college chemistry course should probably include:

64. Scientific information.	1	2	3	(64)
65. Development of an interest in science.	1	2	3	(65)
66. Understanding the relationship of science to the environment of every day life (applications)	1	2	3	(66)
67. Understanding the relationships of chemistry to the other sciences.	1	2	3	(67)
68. The assumption of no previous knowledge of chemistry.	1	2	3	(68)
69. A greater emphasis on the principles of chemistry at the expense of descriptive details.	1	2	3	(69)
70. A certain degree of freedom so that the instructor may formulate his own syllabus.	1	2	3	(70)
71. Assistance to the student in the proper use of chemical facts, theories, principles, and concepts.	1	2	3	(71)

72. Any comments or suggestions to add to this questionnaire will be gratefully received.

APPENDIX D

MEMBERS OF THE VALIDATION JURY

MEMBERS OF THE VALIDATION JURY

1. Professor William P. Sears, Jr., Chairman
   Committee on the Selection and Recommendation
   of Doctoral Candidates
   School of Education
   New York University

2. Professor Everett Lyne,
   Science and Mathematics Education
   School of Education
   New York University

3. Professor Paul J. Gans
   Department of Chemistry
   Washington Square College of Arts & Sciences
   New York University

4. Dr. Louis Weiss, Chairman
   Chemistry Department
   Brooklyn Technical High School

5. David F. Taylor
   Teacher of Chemistry
   Metuchen, New Jersey

APPENDIX E

DISTRIBUTION OF QUESTIONNAIRES AND THEIR RESPONSES (FORMS A, B, AND C)

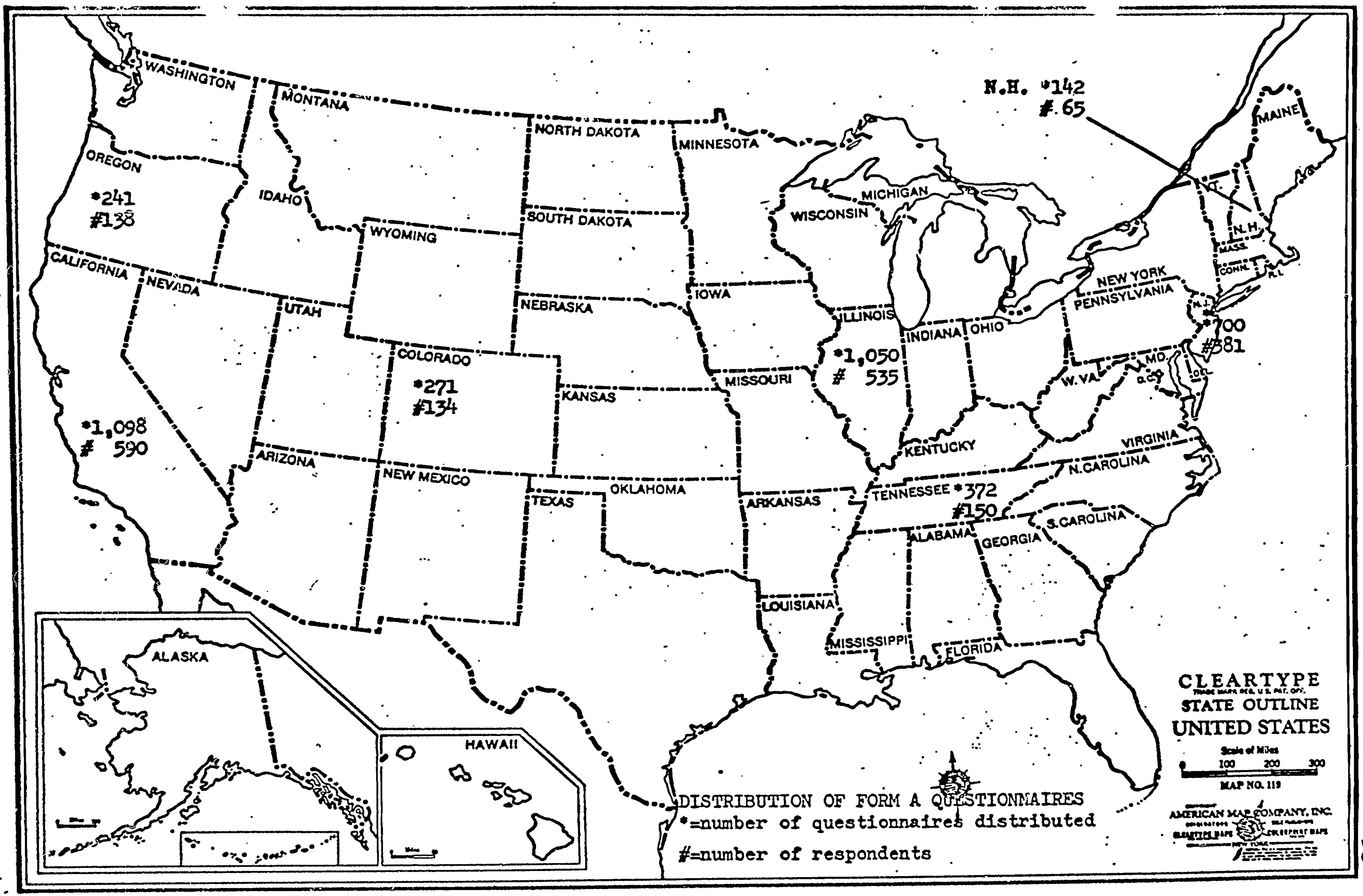
DISTRIBUTION OF FORM A
(HIGH SCHOOL TEACHERS)
BY STATES

FORM A - HIGH SCHOOL
QUESTIONNAIRES

California	1,098
Colorado	271
Illinois	1,050
New Hampshire	142
New Jersey	700
Oregon	241
Tennessee	372
Total	3,874

DISTRIBUTION OF RESPONSES TO FORM A
(HIGH SCHOOL TEACHERS)
BY STATES

California	590
Colorado	134
Illinois	535
New Hampshire	65
New Jersey	381
Oregon	138
Tennessee	150
Total	1,993

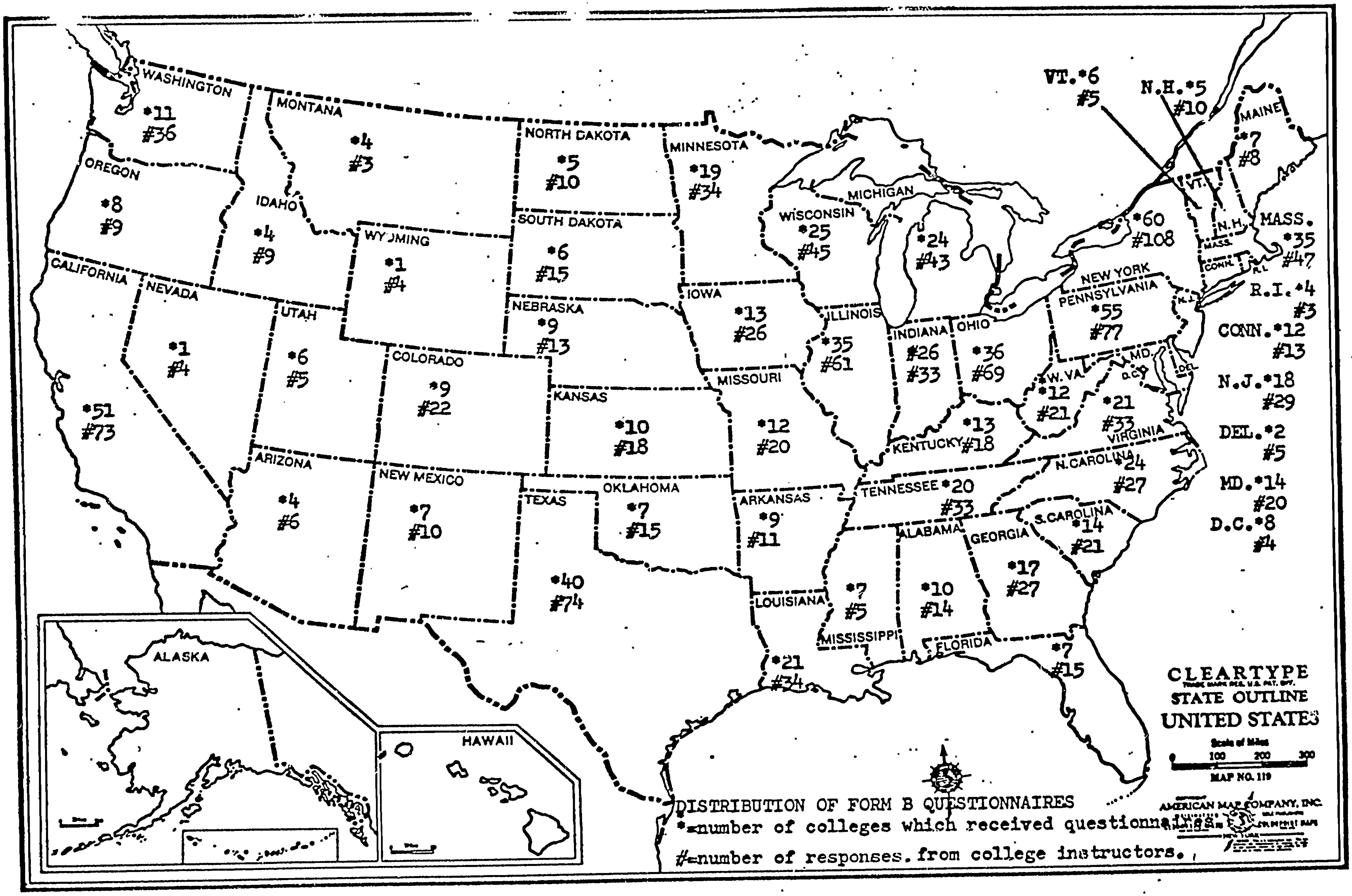

CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
100 200 300
MAP NO. 119
AMERICAN MAP COMPANY, INC.
DISTRIBUTION OF FORM A QUESTIONNAIRES
*=number of questionnaires distributed
#=number of respondents
N.H. *142
#.65
*241
#138
*1,098
590
*271
#134
*1,050
535
*372
#150
*700
#381
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S.CAROLINA
N.CAROLINA
VIRGINIA
W.VA.
MD.
DEL.
D.C.
N.J.
NEW YORK
PENNSYLVANIA
CONN.
R.I.
MASS.
N.H.
VT.
MAINE
ALASKA
HAWAII

DISTRIBUTION OF FORM B (COLLEGE INSTRUCTORS) BY NUMBER OF COLLEGES WITHIN STATES

	Number		Number
Alabama	10	Nebraska	9
Arizona	4	Nevada	1
Arkansas	9	New Hampshire	5
California	51	New Jersey	18
Colorado	9	New Mexico	7
Connecticut	12	New York	60
Delaware	2	North Carolina	24
District of Columbia	8	North Dakota	5
Florida	7	Ohio	36
Georgia	17	Oklahoma	7
Idaho	4	Oregon	8
Illinois	35	Pennsylvania	55
Indiana	26	Rhode Island	4
Iowa	13	South Carolina	14
Kansas	10	South Dakota	6
Kentucky	13	Tennessee	20
Louisiana	21	Texas	40
Maine	7	Utah	6
Maryland	14	Vermont	6
Massachusetts	35	Virginia	21
Michigan	24	Washington	11
Minnesota	19	West Virginia	12
Mississippi	7	Wisconsin	25
Missouri	12	Wyoming	1
Montana	4	Total	774

DISTRIBUTION OF RESPONSES TO FORM B
(COLLEGE INSTRUCTORS) BY STATES

	Number		Number
Alabama	14	Nebraska	13
Arizona	6	Nevada	4
Arkansas	11	New Hampshire	10
California	73	New Jersey	29
Colorado	22	New Mexico	10
Connecticut	13	New York	108
Delaware	5	North Carolina	27
District of Columbia	4	North Dakota	10
Florida	15	Ohio	69
Georgia	27	Oklahoma	15
Idaho	9	Oregon	9
Illinois	61	Pennsylvania	77
Indiana	33	Rhode Island	3
Iowa	26	South Carolina	21
Kansas	18	South Dakota	15
Kentucky	18	Tennessee	33
Louisiana	34	Texas	74
Maine	8	Utah	5
Maryland	20	Vermont	5
Massachusetts	47	Virginia	33
Michigan	43	Washington	36
Minnesota	34	West Virginia	21
Mississippi	5	Wisconsin	45
Missouri	20	Wyoming	4
Montana	3	Total	1,245



DISTRIBUTION OF FORM B QUESTIONNAIRES
*=number of colleges which received questionnaires.
#=number of responses. from college instructors.

BREAKDOWN OF RESPONSES TO FORM B

(COLLEGE INSTRUCTORS)

BY COLLEGES

ALABAMA

Athens:
Athens College, 2

Birmingham:
Birmingham Southern College

Mobile:
Spring Hill College, 4

Montevallo:
Alabama College

Montgomery:
Huntingdon College

Troy:
Troy State College, 2

Tuskegee:
Tuskegee Institute, 2

University:
University of Alabama

ARIZONA

Tempe:
Arizona State University, 2

Tucson:
University of Arizona, 4

ARKANSAS

Arkadelphia:
Henderson State Teachers College
Ouachita Baptist University

Clarksville:
College of the Ozarks

Fayetteville:
University of Arkansas, 4

Little Rock:
Little Rock University, 3

Searcy:
Harding College

CALIFORNIA

Angwin:
Pacific Union College, 3

Azusa:
Azusa-Pacific College

Berkeley:
University of California, 4

Claremont:
Harvey Mudd College
Pomona College

Davis:
University of California, 2

Fresno:
Fresno State College, 3

Fullerton:
State College at Fullerton

Hayward:
California State College, 2

La Verne
La Verne College, 2

(California - continued)

Long Beach:
California State College, 4

Los Angeles:
Immaculate Heart College, 2
Loyola University
Occidental College
Pepperdine College
University of California, 3
University of Southern California, 3

Oakland:
Mills College, 2

Pasadena:
California Institute of Technology, 3
Pasadena College, 2

Pomona:
California State Polytechnic College, 4

Redlands:
University of Redlands, 2

Riverside:
La Sierra College, 3
University of California, 2

Sacramento:
Sacramento State College, 4

Saint Marys College
Saint Marys College, 2

San Bernardino:
California State College, 2

San Diego:
San Diego State College, 3
University of San Diego

San Francisco:
San Francisco State College, 2

San Jose:
San Jose State, 4

Santa Barbara:
University of California, 3

COLORADO

Boulder:
University of Colorado, 2

Colorado Springs:
Colorado College

Denver:
Regis College
University of Denver

Durango:
Fort Lewis College, 3

Fort Collins:
Colorado State University, 3

Golden:
Colorado School of Mines, 5

Gunnison:
Western State College

Loretto:
Loretto Heights College

Pueblo:
Southern Colorado State College, 4

CONNECTICUT

Bridgeport:
University of Bridgeport, 3

Fairfield:
Fairfield University

Hartford:
University of Hartford, 3

Middletown:
Wesleyan University, 2

New Haven:
Yale University, 3

Storrs:
University of Connecticut

DELAWARE

Dover:
Delaware State College

Newark:
University of Delaware, 4

DISTRICT OF COLUMBIA

Gallaudet College
George Washington Univer
Howard University, 3

FLORIDA

Coral Gables:
University of Miami, 3

Daytona Beach:
Bethune-Cookman College

Gainesville:
University of Florida, 2

Jacksonville:
Jacksonville University, 2

Tallahassee:
Florida State University

Tampa:
University of South Fla

GEORGIA

Athens:
University of Georgia, 3

Atlanta:
Emory University, 2

Georgia Institute of Te
Georgia State College, 5

Carrollton:
West Georgia College, 2

Decatur:
Agnes Scott College

ersity, 4

College of
3

State College

State College

of Idaho, 5

Nazarene College, 2

University, 2

College, 2

Illinois University, 3

iversity, 4
Institute of
4
niversity, 4
College, 2

University, 3

Illinois University, 3

College, 2

University, 2

(Illinois - continued)

Galesburg:
Knox College, 2

Greenville:
Greenville College, 2

Jacksonville:
Illinois College, 2
Mac Murray College, 2

Lake Forest:
Lake Forest College, 2

Lisle:
St. Procopius College, 3

Lockport:
Lewis College

Monmouth:
Monmouth College

Naperville:
North Central College

Normal:
Illinois State University, 5

Peoria:
Bradley University, 2

Quincy:
Quincy College

Rock Island:
Augustana College, 3

Urbana:
University of Illinois, 3

Wheaton:
Wheaton College

INDIANA

Anderson:
Anderson College

Angola:
Tri-State College, 2

Bloomington:
Indiana University, 4

Evansville:
Evansville College, 3

Fort Wayne:
Indiana Institute of
Technology, 2
Saint Francis College

Goshen:
Goshen College

Greencastle:
De Pauw University, 2

Indianapolis:
Butler University, 2
Indiana University (Extension)

North Manchester:
Manchester College, 2

Notre Dame:
University of Notre Dame, 2

Rensselaer:
St. Joseph's College

Richmond:
Earlham College, 2

Terre Haute:
Rose Polytechnic Institute, 3

Upland:
Taylor University, 2

Valparaiso:
Valparaiso University, 3

IOWA

Ames:
Iowa State University, 4

Cedar Rapids:
Coe College, 2

(Iowa - continued)

Davenport:
St. Ambrose College, 2

Des Moines:
Drake University

Dubuque:
Loras College, 2

Fairfield:
Parsons College, 3

Grinnell:
Grinnell College, 2

Indianola:
Simpson, 3

Iowa City:
University of Iowa, 3

Le Mars:
Westmar College

Mt. Vernon:
Cornell College

Sioux City:
Morningside College, 2

KANSAS

Atchison:
St. Benedict's College

Baldwin:
Baker University, 2

Emporia:
College of Emporia

Hays:
Fort Hays State College, 3

Lawrence:
University of Kansas, 2

Pittsburg:
Kansas State College, 3

Salina:
Marymount College, 2

Wichita:
Wichita State University, 2

Winfield:
Southwestern College

KENTUCKY

Bowling Green:
Western Kentucky State College, 2

Frankfort:
Kentucky State College

Lexington:
University of Kentucky, 4

Louisville:
Bellarmine College
Catherine Spalding College

Murray:
Murray State College, 3

Owensboro:
Kentucky Wesleyan College

Richmond:
Eastern Kentucky State College, 5

LOUISIANA

Baton Rouge:
Louisiana State University, 3

Hammond:
Southeastern Louisiana College, 2

Lafayette:
University of Southwestern Louisiana, 5

(Louisiana - continued)

Lake Charles:
McNeese State College, 2

Monroe:
Northeast Louisiana State College, 5

Natchitoches:
Northwestern State College, 4

New Orleans:
Louisiana State University, 4
St. Mary's Dominican College, 2

Pineville:
Louisiana College

Ruston:
Louisiana Polytechnic Institute, 3

Shreveport:
Centenary College of Louisiana, 3

MAINE

Biddeford:
St. Francis College

Brunswick:
Bowdoin College

Lewiston:
Bates College

North Windham:
St. Joseph's College

Orono:
University of Maine, 3

Waterville:
Colby College

MARYLAND

Baltimore:
Loyola College, 3
Morgan State College, 2

Chestertown:
Washington College

College Park:
University of Maryland, 5

Emmitsburg:
Mt. St. Mary's College
St. Joseph College

Frederick:
Hood College, 2

Frostburg:
Frostburg State College

Princess Anne:
Maryland State College

Takoma Park:
Columbia Union College

Towson:
Goucher College, 2

MASSACHUSETTS

Amherst:
Amherst College, 7

Boston:
Boston University
Emmanuel College
Northeastern University, 3
Simmons College
Suffolk University, 2

Bridgewater:
State College of Bridgewater

Cambridge:
Harvard University, 2

Chestnut Hill:
Boston College

Medford:
Tufts University

Northampton:
Smith College, 2

(Massachusetts - continued)

North Andover:
Merrimack College, 3

North Dartmouth:
Southeastern Massachusetts Technological Institute, 2

Norton:
Wheaton College

South Hadley:
Mount Holyoke College, 2

South Lancaster:
Atlantic Union College

Springfield:
Western New England College

Waltham:
Brandeis University, 3

Wellesley:
Wellesley College, 5

Wenham:
Gordon College

Weston:
Regis College

Wollaston:
Eastern Nazarene College

Worcester:
Assumption College, 2
Clark University
Holy Cross College, 2

MICHIGAN

Adrian:
Siena Heights College

Allendale:
Grand Valley State College

Alma:
Alma College

Ann Arbor:
University of Michigan, 2

Berrien Springs:
Andrews University

Detroit:
University of Detroit, 3
Wayne State University, 4

Flint:
General Motors Institute, 4

Grand Rapids:
Aquinas College, 2
Calvin College, 2

Holland:
Hope College, 2

Houghton:
Michigan Technological University, 2

Kalamazoo:
Western Michigan University, 4

Marquette:
Northern Michigan University

Mount Pleasant:
Central Michigan University, 3

Rochester:
Oakland University, 3

Southfield:
Lawrence Institute of Technology, 3

Ypsilanti:
Eastern Michigan University, 4

MINNESOTA

Collegeville:
St. John's University

Duluth:
University of Minnesota, 2

(Minnesota - continued)

Mankato:
Mankato State College, 3

Minneapolis:
Augsburg College
University of Minnesota, 5

Moorhead:
Concordia College, 5

Northfield:
St. Olaf College, 2

St. Cloud:
St. Cloud State College, 2

St. Paul:
Bethel College
College of St. Catherine, 2
Hamline University
Macalester College

St. Peter:
Gustavus Adolphus College

Winona:
St. Mary's College, 2
College of St. Teresa, 5

MISSISSIPPI

Clinton:
Mississippi College, 2

Hattiesburg:
University of Southern Mississippi

State College:
Mississippi State University

University:
University of Mississippi

MISSOURI

Columbia:
University of Missouri, 4

Kansas City:
University of Missouri, 3

Liberty:
William Jewell College, 2

Rolla:
University of Missouri, 5

St. Louis:
Notre Dame College
St. Louis University, 3
Washington University, 2

Springfield:
Drury College

MONTANA

Bozeman:
Montana State University, 2

Butte:
Montana College of Mineral Science and Technology

NEBRASKA

Hastings:
Hastings College, 2

Kearney:
Kearney State College, 4

Lincoln:
Nebraska Wesleyan University
University of Nebraska

Omaha:
Creighton University
Duchesne College
College of Saint Mary
University of Omaha

Wayne:
Wayne State College

NEVADA

Reno:
University of Nevada, 4

NEW HAMPSHIRE

Durham:
University of New Hampshire, 5

Hanover:
Dartmouth College

Manchester:
Saint Anselm's College, 4

NEW JERSEY

Convent Station:
College of St. Elizabeth, 2

East Orange:
Upsala College, 2

Glassboro:
Glassboro State College, 2

Hoboken:
Stevens Institute of Technology, 2

Jersey City:
St. Peter's College

Lakewood:
Georgian Court College

Lawrenceville:
Rider College

Madison:
Drew University, 3

Newark:
Newark College of Engineering, 4

New Brunswick:
Rutgers University, 8

South Orange:
Seton Hall University, 2

West Long Branch:
Monmouth College

NEW MEXICO

Albuquerque:
University of New Mexico, 6

Portales:
Eastern New Mexico University

Socorro:
New Mexico Institute of Mining and Technology, 3

NEW YORK

Albany:
State University of New York, 2

Aurora:
Wells College, 2

Binghamton:
State University of New York, 2

Briarcliff Manor:
The King's College, 2

Bronx:
Fordham University, 4
Hunter College, 3

Brooklyn:
Brooklyn College, 2
Long Island University, 2
Brooklyn Polytechnic Institute, 2
Pratt Institute

Buffalo:
D'Youville College
State University of New York, 2

Canton:
St. Lawrence University, 2

(New York - continued)

Clinton:
Hamilton College, 2

Cortland:
State University of New York, 5

Elmira:
Elmira College, 2

Flushing:
Queens College, 2

Fredonia:
State University College, 2

Garden City:
Adelphi University, 4

Greenvale:
C. W. Post College, 3

Hamilton:
Colgate University, 6

Ithaca:
Cornell University, 2

Jamaica:
St. John's University, 2

Loudonville:
Siena College, 2

New Rochelle:
Iona College, 2

New York City:
Barnard College
City College of New York, 2
Columbia University, 4
Hunter College, 2
New York University

Oswego:
State University College, 3

Potsdam:
Clarkson College, 2

Rochester:
Nazareth College of Rochester, 2
Rochester Institute of Technology, 3
St. John Fisher College
University of Rochester

St. Bonaventure:
St. Bonaventure University, 3

Saratoga Springs:
Skidmore College, 3

Schenectady:
Union College, 4

Stony Brook:
State University of New York, 3

Syracuse:
Le Moyne College
Syracuse University, 3

Tarrytown:
Marymount College, 2

Troy:
Rensselaer Polytechnic Institute, 4
Russell Sage College, 2

NORTH CAROLINA

Boone:
Appalachian State Teachers College, 2

Chapel Hill:
University of North Carolina, 2

Charlotte:
J. C. Smith University
Queens College, 3

Davidson:
Davidson College, 2

(North Carolina - continued)

Greensboro:
Bennett College, 2
University of North Carolina, 4

Greenville:
East Carolina Teachers College, 2

Hickory:
Lenoir Rhyne College, 2

Mars Hill:
Mars Hill College

Raleigh:
North Carolina State College, 5

NORTH DAKOTA

Dickinson:
Dickinson State College, 3

Fargo:
North Dakota State University, 4

Grand Forks:
University of North Dakota

Jamestown:
Jamestown College, 2

OHIO

Akron:
University of Akron, 2

Alliance:
Mount Vernon College, 2

Ashland:
Ashland College

Athens:
Ohio University, 4

Berea:
Baldwin Wallace College, 2

Bowling Green:
Bowling Green State University, 3

Cincinnati:
University of Cincinnati, 2
Xavier University, 3

Cleveland:
Case Technical Institute
John Carroll University, 4
Western Reserve University

Columbus:
Capital University, 2
Ohio State University, 4

Delaware:
Ohio Wesleyan University, 3

Gambier:
Kenyon College, 3

Granville:
Denison College, 2

Hiram:
Hiram College

Kent:
Kent State University, 4

Marietta:
Marietta College, 3

New Concord:
Muskingum College, 2

Oberlin:
Oberlin College, 2

Oxford:
Miami University, 3
Western College for Women

Springfield:
Wittenberg University, 4

Toledo:
University of Toledo, 5

(Ohio - continued)

Wilberforce:
Central State University, 3

Wooster:
College of Wooster

Yellow Springs:
Antioch College

OKLAHOMA

Bethany:
Bethany Nazarene College, 2

Edmond:
Central State College, 2

Norman:
University of Oklahoma, 2

Shawnee:
Oklahoma Baptist University, 2

Stillwater:
Oklahoma State University, 3

Weatherford:
Southwestern State College, 4

OREGON

Corvallis:
Oregon State University, 2

Eugene:
University of Oregon, 2

Portland:
Lewis and Clark College
Portland State College
Reed College
University of Portland, 2

PENNSYLVANIA

Allentown:
Muhlenberg College

Annville:
Lebanon Valley College, 2

Beaver Falls:
Geneva College

Bethlehem:
Lehigh University, 2

Bryn Mawr:
Bryn Mawr College

Carlisle:
Dickinson College, 2

Clarion:
Clarion State College, 3

Collegeville:
Ursinus College, 3

Easton:
Lafayette College, 4

Elizabethtown:
Elizabethtown College, 3

Erie:
Gannon College, 2

Gettysburg:
Gettysburg College, 2

Greensburg:
Seton Hall College

Greenville:
Thiel College, 3

Gwynedd Valley:
Gwynedd-Mercy College

Haverford:
Haverford College

Lancaster:
Franklin and Marshall College

Latrobe:
St. Vincent College

(Pennsylvania - continued)

Meadville:
Alleghany College

Millersville:
Millersville State College

Philadelphia:
Chestnut Hill College
Drexel Institute of Technology, 3
La Salle College, 4
Phila. College of Pharmacy and Science, 2
St. Joseph's College, 2
University of Pennsylvania, 3

Pittsburgh:
Carnegie Institute of Technology
Chatham College, 2
Duquesne University, 5
University of Pittsburgh, 3

Reading:
Alvernia College

Rosemont:
Rosemont College, 2

Scranton:
University of Scranton, 3

Swarthmore:
Swarthmore College

Villanova:
Villanova University, 3

Wilkes-Barre:
King's College
Wilkes College, 4

RHODE ISLAND

Providence:
Brown University
Providence College, 2

SOUTH CAROLINA

Charleston:
The Citadel, 5

Clemson:
Clemson University, 3

Columbia:
Columbia College
University of South Carolina, 4

Newberry:
Newberry College

Rock Hill:
Winthrop College, 4

Spartanburg:
Converse College
Wofford College

Sumter:
Morris College

SOUTH DAKOTA

Brookings:
South Dakota State University, 4

Rapid City:
South Dakota School of Mines and Technology, 3

Sioux Falls:
Augustana College, 3
Sioux Falls College, 2

Springfield:
Southern State College

Vermillion:
University of South Dakota, 2

TENNESSEE

Chattanooga:
University of Chattanooga, 2

Collegedale:
Southern Missionary College, 4

Cookeville:
Tennessee Polytechnic Institute, 5

Jackson:
Lambuth College
Lane College

Knoxville:
Knoxville College

Martin:
University of Tennessee, 4

Maryville:
Maryville College, 2

Memphis:
Memphis State University
Siena College
Southwestern at Memphis, 2

Murfreesboro:
Middle Tennessee State University, 5

Nashville:
David Lipscomb College, 4
Fisk University
Tennessee Agricultural and Industrial State University
Vanderbilt University, 2

TEXAS

Abilene:
Hardin Simmons University
McMurry College

Alpine:
Sul Ross State College, 2

Arlington:
Arlington State College, 5

Austin:
University of Texas, 2

Beaumont:
Lamar State College of Technology, 2

College Station:
Texas Agricultural and Mining University, 4

Commerce:
East Texas State University, 4

Dallas:
Southern Methodist University, 2
University of Dallas, 2

Denton:
North Texas State University, 4
Texas Women's University

Edinburg:
Pan American College, 2

El Paso:
Texas Western College, 3

Fort Worth:
Texas Christian University, 3

Houston:
Rice University, 2
Texas Southern University
University of Houston, 2
University of St. Thomas, 2

Huntsville:
Sam Houston State College, 5

Kingsville:
Texas Agricultural and Industrial College

Lubbock:
Texas Technological College, 4

(Texas - continued)

Marshall:
East Texas Baptist College

Nacogdoches:
Stephen F. Austin State College, 3

San Antonio:
Our Lady of the Lake College, 2
St. Mary's University

San Marcos:
Southwest Texas State College, 4

Stephenville:
Tarleton State College, 5

Waco:
Baylor University, 3

UTAH

Cedar City:
College of Southern Utah:

Logan:
Utah State University, 3

Salt Lake City:
University of Utah

VERMONT

Burlington:
University of Vermont, 3

Middlebury:
Middlebury College

Northfield:
Norwich University

VIRGINIA

Bridgewater:
Bridgewater College

Charlottesville:
University of Virginia, 3

Fredericksburg:
Mary Washington College, 5

Hampton:
Hampton Institute, 2

Harrisonburg:
Madison College

Lexington:
Washington and Lee University, 4

Lynchburg:
Randolph-Macon Woman's College, 2

Norfolk:
Old Dominion College, 4

Petersburg:
Virginia State College, 2

Portsmouth:
Frederick College, 2

Radford:
Radford College, 2

Richmond:
Richmond Professional Institute, 3

Sweet Briar:
Sweet Briar College, 2

WASHINGTON

Bellingham:
Western Washington State College, 4

Cheney:
Eastern Washington State College, 3

(Washington - continued)

Ellensburg:
Central Washington State College, 4

Pullman:
Washington State University

Seattle:
Seattle Pacific College, 2
Seattle University
University of Washington, 11

Spokane:
Gonzaga University, 4

Tacoma:
Pacific Lutheran University, 3
University of Puget Sound, 2

Walla Walla:
Whitman College

WEST VIRGINIA

Athens:
Concord College

Bethany:
Bethany College, 2

Charleston:
Morris Harvey College, 2

Elkins:
Davis and Elkins College, 2

Fairmont:
Fairmont State College, 2

Huntington:
Marshall University, 5

Institute:
West Virginia State College

Morgantown:
West Virginia University, 4

Wheeling:
Wheeling College, 2

WISCONSIN

Appleton:
Lawrence University

Beloit:
Beloit College, 2

Eau Claire:
Wisconsin State University, 5

Kenosha:
Carthage College, 2

La Crosse:
Wisconsin State University, 5

Ladysmith:
Mt. Senario College

Madison:
University of Wisconsin, 3

Milwaukee:
Alverno College, 4
Marquette University
Mount Mary College, 2
University of Milwaukee, 4

Oshkosh:
Wisconsin State University, 4

Platteville:
Wisconsin State University, 3

Ripon:
Ripon College, 2

Superior:
Wisconsin State University

West De Pere:
St. Norbert College, 2

(Wisconsin - continued)

Whitewater:
Wisconsin State University, 3

WYOMING

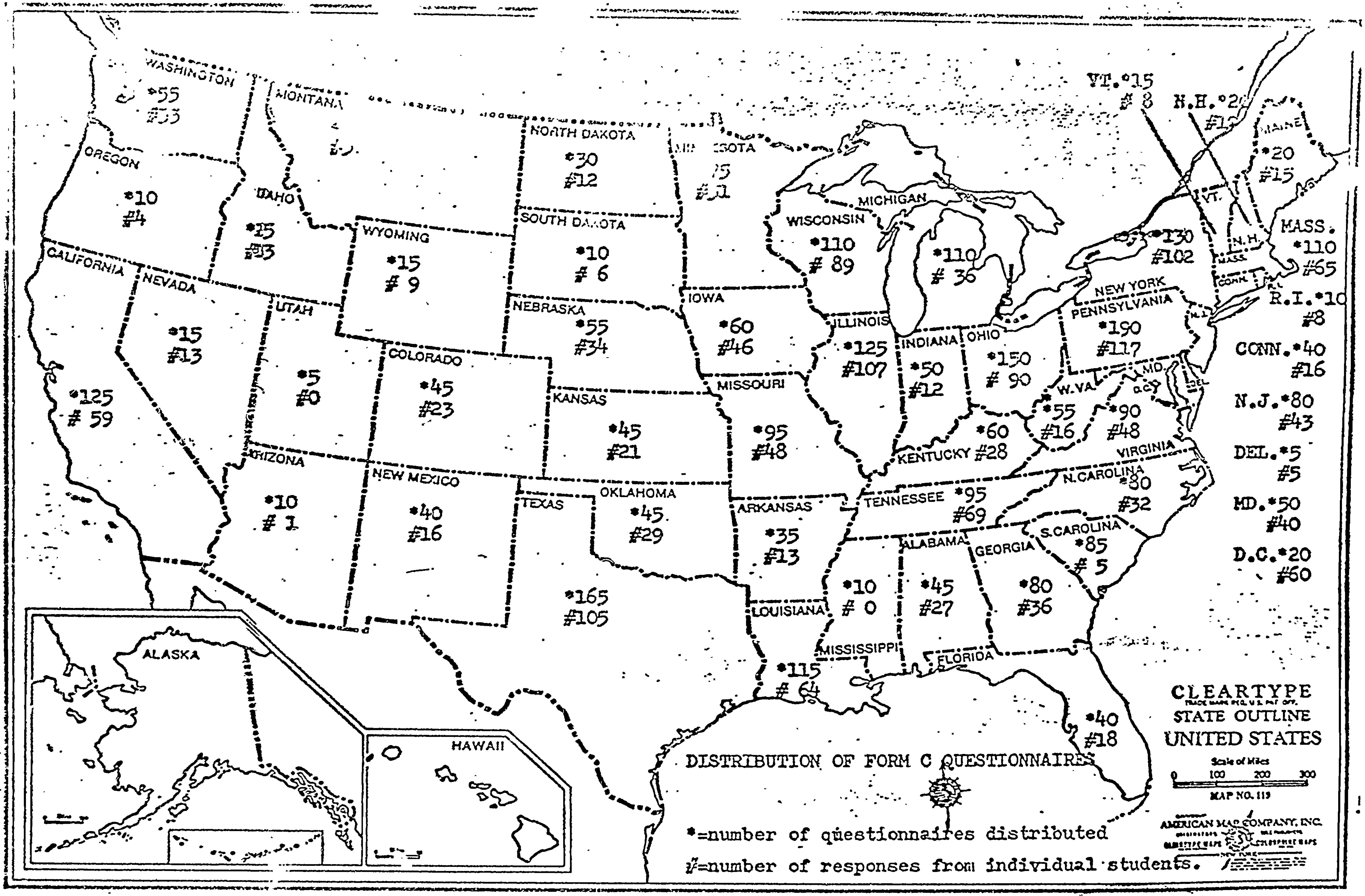
Laramie:
University of Wyoming, 4

DISTRIBUTION OF REQUESTS FROM COLLEGE INSTRUCTORS FOR FORM C (FIRST-YEAR COLLEGE CHEMISTRY STUDENTS) BY STATES

	Number		Number
Alabama	45	Nebraska	55
Arizona	10	Nevada	15
Arkansas	35	New Hampshire	20
California	125	New Jersey	80
Colorado	45	New Mexico	40
Connecticut	40	New York	130
Delaware	5	North Carolina	80
District of Columbia	20	North Dakota	30
Florida	40	Ohio	150
Georgia	80	Oklahoma	45
Idaho	25	Oregon	10
Illinois	125	Pennsylvania	190
Indiana	50	Rhode Island	10
Iowa	60	South Carolina	85
Kansas	45	South Dakota	10
Kentucky	60	Tennessee	95
Louisiana	115	Texas	165
Maine	20	Utah	5
Maryland	50	Vermont	15
Massachusetts	110	Virginia	90
Michigan	110	Washington	55
Minnesota	75	West Virginia	55
Mississippi	10	Wisconsin	110
Missouri	95	Wyoming	15
Montana	5	Total	3,000

DISTRIBUTION OF RESPONSES TO FORM C (FIRST-YEAR COLLEGE CHEMISTRY STUDENTS) BY STATES

	Number		Number
Alabama	27	Nebraska	34
Arizona	1	Nevada	13
Arkansas	13	New Hampshire	17
California	59	New Jersey	43
Colorado	23	New Mexico	16
Connecticut	16	New York	102
Delaware	5	North Carolina	32
District of Columbia	16	North Dakota	12
Florida	18	Ohio	90
Georgia	36	Oklahoma	29
Idaho	13	Oregon	4
Illinois	107	Pennsylvania	117
Indiana	12	Rhode Island	8
Iowa	46	South Carolina	5
Kansas	21	South Dakota	6
Kentucky	28	Tennessee	69
Louisiana	64	Texas	105
Maine	15	Utah	0
Maryland	40	Vermont	8
Massachusetts	65	Virginia	48
Michigan	36	Washington	33
Minnesota	31	West Virginia	16
Mississippi	0	Wisconsin	89
Missouri	48	Wyoming	9
Montana	5	Total	1,650


DISTRIBUTION OF FORM C QUESTIONNAIRES
*=number of questionnaires distributed
#=number of responses from individual students.
WASHINGTON *55 #33
OREGON *10 #4
CALIFORNIA *125 # 59
NEVADA *15 #13
IDAHO *15 #13
MONTANA
WYOMING *15 # 9
UTAH *5 #0
ARIZONA *10 # 1
COLORADO *45 #23
NEW MEXICO *40 #16
NORTH DAKOTA *30 #12
SOUTH DAKOTA *10 # 6
NEBRASKA *55 #34
KANSAS *45 #21
OKLAHOMA *45 #29
TEXAS *165 #105
MINNESOTA *15 #11
IOWA *60 #46
MISSOURI *95 #48
ARKANSAS *35 #13
LOUISIANA *115 # 64
WISCONSIN *110 # 89
ILLINOIS *125 #107
MICHIGAN *110 # 36
INDIANA *50 #12
OHIO *150 # 90
KENTUCKY *60 #28
TENNESSEE *95 #69
MISSISSIPPI *10 # 0
ALABAMA *45 #27
GEORGIA *80 #36
FLORIDA *40 #18
S.CAROLINA *85 # 5
N.CAROLINA *80 #32
VIRGINIA *90 #48
W.VA. *55 #16
PENNSYLVANIA *190 #117
NEW YORK *130 #102
VT. *15 # 8
N.H. *2 #1
MAINE *20 #15
MASS. *110 #65
R.I. *10 #8
CONN. *40 #16
N.J. *80 #43
DEL. *5 #5
MD. *50 #40
D.C. *20 #60
ALASKA
HAWAII
CLEARTYPE
STATE OUTLINE
UNITED STATES
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MAP NO. 119
AMERICAN MAP COMPANY, INC.

DISTRIBUTION OF RESPONSES TO FORM C
(FIRST-YEAR COLLEGE CHEMISTRY STUDENTS)
BY COLLEGES

ALABAMA

Athens:
Athens College, 1

Mobile:
Spring Hill College, 5

Montgomery:
Huntingdon College, 5

Troy:
Troy State College, 5

Tuskegee:
Tuskegee Institute, 9

University:
University of Alabama, 2

ARIZONA

Tempe:
Arizona State University, 1

ARKANSAS

Arkadelphia:
Ouachita Baptist University, 4

Fayetteville:
University of Arkansas, 9

CALIFORNIA

Angwin:
Pacific Union College, 7

Berkeley:
University of California, 4

Claremont:
Pomona College, 4

Fresno:
Fresno State College, 3

Riverside:
La Sierra College, 4

La Verne:
La Verne College, 4

Long Beach:
California State College, 1

Los Angeles:
Loyola University, 5
University of Southern California, 2

Pasadena:
Pasadena College, 1

Sacramento:
Sacramento State College, 8

St. Marys College:
St. Marys College, 5

San Diego:
California Western University, 2

Santa Barbara:
University of California, 4

Stockton:
University of the Pacific, 3

COLORADO

Denver:
Loretto Heights, 3

Fort Collins:
Colorado State University, 4

(Colorado - continued)

Golden:
Colorado School of Mines, 4

Pueblo:
Southern Colorado State College, 12

CONNECTICUT

Bridgeport:
University of Bridgeport, 9

Hartford:
University of Hartford, 3

New Haven:
Yale University, 4

DELAWARE

Dover:
Delaware State College, 5

DISTRICT OF COLUMBIA

Gallaudet College, 3
Howard University, 13

FLORIDA

Daytona Beach:
Bethune-Cookman College, 4

Jacksonville:
Jacksonville University, 5

Tallahassee:
Florida State University, 4

Tampa:
University of South Florida, 5

GEORGIA

Athens:
University of Georgia, 5

Atlanta:
Emory University, 9
Georgia State College, 4

Macon:
Mercer College, 8

Savannah:
Savannah State College, 5

Valdosta:
Valdosta State College, 5

IDAHO

Moscow:
University of Idaho, 13

ILLINOIS

Carlinville:
Blackburn College, 5

Champaign:
University of Illinois, 3

Charleston:
Eastern Illinois University, 9

Chicago:
De Paul University, 4
Illinois Institute of Technology, 10
Roosevelt University, 5

Decatur:
Millikin University, 13

De Kalb:
Northern Illinois University, 5

(Illinois - continued)

Elmhurst:
Elmhurst College, 4

Jacksonville:
Illinois College, 4

Lake Forest:
Lake Forest College, 5

Lisle:
St. Procopius College, 5

Monmouth:
Monmouth College, 5

Naperville:
North Central College, 4

Normal:
Illinois State University, 5

Quincy:
Quincy College, 5

Urbana:
University of Illinois, 2

Wheaton:
Wheaton College, 14

INDIANA

Angola:
Tri-State College, 4

Evansville:
Evansville College, 4

Fort Wayne:
Indiana Institute of Technology, 4

IOWA

Ames:
Iowa State University, 5

Cedar Rapids:
Coe College, 4

Davenport:
St. Ambrose College, 5

Des Moines:
Drake University, 4

Grinnell:
Grinnell College, 9

Indianola:
Simpson College, 4

Mount Vernon:
Cornell College, 5

Sioux City:
Morningside College, 10

KANSAS

Emporia:
College of Emporia, 5

Lawrence:
University of Kansas, 4

Pittsburg:
Kansas State College, 12

KENTUCKY

Bowling Green:
Western Kentucky State College, 5

Louisville:
Catherine Spalding College, 3

Lexington:
University of Kentucky, 9

Murray:
Murray State College, 1

Richmond:
Eastern Kentucky State College, 10

LOUISIANA

Baton Rouge:
Louisiana State University, 3

Hammond:
Southeastern Louisiana College, 8

Lafayette:
University of Southwestern Louisiana, 6

Monroe:
Northeast Louisiana State College, 6

New Orleans:
Louisiana State University, 7
St. Mary's Dominican College, 2
Tulane University, 15

Ruston:
Louisiana Polytechnic Institute, 5

Shreveport:
Centenary College, 12

MAINE

Biddeford:
St. Francis College, 6

Brunswick:
Bowdoin College, 5

North Windham:
St. Joseph's College, 4

MARYLAND

Baltimore:
Loyola College, 5
Morgan State College, 5

Emmitsburg:
Mount St. Mary's College, 5
St. Joseph's College, 5

Frederick:
Hood College, 10

Princess Anne:
Maryland State College, 5

Towson:
Goucher College, 5

MASSACHUSETTS

Amherst:
University of Massachusetts, 5

Boston:
Northeastern University, 4
Simmons College, 5

Northampton:
Smith College, 2

North Andover:
Merrimack, 5

North Dartmouth:
Southeastern Massachusetts Technological Institute, 3

Norton:
Wheaton College, 5

South Lancaster:
Atlantic Union College, 5

Springfield:
Western New England College, 5

Waltham:
Brandeis, 5

Weston:
Regis College, 5

Wollaston:
Eastern Nazarene College, 4

Worcester:
Assumption College, 5
Clark University, 2
Holy Cross College, 5

MICHIGAN

Adrian:
Siena Heights College, 5

Berrien Springs:
Andrews University, 5

Detroit:
Lawrence Institute of Technology, 2
University of Detroit, 3

Flint:
General Motors Institute, 6

Grand Rapids:
Aquinas College, 5

Kalamazoo:
Western Michigan University, 4

Mt. Pleasant:
Central Michigan University, 4

Ypsilanti:
Eastern Michigan University, 2

MINNESOTA

Duluth:
University of Minnesota, 4

Mankato:
Mankato State College, 9

Minneapolis:
Augsburg College, 3
University of Minnesota, 4

St. Cloud:
St. Cloud State College, 4

St. Paul
College of St. Catherine, 2

Winona:
College of St. Teresa, 5

MISSOURI

Cape Girardeau:
Southeast Missouri State College, 5

Columbia:
University of Missouri, 13

Liberty:
William Jewell College, 5

Rolla:
University of Missouri, 19

St. Louis:
Notre Dame College, 5

MONTANA

Butte:
Montana College of Mining and Technology, 5

NEBRASKA

Hastings:
Hastings College, 3

Kearney:
Kearney State College, 15

Lincoln:
University of Nebraska, 3

Omaha:
College of St. Mary, 5
Duchesne College, 2
Omaha University, 1

Wayne:
Wayne State College, 5

NEVADA

Reno:
University of Nevada, 13

NEW HAMPSHIRE

Durham:
University of New Hampshire, 12

Manchester:
St. Anselm's College, 5

NEW JERSEY

Convent Station:
College of St. Elizabeth, 5

East Orange:
Upsala College, 5

Lakewood:
Georgian Court College, 5

Newark:
Newark College of Engineering, 5

New Brunswick:
Douglass College, 11

South Orange:
Seton Hall University, 7

Trenton:
Rider College, 5

NEW MEXICO

Albuquerque:
University of New Mexico, 12

Socorro:
New Mexico Institute of Mining and Technology, 4

NEW YORK

Albany:
State University of New York, 5

Aurora:
Wells College, 4

Bronx:
Fordham University, 12
Hunter College, 5

Brooklyn:
Long Island University, 4
Polytechnic Institute of Brooklyn, 5
Pratt Institute, 1

Cortland:
State University of New York, 5

Fredonia:
State University of New York, 5

Garden City:
Adelphi University, 5

Greenvale:
C. W. Post College, 3

Ithaca:
Cornell University, 7

New York City:
Columbia University, 7

Potsdam:
Clarkson College of Technology, 5

Rochester:
Rochester Institute of Technology, 5

St. Bonaventure:
St. Bonaventure University, 4

Schenectady:
Union College, 5

Troy:
Rensselaer Polytechnic Institute, 4
Russell Sage College, 4

NORTH CAROLINA

Boone:
Appalachian State Teachers College, 3

Charlotte:
Johnson C. Smith University, 2
Queens College, 4

Greensboro:
University of North Carolina, 12

Hickory:
Lenoir Rhyne College, 3

Raleigh:
North Carolina State University, 8

NORTH DAKOTA

Dickinson:
Dickinson State College, 7

Grand Forks:
University of North Dakota, 5

OHIO

Berea:
Baldwin-Wallace College, 8

Bowling Green:
Bowling Green University, 5

Cincinnati:
Xavier University, 14

Cleveland:
John Carroll University, 10

Delaware:
Ohio Wesleyan University, 6

Granville:
Denison University, 5

New Concord:
Muskingum College, 9

Oxford:
Miami University, 5
Western College for Women, 3

Springfield:
Wittenberg University, 5

Toledo:
University of Toledo, 20

OKLAHOMA

Bethany:
Bethany Nazarene College, 5

Edmond:
Central State College, 7

Norman:
University of Oklahoma, 3

Shawnee:
Oklahoma Baptist University, 4

Stillwater:
Oklahoma State University, 10

OREGON

Corvallis:
Oregon State University, 4

PENNSYLVANIA:

Carlisle:
Dickinson College, 3

Clarion:
Clarion State College, 14

Collegeville:
Ursinus College, 6

Elizabethtown:
Elizabethtown College, 9

Gettysburg:
Gettysburg College, 5

(Pennsylvania - continued)

Greensburg:
Seton Hill College, 5

Greenville:
Thiel College, 3

Gwynedd Valley:
Gwynedd Mercy College, 5

Lancaster:
Franklin and Marshall College, 5

Latrobe:
St. Vincent College, 5

Millersville:
Millersville State College, 4

Philadelphia:
Chestnut Hill College, 5
Drexel Institute of Technology, 2
La Salle College, 14
Philadelphia College of Pharmacy, 5
St. Joseph's College, 3

Pittsburgh:
Chatham College, 4

Rosemont:
Rosemont College, 5

Scranton:
University of Scranton, 11

Wilkes-Barre:
Wilkes College, 4

RHODE ISLAND

Providence:
Brown University, 2
Pembroke College, 2
Providence College, 4

SOUTH CAROLINA

Clemson:
Clemson University, 5

SOUTH DAKOTA

Sioux Falls:
Sioux Falls College, 3

Vermillion:
University of South Dakota, 3

TENNESSEE

Chattanooga:
University of Chattanooga, 5

Collegedale:
Southern Missionary College, 15

Jackson:
Lambuth College, 5

Martin:
University of Tennessee, 9

Maryville:
Maryville College, 5

Memphis:
Siena College, 3
Southwestern at Memphis, 4

Murfreesboro:
Middle Tennessee State University, 12

Nashville:
David Lipscomb College, 9

TEXAS

Abilene:
McMurry College, 5

College Station:
Texas Agricultural and Mining, 9

Commerce:
East Texas State University, 5

Denton:
North Texas State University, 6

(Texas - continued)

Edinburg:
Pan American College, 10

El Paso:
Texas Western College, 5

Fort Worth:
Texas Christian University, 4

Houston:
Rice University, 4
St. Thomas University, 4
University of Houston, 4

Huntsville:
Sam Houston State College, 12

Lubbock:
Texas Technological College, 6

Marshall:
East Texas Baptist College, 5

San Antonio:
St. Mary's University, 5
Our Lady of the Lake College, 5

San Marcos:
Southwest Texas State College, 10

Stephenville:
Tarleton State College, 4

VERMONT

Burlington:
University of Vermont, 3

Middlebury:
Middlebury College, 5

VIRGINIA

Fredericksburg:
Mary Washington College, 14

Hampton:
Hampton Institute, 4

Norfolk:
Old Dominion College, 13

Petersburg:
Virginia State College, 4

Richmond:
Richmond Professional Institute, 9
Virginia Polytechnic Institute Extension, 1

Sweet Briar:
Sweet Briar College, 1

WASHINGTON:

Cheney:
Eastern Washington State College, 10

Ellensburg:
Central Washington State College, 5

Seattle:
Seattle Pacific College, 5

Spokane:
Gonzaga University, 8

Walla Walla:
Whitman College, 5

WEST VIRGINIA

Huntington:
Marshall University, 13

Wheeling:
Wheeling College, 3

WISCONSIN

Eau Claire:
Eau Claire State College, 3
Wisconsin State University, 5

(Wisconsin - continued)

Kenosha:
Carthage College, 10

La Crosse:
La Crosse State University, 5
Wisconsin State University, 14

Ladysmith:
Mount Senario College, 5

Madison:
University of Wisconsin, 5

Milwaukee:
Alverno College, 5
Mount Mary College, 7

Oshkosh:
Wisconsin State University, 13

Ripon:
Ripon College, 3

West De Pere:
St. Norbert College, 10

Whitewater:
Wisconsin State University, 2

WYOMING

Laramie:
University of Wyoming, 9

APPENDIX F

THE t TEST AND THE STANDARD ERROR OF DIFFERENCE BETWEEN THE PROPORTIONS

APPENDIX F

The standard error of difference between the proportions in two independent populations may be found as follows:

$$\sigma\, p_1 - p_2 = \sqrt{\frac{p_1\, q_1}{n_1} + \frac{p_2\, q_2}{n_2}}$$

p_1 = proportion 1
p_2 = proportion 2
q_1 = $1-p_1$
q_2 = $1-p_2$
n_1 = population 1
n_2 = population 2

The "t-test" value may be found as follows:

$$t = \frac{p_1 - p_2}{\sigma}$$

SAMPLE PROBLEM TAKEN FROM THIS STUDY:

$$\sigma = \sqrt{\frac{.884 \times .116}{1245} + \frac{.849 \times .151}{1993}}$$

$$\sigma = \sqrt{.000064 + .000083}$$

$$\sigma = \sqrt{.000147}$$

$$\sigma = .012$$

p_1 = 88.4% = .884
q_1 = 1-.884 = .116
n_1 = 1245
p_2 = 84.9% = .849
q_2 = 1-.849 = .151
n_2 = 1993

$$t = \frac{.884 - .849}{.012}$$

$$t = 2.9$$

NOTE: (A "t-test" of 2.9 is significant beyond the .01 level.)