AIMS AND OBJECTIVES FOR AN INITIAL COURSE IN COLLEGE CHEMISTRY DESIGNED FOR THE NON-SCIENCE MAJOR

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CHAPTER I

THE PROBLEM

For the last twenty-five years there has been a steadily increasing interest in science as a part of the cultural background for all students at the college level. Major emphasis has been directed toward making the college course in science for the non-science major one that is of functional as well as of esthetic value. Much thought and study has been focused upon the attempt to determine which of the five basic natural science courses of study or which combination of courses--physics, chemistry, biology, astronomy, or geology--offers the most in fulfilling the educational needs of the majority of students.

The importance of science in a democratic society was recognized by Thomas Jefferson when he said:

> While the art of printing is left to us, science can never be retrograde; what is once acquired of real knowledge can never be lost. To preserve the freedom of the press every spirit should be ready to devote itself to martyrdom; for as long as we may think as we will, and speak as we think, the condition of man will proceed in improvement (46--p. 108).

Conant was more explicit about the need of science at the present time. He said:

> ...we need a widespread understanding of science in this country, for only thus can science be assimilated into our secular cultural pattern. When that has been achieved, we

shall be one step nearer the goal which we now desire so earnestly, a unified, coherent culture suitable for our American democracy in this new age of machines and experts (33--p. 3).

A failure to assimilate science into western culture possibly might explain why so many feel spiritually lost in the modern world.

Once an object has been assimilated, it is no longer alien; once an idea has been absorbed and incorporated into an integrated complex of ideas, the erstwhile foreign intruder becomes an element of strength. And in this process of assimilation, labels may well disappear. When what we now roughly designate as science has been fully assimilated into our cultural stream, we shall perhaps no longer use the word as we do today. When this time arrives, as I have no doubt it will, the subject (understanding science) will be fused into the age-old problem of understanding man and his works: in short, secular education (33--p. 2).

In times past, subject matter was taught upon an authoritarian basis. In earlier times, the teacher was the point of focus, but later the subject matter became the primary focal point. Today, the student and the welfare of the student are taking the center of the stage. Motivation has changed from placing emphasis upon extrinsic methods to emphasizing intrinsic methods. As a case in point, until the twentieth century, chemistry was taught for its disciplinary qualities. As a course of study, chemistry was for chemistry majors only and was taught to those other than majors as a curious study of natural phenomena only. Today, the view is apparently becoming that of Nash, who said:

The objective of a science course...is to present science as a part of our civilization (not simply as a basis of technology), as a rich part of our cultural heritage, and as one of the intensely creative aspects of human endeavor. ...we do not teach scientific facts and theories for their own sake, but as a means toward the end of an understanding of science; and ... we must not hope to teach the persistent characteristics of the scientific enterprise in a pat, capulated form ... (32--p. 97).

McGrath summed up the general feeling of leaders in the field of science in general education by saying, "Courses in the physical sciences should ... be pertinent to the student's life." (43--p. 22)

Within the last decade, there probably have been more college level investigations and evaluation of the sciences for general educational purposes than at any time in history. There have been symposiums, workshops, and investigative reports on a national scale that are producing much thought and talk among the leaders in science education. Newer theories of learning processes, psychological studies of mental functions, improved methods of testing, and changing of the focal point from teacher and subject matter to student and student welfare have all contributed their share to the changes being made. McGrath (43--p. 4) pointed out the changes taking place by emphasizing the fact that many teachers still have the persistent idea that a thorough grounding in science gives the student a concept of the nature of science and that training in memorizing facts transfers to other fields. This misconception has been disproved completely by some of the leading educational psychologists of the present time. Generalizations that are understood transfer more readily than merely memorized facts. A concept of the student as to the applicability of a generalization in several fields may help transfer of training by pointing out applications. However, as stated by McGrath:

> An almost essential lubricant for the process of generalization is the emotional attachment the student develops--the extent to which he associates feelings of enjoyment, interest, inspiration with his studies. The more he likes discussing its philosophy, the more likely he is to retain and generalize the teaching (43--p. 6).

The expressed concerns of such contemporary leaders in the field of science in general education as McGrath, Conant, Alyea, and a host of others, the dissatisfactions expressed both in words and actions by teachers in the field of elementary science at the college level, and the experimentations with various science courses for both cultural and utilitarian value designed to fill the needs of the student majoring in fields other than professional science all indicate a need for a study of science in the present educational program.

Before an answer can be obtained as to what subject matter should be presented in an initial course of college science designed for the non-science major, there must be specific aims and objectives set forth for such a course of study. If such educational aims and objectives can be obtained, and if there can be a measure of agreement upon these aims and objectives, then the content that can be used best to attain these ends sought may be selected.

Since the basic principles of chemistry are applicable to all the other natural sciences, the question arises as to whether or not an initial course of college chemistry can be designed and used to reach the desired educational aims and objectives for a specific group, i.e., those who are not science majors and those undecided as to a major field of study.

Statement of the Problem

The problem with which this study is concerned is: What should be the outcomes of an initial course of college chemistry designed for those desiring a cultural background in natural science?

Need for the Study

The development of the complicated social and economic life of today has forced the realization among many educators that some comprehension of science is a necessity for an active citizen who is to live and contribute to the technological age in which he lives. Out of this realization has come the conviction that it is a duty of colleges and universities to make available to students a form of training in science that is adapted to the needs of all citizens. It should not be restricted to technical training for the specialists, although students endowed with natural aptitudes for scientific study must be identified and must be attracted to specialized study in the various fields of science. On the other hand, there is almost universal agreement that all persons need some scientific concepts, and there is also agreement that not all should be specialized scientists.

McGrath has this to say about the uncertainty of leaders in higher education as to the best plan to pursue in offering the youth of today a curriculum that will best fit the needs of present and future citizens:

Higher education is in a state of ferment. There is scarcely a college in the country that is not at present re-examining its purposes and its program. Already a host of institutions have launched new programs intended to improve the preparation of youth for life in a highly complex and troubled world. Most of these new ventures have to do with general education, that which prepares young people for their common activities as citizens in a free society. Concerning the objectives (broad and general type) of general education, there seems to be an increasing agreement. Wide divergence of opinion still exists, however, with regard to the means that should be employed to reach the desired goals... (43--p. ii).

Dubos thinks that any program aimed at fostering a general interest in science among the public at large must recognize that individuals have no right to expect others to be interested in the tricks of their specialized trades (32--p. 5). To popularize science, a program must be worked out that will present to the public those aspects of science activities that possess broad human values. The public must be attracted by those scientific phases of work that affect their well-being and social advancement, or, as Conant expresses it, one should "relate development in natural science to those in the other fields of activity" (35--p. 4).

A study by Schenberg shows that, in 1952 in all New York City high schools, only 17.4 per cent of junior and senior students were taking chemistry. Other studies in various areas of the nation show that the percentage of freshmen who have had chemistry before entering college range as low as 7.6 per cent to as high as 30 per cent with the figure in most cases being toward the lower end of the range of these percentages (113). The above indications are that most students entering college have not taken, or had the opportunity to take, a course in chemistry. The percentages run somewhat higher for biology and lower for physics. Most students have little or no understanding of the opportunities science offers for widening their horizons. There are thousands of these students who doubtlessly have the ability to become specialists in one of the fields of science, but their experiences have not been such as to arouse their curiosity and desire to major in a field unknown to them.

There seems to be almost universal agreement that something needs to be done to encourage young people to investigate further the opportunities for vocational careers in the sciences. The general education program of the colleges and universities has fallen heir to this task. The responsibility has been placed upon the science divisions and administrators of colleges to provide a science program that has broader aims than merely making chemists or physicists or biologists. They must encourage student interest in these professions.

This new responsibility entails a revision (11--p. 66) of the philosophy of scientists in general, most of whom ceased trying to interpret sciences to the laymen in the nineteenth century when science broke up into highly specialized subdivisions. McGrath (44--p. 11) describes the present orthodox, natural science courses in a single field as following a small, narrow stripe across the whole area of natural sciences and covering the subject matter in this narrow band or stripe as thoroughly as time and the students' preparation will permit. Usually, these courses have a single over-all aim of laying a foundation for later courses. All of the supposedly important topics are treated, in turn, often with little time to show their consequences or their interrelations. These courses of study are generally well packed with content, but they do little to help the student develop adequate understanding of the nature of science.

On the other hand, one type of the so-called survey course mentions so many topics from the whole realm of sciences, with barely a thread of connection, that it is a "smorgasbord course." This type of course is dangerous in that it does too little to show the structure of science and tends to glorify the wonders of science. Glorification of science or scientists gives the wrong impression to students. Teachers of science should debunk the popular impression that the scientist is a wizard and that all science works miracles.

Many plans for meeting the student's needs have been tried within the last few years. One innovation has been the so-called survey course attempting to integrate all fields of natural science into a course or series of courses for the non-science major. However, a survey (130) of 234 members of the Southern Association of Colleges showed that only 50 per cent of senior colleges and 60 per cent of the junior colleges accept integrated or survey courses toward graduation, and some of these accept the survey course only under certain conditions. Only 34 per cent of the senior colleges accepted survey courses as fulfilling the science requirement under any conditions. Fifteen of the colleges surveyed had discontinued integrated or survey courses after starting them. Various reasons have been given for this dissatisfaction with survey courses. Among these reasons are:

1. All teachers try to drag in and stress their own pet subjects (78).
2. There is failure to have the ends of the course in mind before designing the means, but the means available should be known before selecting the ends (116).
3. Teachers trained to teach in the survey fields are scarce (44--p. 188).
4. So many facts are to be found in a survey course that real teaching for change in the behavior of the student is lost in the rush of presenting

facts. Often these facts are so isolated as to offer very little in the way of generalizations and principles (44--p. 13).

5. The courses are too "watered down" to be of real value.

The above reasons, along with others, are offered so often for not having survey courses that the praises for successful courses of this type are outnumbered at times by the negative criticisms. Quite a few have the same opinion as Chalmers who said, "Survey courses are superficial, trivial and unscientific ... but (for general education) better than the specialized courses." (30--p. 1)

Other plans than survey courses have been tried. For example, professors at Harvard and the University of Chicago have tried teaching chemistry from original papers but have found that too often these papers have few present day applications, or they often are presented in terms difficult to understand.

The argument has been presented that the student who knows basic phases of one science well is better equipped than one who has been exposed to the whole field of science but has little understanding of any science (78). Pearson was one of the first to advocate what is now known as the "block-and-gap" method of teaching (48). His argument was that the logical structure of any science or of science as a whole or of science's method of dispassionate investigation could be understood best by using all facets of one science.

McGrath (44--p. 15) also appreciated the "block-and-gap" principle for general education. He described the method as follows:

This may be a single science or ... a mixture. Its essential characteristic is that large quantities of material are omitted outright so that only some of the topics of an orthodox course ... are dealt with ... . Those (topics) included are treated thoroughly as to subject matter. The blocks representing such topics are dense ... and extend out toward other topics and other sciences ... . These blocks are clearly related to other blocks. ... the gaps are essential ... they reduce the content of the course so that there is time for discussion, time for ideas to sink in, and time for the student to look back and reconsider ... .

Conant thinks a greater degree of understanding of science might be achieved by the close study of a relatively few historical examples of the development of science (33--p. 16). Wendt believes that a broad (not deep) insight may be obtained by the student through surveying a relatively small number of basic principles from one field of science which illuminate facts. He says that it is apparent that within the coming decade an elementary understanding of chemistry will be as necessary as wood lore to the Indians (129). If this is true, then a chemistry course may be so organized and presented as to fill the need for factual material with which to define those principles and concepts necessary for twentieth century living in a free society.

Sy said:

Everybody ought to know some chemistry, some ought to know more, and some ought to know as much as they possibly can. This will follow when the subject is presented more attractively to the beginner. A genuine interest is necessary ... (24).

The above facts and opinions and others of like nature lead to the conclusion that the broad aim of basic understanding of science on the part of the student might be attained more readily by studying a few related phases of science rather than either the extensive study of professional techniques and facts or of a superficial summary of all science.

Chemists have a talking point for chemistry being selected as an excellent course of study for the non-science major since it is actually a derived course taken from and used in all other fields of natural science (56). There are no sharp lines of demarcation between chemistry and any other natural science (56). However, chemistry is the only course taken by the great majority of students in which they learn of the structure and behavior of matter of which their environment is composed (64).

Newland (99) found a total of 2,490 different allusions to science in 201 issues of popular magazines. There were 24,022 attendant meanings or contexts. Of these contexts, most were pertinent to health, food in relation to health, and household appliances. Most of the allusions were made directly to ideas or concepts that are or could be incorporated into an initial course of college chemistry. Taylor sums up the situation as it now exists in this manner:

Today a wide and early "appreciation" of science is no less than a matter of life and death for our civilization. ... ever since the day of early general science and science survey courses, a general feeling seems to have been abroad that scientific appreciation can be attained only by exposure to a potpouri of at least several of the basic sciences. There is no doubt a great deal to be said for this point of view. Certainly no one of the sciences has a monopoly on the "scientific method" and there could conceivably be some notable advantages in approaching that elusive concept from several angles. ... but standing in the way of general use of a multiple-science approach is an almost complete lack of properly qualified teachers. ... science teachers are at present almost exclusively single-subject specialists. ... the typical teacher now in the profession is much better prepared ... for ... the single-science type of scientific appreciation course. He has at least the science-subject-matter foundation on which to build the historical, philosophical, and the educational superstructure of appreciation. ... the single-science course, ... broadened to meet the current need, may not be the final solution of the problem of inculcating a wide general appreciation of science. But as a short-range measure, it seems to constitute a solution to the dilemma created by the urgency of time. This urgency puts a heavy premium on the maximum use of existing channels of instruction... (44--p. 188).

Such statements as the above emphasize the need of immediate attention by all interested educators to the course or courses that offer the most to a general education program.

Instructors now teaching science and all students who plan to teach science in the future should be made aware of the existing problem of a shortage of qualified teachers within the field of science for general education purposes.

The first step in organizing the kind of course in chemistry designed for fulfilling the educational needs for all college students in the formulation of definitive statements of aims and objectives. After this is done, subject matter may be judiciously chosen, methods of teaching evolved, and a system of testing developed to evaluate outcomes.

An obvious source of statements of aims and objectives for an initial course in college chemistry should be the general course in college chemistry, but such statements are lacking. Without unity of purpose, science education cannot be what it ought to be (69). Lack of unity of purposes among teachers has caused lack of uniformity in courses (62--p. 112). At the present time, there are numerous statements of aims and objectives, but they are too often of such a generalized nature that they have little meaning within themselves. There is no clear definition of the aims and objectives of general educational chemistry (89). This has been a realized truth for almost two decades. In many of the national meetings for discussion of aims and objectives of an initial course in chemistry, broad aims have been agreed upon generally, but a comprehensive and evaluated list of specific, workable aims, covering the various facets and aspects of an initial course in college chemistry, has yet to make its appearance. Since differences in aims are likely to lead to differences of treatment (44--p. 5), the first task that must be attempted is to determine a consensus as to what these aims and objectives might be. McGrath reports that committees have succeeded in evolving statements of aims, but these statements are too impractical or too long (44--p. 4). As a result, all of the aims that are at this time agreed upon are those broad and general aims that offer little as goals for definite and specific accomplishment.

Since differences in aims are likely to lead to differences in treatment (44--p. 4), the first task in the development of the kind of chemistry course that can fill the needs of a general education program is the clear-cut statement of its aims and objectives. An obvious and practicable source is a consensus of college teachers and workers in the field.

Purposes of the Study

The study has the following primary purposes:

1. To identify, by consensus, the outcomes that should be expected from an initial course in college chemistry.
2. To ascertain the differences and similarities between a population of college teachers of education and a population of college teachers of chemistry as to desirable aims and objectives for an initial course in college chemistry.
3. To ascertain the differences and similarities between teachers of chemistry in large colleges and those in small colleges as to the desirable aims and objectives for an initial course in college chemistry.

Limitations

This study is concerned with the aims and objectives of science in an educational program designed for all college students. It is concerned particularly about these aims and objectives as they may be applied to an initial course in chemistry. Each of the aims must apply to students and must be stated in terms of recognizable evidence for changes in the behavior of students.

No attempt is made to make subject matter, methods, or tests of outcomes of a course in chemistry more than of incidental importance in this study. However, it is hoped that the results of the study may serve as criteria for an evaluation and selection of subject matter, methods, and testing procedures.

Assumptions

There are at least two general propositions concerning science in a background education or general education program upon which there is general agreement (93). First, science is a necessary part of a general or secular education and, second, for most non-science majors a different kind of course is needed from the traditional specialized courses provided in the various science departments. Other propositions (44--p. 64) pertaining to course content that are agreed upon generally are that some emphasis on scientific methods and attitudes is desirable, the block-and-gap intensive study of a few topics is more rewarding than either a superficial survey or a diluted orthodox course, and that physical sciences are better taught separately from the biological sciences. Assuming chemistry can fill the felt needs for science in an educational program, there must be a clear statement of outcomes desired before a different kind of course can be either organized and presented or evaluated, for the aims and objectives certainly will determine the outcomes.

A brief summary of assumptions used in the study may be stated thus:

1. A basic contribution to the education of any college student can be found in chemistry as a fundamental aspect of that phase of human culture known as natural science.
2. An initial course in chemistry can be presented in such a manner as to fill the needs of a generalized background for non-science majors.

Sources of Data

The data for this study have been secured and compiled from the following sources:

1. Nineteenth century and current textbooks in college chemistry.
2. Reports from chemistry workshop meetings of groups within the American Chemical Society.

3. Literature and studies related to the study.
4. Evaluation and judgments of teachers of an initial course in college chemistry and of college teachers in professional education.

Definition of Terms

1. Outcome: degree of attainment of the stated aims and objectives. Outcomes include the attainment of values, attitudes, concepts, techniques, and understandings.
2. Course of Study: an order, sequence, and scope of experiences in presented facts, activities, methods of procedure, principles, concepts, and appreciations to be offered in an integrated field of work.
3. Initial Experience in College Chemistry: the students' first contacts with a formal course of college chemistry.
4. Natural Sciences: the collective branches of knowledge which deal with biological fields and matter and energy phenomena. Natural sciences include fields of study designated as physics, chemistry, biology, astronomy, geology, and other related fields.
5. General Education: that accumulation of knowledge and understandings which prepares young people for their common activities in a free society.

Working Hypotheses

1. There is a consensus as to the desired aims and objectives of such a course. A properly planned survey should reveal such a consensus.
2. In addition, the hypothesis was made that there are differences of opinion as well as a community of interest in the various aims and objectives that may be advanced as an ideal. These differences and likenesses may be not only in the individual items, but also in the relative importance of such items. The variances and similarities exist between populations from (1) different teaching fields and (2) the same teaching field when the colleges are grouped into large and small colleges.

Outline of Procedure

The procedure for this study consisted of two phases. The first phase was composed of two steps. The first step consisted of a collection of specific aims from the various available sources. In the second step, these were restated and were placed in four categories. This list of aims was used as a starting point for the second phase of the study.

The second phase was concerned primarily with obtaining a consensus as to what the educational aims and objectives of an initial course in chemistry should be. A questionnaire with a rating scale constructed from the lists of aims and objectives obtained from various sources was reviewed, criticized, modified, and corrected by three different groups of respondents before being sent to juries distributed throughout the United States. The judgments of the college teachers of chemistry and teachers of professional education were summarized statistically. Findings of fact were identified, and conclusions were drawn.

Organization of the Study

Chapter I is an introduction to the study. In it the problem is stated. The need for the study, basic assumptions, purposes of the study, limitations of the study, definitions of terms, procedure of the study, and organization of the study are given. In Chapter II the assumptions, (1) there is need for some science in a general education program, (2) a classical chemistry course fails to fill this need, and (3) an initial course in college chemistry can be designed to fill the present day need for science in general education, are defended. In Chapter III, procedure is described for collecting a list of aims and objectives for an initial course in college chemistry designed for general educational purposes. Chapter IV is a continuation of procedure in which the method for development of a questionnaire for final juries is described. The manner of selecting the test population is given.

Chapter V is a description of the treatment of data gathered from the respondents. Conclusions are reported in Chapter VI.

CHAPTER II

THE INITIAL COURSE IN COLLEGE CHEMISTRY AS A PART OF GENERAL EDUCATION

The aims and objectives of scientists of the past are to be found implied in the annals of history. Contributions of scientists throughout recorded history ranged from the wholly practical to the completely philosophical viewpoint--from the utility of material applications to mysticism and abstruse theories. Apparent aims varied as philosophies of people changed. The culture and prosperity of the people generally dictated the direction and magnitude of the early scientists' efforts. Endeavors of the alchemists were directed primarily toward discovering and using secret formulae for the benefit and enrichment of the few. The sixteenth century philosopher, doctor, and experimenter, Paracelsus, has the honor of separating the mystical, secret work of the alchemist from true chemical experimentation. His efforts were directed toward finding medicines and chemicals for the diseased multitude of peasants that existed in his day. After Paracelsus, such devious paths opened up for exploration in chemistry that the chemists of the seventeenth century became the first real experimenters interested in chemical reactions. Their curiosity-inspired seeking may be traced by a study of the history of such men as Stahl, Boyle, Bacon, Priestly, Lavoisier, Davy, Cavendish, Scheele, Berthollet, Proust, Berzelius, Liebig, Bunsen, Dalton, Wohler, Newlands, Mendeleef, Kekule, Pasteur, and many others.

Colleges and universities as late as the eighteenth century were slow in adopting as an aim the method of experimentally searching for truth. They were authoritarian and classic in nature. As a result, most of the real contributions to science in that period were made by men who were trained as apprentices of other scientists or who learned from their own curious seeking of nature's secrets.

Science As a Part of General Education

For centuries science has been considered a part of the education of free men, but only the noble and the rich were considered free. The place of science in the education of the masses has been realized only recently. Since the beginning of the twentieth century there has been an ever increasing realization of the need, and ever increasing efforts have been made to fill the need for some scientific understanding in the background education of every person.

The framework of modern science is based upon the nominalisms of the middle ages that

> ... taught and partially proved that we know only individual things and that general concepts are the result of combining individual experiences according to similarities and by means of subjective notions (39--p. 3).

However, these individual experiences must be integrated and correlated into a unity or whole. Today, the mass of subject matter in the whole field of natural science is so great that Bacon's concept of the whole of knowledge in the mind of any one individual is an absurdity. Andrea Libavives (39--p. 48), who wrote what was probably the first chemistry book about 1600 A.D., taught a unity of all nature, and Descartes (39--p. 49) taught that men know space only through motion. If these seventeenth century philosophers were right, associations between subject matter, facts, and actual life experiences must be made in the students' minds before facts have a meaning to the students. The consensus of twentieth century psychologists seems to be that learning takes place much more readily when observed phenomena are associated with simple principles at the time the observation takes place. By making associations in the student's mind between the physical phenomena and a stated principle, the principle comes to have meaning. Then and then only is there likely to be a transfer of learning or a noticeable change in the behavior of the student.

What cannot be understood cannot be managed intelligently (37--p. 2). Where physical phenomena are not understood, there will be found the superstitious belief in magic and the political tyranny that comes when a population is kept submissive through ignorance and fear of the unknown. The present day democratic belief in an educated populace in a self-governing nation is strongly influenced by such men as Dewey (37--p. 2).

People are naturally curious, but they are not naturally scientific (70). If a single generation were left uninstructed, or completely untutored, it is probable that there would be a very nearly complete reversion to the superstitions and fears that were a dominant feature of the lives and morals of thousands of years ago. The present knowledge of the organizations and functions of nature which, for lack of a better name, is called science, is a rather fragile skeleton painstakingly pieced together from scraps and bits of information and knowledge collected, proved, and preserved over the centuries of progress. The preservation of the present status of any of the natural sciences and the advance to new and greater importance of the sciences depend upon two things. First, there must be specialists--men interested in research and new facts and new applications of long known facts--and, second, a populace that understands and appreciates science. The second group is the one that sustains the first. Regarding the second group, Nash makes this statement (32--p. 98):

It has often been claimed that the traditional specialists' courses are really the best way of inculcating some appreciation of the nature of science. ... At this point there is some risk of confusing the nature of science with the content of science. It is possible to learn much about the content of science without securing any real appreciation of the nature of science. But it also seems possible, and infinitely more valuable to the non-specialist, to gain some understanding of the nature of science while mastering only a relatively small proportion of the subject matter of science. Though highly successful in teaching the content of a given science, the specialists' courses are all too often completely unsuccessful in inculcating a conception of what science is about, how scientists work, and what the real character of scientific enterprise is. ... By and large, their (specialists' courses) subject matter is highly static and elaborately developed material that is remote from the scientific frontiers which are the only places where one might learn by seeing the supposed "method" in action... .

A course of science, which is designed for the majority of people, needs to give some grasp of the "varieties of scientific experience (32--p. 103)." This particular need might possibly be met to a greater or lesser degree by any of the natural sciences. Chemistry, however, would offer probably the greatest opportunity of any one science because of its relationship to all the sciences (64).

Trends in Present Day Chemistry

The changes that have taken place in the philosophy of teaching chemistry seem to have run a cycle. Originally, all phases of the natural sciences were offered and taught as liberalizing studies. The industrial revolution is associated with a gradual change in this to an emphasis upon only the technical and specialized aspect that reached its height immediately following World War II. Since 1950, the trend is again turning to the liberalizing or cultural aspect of science.

Obviously there are those who work upon the premise that the number one objective of an elementary course in chemistry is to teach facts and more facts. Others are taking the view that the greatest value of an elementary course in chemistry is the enlightenment of the student and the cultural effect that it has on his mind. Men of this latter school of thought would say that the aims and objectives for a course of study should reach beyond mechanical memorization; i.e., the mental attitudes, concepts, and understandings that may be developed are worth far more than encyclopedic facts memorized. Present day philosophies of learning seem to lean toward the psychologically proved fact that data learned by rote memory without reason are soon forgotten (71). Cultural development implies contact with understanding the extractions from and additions to the general body of history, inventions, morals, knowledges, and philosophies of environment that make up culture. To attain these understandings is definitely a student accomplishment and may be attained only by using the course of study as a tool.

There are two views as to how aims and objectives may be defined. More often they are stated as course aims and objectives when actually they are accomplishment aims and objectives from the student's viewpoint. In order to bring about student development, there must be clearly defined aims, carefully selected subject matter, efficient presentation, and possibly a testing program devised whereby measurements may be made in the development of the individual. Of these four necessary ingredients, clearly defined aims must come first (66). Too often in the past statements of aims have been mere aphorisms or statements so general as to be largely meaningless without extensive qualifications and specifications (43--p. 6).

Science has gained its present place of importance in the subject matter curriculum of liberal arts colleges by science teachers promising and working on the premise that it offered a new approach to mental discipline, i.e., the "scientific" way of thinking (70). There are many who doubt the tenability of the premise and many others who question that the promise is being fulfilled. As an example, the presentation of chemistry has been guilty of trying to serve two masters: (1) training technicians and (2) training in logical thinking. Apparently (70) the latter has suffered in deference to the former. The accumulation of facts, formulae, symbols, and principles has led to the necessity of force feeding of so-called fundamental facts, formulae, symbols, and principles into the absorbent cranial sponges of willing students (70). Seemingly the trend today is to make facts only incidental to training and understanding.

There is an apparent resistance to this trend by science teachers themselves. Whatever the reasons, the instructor must develop a philosophy as to whether technicalities must take precedence with logical thinking becoming incidental, or whether logical thinking must take first place with technicalities incidental. Aims and objectives for students will be influenced by the instructors' philosophies.

Probably the greatest difficulty in agreement of philosophy lies in a confusion of purpose in the minds of the teachers of science. According to Buchanan (56), if chemistry has defaulted as a liberal arts course, it is due to uncertainty and disagreement concerning aims.

Usually the undergraduate special courses in chemistry represent resumes of the important works in various fields. These the student is expected to copy into his notebook and reproduce on demand. Yet, if the desires of graduate schools and industry were examined for preferences in students, they probably would show that there is a great need for students who are able to think. These are the ones who have the ability to attack single-handedly and to master independently a phase of work which is new and strange to them. Then teachers who help train such men mutually must understand one another and must be able to communicate with one another. This common ground for mutual understanding and communication among teachers probably will be found in a list of the aims and objectives in teaching an initial course in college chemistry designed for everyone. With a meeting of minds on these listed points, teachers will be enabled more readily to set goals and devise methods for the improvement of their teaching practices. There should be a consensus as to what these aims and objectives should be. It is the purpose of this study to determine, in so far as possible, the consensus.

The trend today in natural science instruction places emphasis (40--p. 31) upon functional facts, functional concepts, and functional principles which would seem to indicate that science instruction on all levels must be directed toward the learning of larger principles rather than the learning of isolated facts. Larue (42--p. 189) says:

The first challenge of the lesson for information is to get its meanings, i.e., to relate it to the map of images, symbols and feelings already in our heads; to interpret it. To perceive the outer world is to interpret situations; a moving light in the sky turns out not to be a meteor but an airplane; that red on Johnny's finger is not blood from a cut, but a splotch of ink; the tadpole's tail disappears--what does that mean?

In other words, the modern psychology of learning states that facts without understanding are useless. To follow these psychological findings would influence and change the aims and objectives of most science courses from learning a fact that might be used in the future to learning a principle that is used in the present.

There is a multitude of statements from science teachers themselves concerning the importance of teaching attitudes, manual skills, applicability of scientific concepts, and beliefs fundamental to a democratic society. Apparently, most teachers think that no study of a natural science course can be directed at only the learning of natural science. Probably, no program of natural science in an educational program can be evaluated fairly except in terms of the total curricular framework in which it is placed. The liberal arts, as conceived in the eighteenth and nineteenth centuries, had too narrow a framework (114). Today the impact of vocational compulsion, i.e., economic necessity, is being felt. Economic necessity leads to a desire by the many for a more flexible program than that of the past. A modified program must be worked out now within a new framework that will allow the flexibility necessary to fill the needs of an educated populace. This framework must be built on certain convictions concerning the nature of the educational process (43--p. 281).

Researchers at Pennsylvania College for Women worked out the following three generalized headings as a framework for goals in an educational program (43--p. 282): (1) abilities, (2) attitudes, and (3) beliefs which make for a wisdom, a deep understanding of life, and an effective means of adjustment to it.

According to French (32--p. 16), the teacher's motives cannot be merely a struggle to preserve science for science's sake. Too many teachers of the past apparently have done this by labeling students as not of college caliber because they apparently cannot learn science. Yet many of these same students have made outstanding successes in other fields of endeavor. Perhaps the fault has lain with the teachers and science teaching rather than with the students. Perhaps in the past teachers have been expecting too much in attempting to teach all science to all people.

The situation at the mid-century mark was summed up by French (33--p. 17) thus:

There is no need to rehearse what has happened to the teaching of science in the colleges during the past century. It parallels what has happened in other fields but the natural sciences, having a good head start over most of the social sciences, their teaching has gone its specialized way in considerably greater measure. Science is no longer the liberalizing study it once aspired to be. Here and there through the sheer force of a great personality it still retains vestiges of liberalism, but in the main, the teaching of science has been subjugated to the training of specialists. Without at the moment getting committed upon the question of whether the kind of introductory science we now teach is good training even for prospective scientists, we can probably agree at least that it is not good education for the non-scientist.

By 1958 a clamor had been set up by business and industry for even the specialists to be trained in more than technology. Executives of many industries now say that the great need is for men with a broad background of training in cultural subjects. Industry itself, in many cases, is training its own technicians, but industry has neither the time nor facilities for instructing in those broad fields of knowledge that must come only from a continuous and persistent attempt by the schools as a whole to work on an integrated program of education from the primary grades through college. The above emphasizes the present need for an initial course in college chemistry that offers much more than scientific facts.

Only by teaching for change can a college program be wholly successful. This cannot be done with the traditional specialist's courses with their set patterns of thinking and procedures. The stated aims and objectives listed in current literature are obvious attempts to change tradition to meet the needs of the times. However, indications are strong that there is general agreement upon this point: Some science is needed in a general education program designed to meet the needs of all college students.

Since chemistry is a science derived from the other natural sciences, it by its nature covers materials, words, concepts, and skills pertinent to all the others. Due to this factor, it has been more and more discussed as the one course of science offering most to general education. However, the problem of the role of chemistry in general education is as yet far from solved (54). If this problem can be solved for chemistry, the solution will aid the other sciences in finding their rightful places in the educational scheme.

The aims of general or background education are still somewhat hazy and argumentative (64). This possibly may explain the haziness and apparent lack of agreement for the aims and objectives of an initial course in college chemistry as presented in the majority of American colleges and universities today.

Chemistry in Today's Curriculum

Chemistry, as it generally is taught today, usually stresses facts more than principles. Dewey (38--p. 193), in dealing with methods in science, stressed the application of learned facts by saying:

> Our present methods put the cart before the horse ... what we need is to hitch the horse of concrete experience with daily occupations and surroundings to a cart loaded with scientific knowledge ... .

By this he meant the initial course in chemistry was primarily a job of hitching the horse--not filling the cart. If the student learns to translate facts learned into daily life, then he is equipped to translate the facts that may be acquired long after school days are over. When this sort of program is adopted (38--p. 194)

> ... we shall find that the crop of scientific specialists will increase and not diminish while in addition we shall have a citizenship of men and women really intelligent in judging the affairs of life.

McGrath stated that a survey of present texts showed all to be amazingly alike (44--p. 103). It would appear that one author has been afraid to omit what another has included previously. It also seems that the present prevalent theory held by many is that physical chemistry is the basis of all chemistry and possibly all science. On the other hand, there is an ever increasing number of instructors advocating radical changes in the offerings of a beginning or initial course in college chemistry. There is a persistent theory that a thorough grounding in the so-called fundamental facts in science gives the student an understanding of the nature of science and that training in memorizing facts transfers to other fields. Such a theory has been disproved by many researchers such as Freud and

Cherovis (44--p. 104) who, in an extensive study of mental retention in a physical science course, found that retention depends upon reasoning rather than rote memory. According to their studies, the subject matter best remembered or retained consisted of principles and theories when these were taught or presented in connection with applications and related facts. If a fact were memorized without reason, the results showed very poor retention.

According to McGrath (44--p. 105), the aims of any science course should be (1) understanding what science is about, (2) knowing how scientists go about their work rather than material alone, and (3) learning to transfer cultural values. These rather general aims bring up several questions. One would be, "What is science?" Another would be, "What is culture?" According to Conant (59), the development of the different fields of science came about in the seventeenth and eighteenth centuries because of the union of three streams of thought. These were (1) speculative thinking, (2) deductive reasoning, and (3) empirical experimentation. To define science, he says:

> Science is a series of concepts and conceptual schemes arising out of experiment or observation and leading to new experiment and observation. Today the test of a satisfactory concept or conceptual scheme is in terms of (a) its ability to account for all the known phenomena with a minimum of complexities, and (b) its fruitfulness in terms of new experiments and observations.

The above statement would lead one to understand "science" to refer more to method than to subject matter.

This seems to be the generally accepted thought of the present day leaders in the field of educational chemistry.

Cultural values of chemistry are rather difficult to define. This is not because they do not exist, but rather it is because of the general disagreement upon what makes up culture. In the first place, cultural value is not talk about chemistry but a comprehension of the underlying philosophy of chemistry. The underlying philosophy (125) of chemistry is seldom helped by complicated problems with long, devious paths to mathematical solution. Probably such would throw the average student off the track of comprehension rather than help his understanding. On the other hand, some facts and some fundamental theories should be comprehended by the student. There must be some half-way meeting place for those attempting to teach too many facts and those attempting to teach with too few.

One reason (130) chemistry is not more popular today is that teachers of yesteryear taught an unnecessarily difficult content of subject matter. Everybody ought to know some chemistry; some ought to know more; and some ought to know as much as they possibly can. However, it is not an example of clear thinking to attempt to teach all chemistry to all who sign up for a beginner's course under the pretext that memorization of the periodic chart, various and sundry specific gravities, boiling points, historical names and places, minute details about all individual elements, and other multitudinous encyclopedic type facts or supposed facts is necessary to the enjoyment of the contributions of chemistry to society. To do all this is equivalent to telling a person that he must understand the theories of electronics in order to enjoy a play presented on television. However, a desire to learn electronics possibly might be stimulated in an active mind by learning to tune and enjoy the set. In like manner it is possible for some students to become so interested in chemistry by a course in the philosophy and uses of some well chosen subject matter that they will become inspired to learn all that is possible in formal school classes.

Wilhelm Ostwald (81), in the preface of his book on natural philosophy, said:

> Natural science and natural philosophy are not two great fields which oppose each other, but they belong together just as two paths which lead to the same goal. That goal is: The mastery of nature by the human being.

Natural philosophy in combination with natural science will prevent the teaching of idolatry of science. Science without human thought and use is dead. It is only an instrument for accomplishment. Conant (34) says:

> With idolatry of science I must confess I have little sympathy. Yet a better understanding of the methods of the natural sciences among laymen is certainly to be desired ... .

The need for a widely educated citizenry makes necessary a real appreciation of methods, aspirations, and limitations of science an essential ingredient of general education. If chemistry is the course to accomplish this, teachers as a whole must eliminate many of the "sacred cows" that have been accepted as a part of the gospel that must be imparted to an educated man. It is not necessarily knowledge about science as such that the layman needs, but it is more understanding of science (34--p. 116). The texture of modern science is the interweaving of fruitful concepts, that is, interaction and contributions of science to technological society. If a problem is met and understood, usually the facts necessary for solution can be found. Ordinarily the eventual ability to solve problems is more dependent upon understanding than upon memorized facts and figures that may be found in references (106). The student's need for understanding makes the teacher's primary task one of teaching concepts rather than statistical truths. Accenting concepts rather than memorized facts affects methods of class presentation in that presentation leans from lectures toward discussions and actual problem solving. By the use of the word "problem" it is certainly not the intention to limit problems to those of a mathematical nature.

Dr. Conant (59--p. 166) says:

> The present college courses in physics, chemistry, and biology by necessity are arranged primarily as a foundation for more advanced work. Therefore, they do not fulfill the function of providing for the non-scientific student an adequate introduction to the methods by which knowledge has been advanced in modern times. Such courses fail to meet the educational requirements for the non-scientific student both because they require too much detail as a basis for subsequent scientific courses, and also for another reason closely related to the complexities of our modern industrial society. Those who give such courses, and I am referring in particular to physics and chemistry, feel that they must cover those branches of the sciences which are concerned with every day applications and also must refer to the most

recent discoveries. As a result rather superficial treatment of many phases of physics and chemistry cannot be avoided.

Meyer (45--p. 223) objected to survey courses on the grounds that (1) they tend to be superficial; (2) it is very difficult to get competent teachers; and (3) they tend to leave the false impression that the treatment of the subject dealt with is definitive.

The stated aims of teachers of integrated science polled in Wilson's survey (126) show some interesting differences from stated aims of teachers of specific natural sciences. The integrated group generally agreed that the aims of a survey course did not include the development of laboratory skills, the ability to read technical literature, or the offering of a foundation for further work. On the other hand, almost all sample tests prepared and given by this same group of teachers were based almost entirely upon subject matter mastery and were objective in nature. Although there was an interest manifested in evaluation of aims, little had been done to develop means of such evaluation.

The instructors of science questioned in the survey indicated a general feeling that traditional courses were inadequate for all students, but the survey courses apparently would not be voted as the final answer. Where the teachers of survey courses rated the lecture demonstration method as the most valuable method of teaching, the senior colleges other than teachers' colleges ranked the laboratory method as the best method. Since the laboratory lends itself more completely understandable to the novice in a relatively limited field, indications are that a study limited in scope would give the student a more comprehensive picture than disconnected bits and dashes from many fields.

Gray (78) thinks that the main trouble with traditional texts is that they have too much encyclopedic material and enable a teacher to drag in too much detailed matter on his own pet subject. He feels that the student who knows many basic phases well is better equipped than one who has been either exposed to the whole field or one who has had only a concentrated study of the teacher's pet subject matter. The student should have the broad--not specific--knowledge of orderliness, energy, and science interrelations that can come by study of one field of science such as chemistry.

Due to the haziness of aims, the statement is made often that the same chemistry course taken from three different instructors will be three different courses. This may have some element of truth. The so-called general chemistry, up until the present time, often has been top-heavy on the physical side with comparatively little stress on the organic, on the inorganic, or on bio-chemistry. Some teachers have put in pleas for fusing the various phases so that the structural pictures of compounds and materials may be more complete.

There have been many misconceptions as to the nature of chemistry due possibly to outmoded thought as to the nature of true learning. Rich (112) has listed some of these misconceptions based upon the "mind faculties" idea. They include "general training," a "discipline" training of general abilities, such as "to observe accurately," or "draw correct or reasonable conclusions," and to "teach for transfer of reasoning ability." Actually, there are many kinds of observations. Each has its own skills, group of habits, and mental attitudes.

Another misconception that often has been a stated aim is that the initial course in chemistry covers chemistry as a whole. Chemistry as a whole field cannot be covered completely in dozens of courses. The idea of covering the whole field has been one possible reason for the enormous accumulation of facts that too often has been incorporated in an elementary course in chemistry. To attempt to teach so many facts or so much abstract "logical" reasoning involves omitting things from real life experiences. The average student generally is uninterested in and has seldom, if ever, come in contact with the detailed information necessary for the technologist. This does not mean that the technologists' information is not good; it simply means that it is out of the realm of a real life experience for most students. The average student, if interested, will learn much detailed subject matter to satisfy his own curiosity, but the same subject matter is dull and seldom well learned for the sake of learning.

It may seem peculiar to some to say that many chemistry teachers still attempt to teach subjects instead of pupils, but this is an attempted practice of many and is very difficult to eliminate. Since only that which the student learns can ever benefit him, why cannot that which the student does not learn be deleted from the course of study? This deletion is something that needs to be done, but due to disagreement as to what to eliminate, it is a rather difficult task.

Many people think that chemistry is nothing more than a mass of facts. Probably again the teachers are to blame for this erroneous concept. Most of the testing programs including tests of ability are simple factual type questions. These are not really tests of ability but are too often only tests of feats of rote memory.

Another misconception is that which leads to the thinking that the first college course in chemistry is only a preparation for more advanced study. Various estimates show that almost 70 per cent of entering college freshmen in the southern or agrarian states have not had high school chemistry and only 6 per cent to 8 per cent have had both chemistry and physics. There is not only a possibility but a probability that in these freshmen there are literally thousands that are potentially excellent chemists, or technicians, but they never have had the opportunity of a pleasant introduction to the fields of technological study needed for these various professions. Chemistry can be the means of interesting these students not in chemistry alone but in all natural sciences. A well organized course can and should give some understanding of the nature of other fields of science.

Many have the idea that an Intelligence Quotient must be high before a student can understand chemistry. A five year study of freshmen in Colorado University showed no significant correlation between grades in freshman chemistry and Intelligence Quotient. Other studies (94) show that there is the practice in some colleges of allowing only those in the upper quartile of mental ability, as shown by various tests, to take chemistry. It apparently would be a fruitless or at least undemocratic policy to attempt to educate only 25 per cent of the populace. This does not mean that standards have to be lowered for the "higher" intellects, but it does mean that the others cannot be forgotten.

Obviously too much faith is placed sometimes in the intrinsic worth of new, curious, shining discoveries. These discoveries are not chemistry, nor physics, nor biology; they are products of these various sciences. No science is of relatively great value per se, but they are all of inestimable value as tools and instruments for producing these discoveries.

Science is not an end within itself. It lives and is useful only in so far as it is applied by the minds and hands of men. Science is not just for the scientists; it is for all men everywhere. The man with the most degrees is not the only one qualified to think or invent. All men have creative abilities of one kind or another, and most men can use science or the products of science in their creative thinking and building.

The last misconception to be mentioned here is that chemistry is a well-defined, bounded body of knowledge. Chemistry, or the field of chemistry, is not made by nature. It is man-made. As a man-made course of study, it can go just as far and cover just as much material as is within the man-made definitions of its limits. It is far from an exact science and is in no way a static course of study. It is a growing, changing conception of a phase of science that by its nature is a study of change and should be capable of being used as an instrument for the adaptation to change.

A study (74) made more than twenty-five years ago showed that a large part of chemistry presented in high school did not function in the lives of the students. There was not a close relationship between the subject matter used and the activities of students' lives. There is little evidence that this error in teaching has been corrected at the present time.

Many teachers stress kinetics at the expense of other phases of chemistry as a means of giving general knowledge. A study (99) has shown that the most important contexts of 201 popular magazines were pertinent to health, food, household appliances, and clothing. Very little attention is paid to quantitative measurements or gas laws even in science magazines (111). If courses in chemistry are to be valuable to the average student, they must be pertinent to the student's life (44--p. 281). In a review of Consumers' Guide (101), it was found that the copies studied used 349 scientific terms. A count of these terms, although they refer to all the natural sciences, shows that less than 75 of the terms are not or normally would not appear in use in elementary chemistry. This would verify again the assumption that chemistry offers an excellent opportunity to teach a consumers' vocabulary. Since a usable vocabulary is the most important means of personal communication, chemistry may contribute a bit in this respect to liberal education.

Cook (60) says that a liberal education must include those studies "precious to human life," train in the "integration of knowledge," train in the "methods of thinking," and in the use of the "tools of thought," and prepare for further study or occupation after college. Attempts to attain these goals might be made a part of the general or broad aims of an initial course in chemistry. One barrier to obtaining educational goals other than actual knowledge is the fact that too often the nature of and content of science are confused (32--p. 37). Content can be memorized without the individual ever knowing or appreciating the nature of the material memorized. The memorization of scientific encyclopedic facts may be highly beneficial in a specialist's course, but the specialist does not necessarily have any conception as to what science is about, how scientists have solved problems, or even the character of scientific enterprise.

Chemistry as it is offered presently does not fulfill the needs of general education, but chemistry is the most logical one of the natural sciences to redesign so that it will fulfill the needs of general education (56). Chemistry by its nature is applicable to <u>every</u> field of natural science. Concepts of matter and energy and the interactions of matter and energy compose the very basis of the knowledges and uses of twentieth century technology. However, if a new kind of course in chemistry is organized to fulfill the needs for science in general education, a comprehensive list of aims must be collected and must be agreed upon for such a course. This study is an attempt to find a consensus on aims for an initial course in chemistry designed for the non-science major or the student who is undecided as to a major field.

CHAPTER III

PROCEDURE: INVENTORY OF AIMS AND OBJECTIVES OF AN INITIAL COURSE IN COLLEGE CHEMISTRY

If a list of aims for an initial course in college chemistry can be collected; if a qualified jury of teachers of education agree that these are good objectives for science in a general education program; and if a jury of teachers of chemistry agree with the teachers of education that this list of aims should be accepted for an initial course of chemistry, then a consensus will have been obtained.

If the assumptions are made that a general education should include some understandings of science and that an initial course in college chemistry may be used as a source of those understandings, then there should be a consensus of the desirable aims and objectives for an initial course in college chemistry designed for general educational needs. This consensus should show differences as well as a community of interest when obtained (1) from instructors within the field of chemistry and instructors within the field of professional education and (2) from the field of chemistry alone when the opinions of instructors from small colleges are compared with the opinions of those from large colleges.

An initial course in college chemistry should contribute to aspects of general education, but it cannot do so for all of general education. It may and should contribute to responsible citizenship, effective use of written and spoken language, intellectual curiosity, creative imagination, and philosophy of life (44--p. 149). These are all good general aims, but they are of the type that the teacher should do more with than merely proclaim as laudable ideals. They may be stressed one way or another in almost any class period. It was not the purpose of this paper, however, to stress method. The purpose was to identify the aims of the course which may be associated with methods, subject matter, and materials involved.

Aims from Literature

Scores of articles have been written within the last quarter of a century concerning aims for sciences as a part of the background education that enables one to live intelligently within his environment.

Many feel that no one course can be both "general" and "special" at the same time. However, an initial course in any subject seldom, if ever, is designed to make experts or train professionals (44--p. 20). It only gives the basis of foundation for the later building of professional knowledge. What could be a better foundation upon which to build any professional training than a broad understanding of the interrelations of that field with other fields and the realization of the need and importance of the field of endeavor? Then three primary aims (44--p. 25) may be considered first as questions: (1) What is science about? (2) What is meant by scientific procedure? (3) What are scientists like? To accomplish these three aims, as well as other aims, there must be time for student discussions, careful reading, historical analysis, argument, expositions of the nature of science, and time for the student to look back and try to understand what he has been over rather than merely to memorize soon to be forgotten facts.

According to Wendt (128), science has four aspects.

1. Research: The creative use of our powers of inquiry, the expert method of exploring the unknown and of solving the problems posed by nature and by life.

2. Knowledge: The vast fund of facts, principles, natural laws and generalizations that are the product of research and have been recorded in print and picture.

3. Applications of that knowledge in the production of things and of power, in the improvement of our environment and the enrichment of life through the techniques of agriculture, medicine, engineering and industry.

4. The social force that springs from these applications and by transforming time, space, matter, and life itself, inevitably transforms man and society, history and cultures, philosophy and even religion.

No one man can master all of the above. Education for citizenship, however, requires an awareness of the first three aspects in order to evaluate the fourth. The fourth aspect must be evaluated to a greater or lesser degree before one can partially know with what science is concerned. As for research, it is good to say that research thinking under the guise of scientific method is an objective, and research ability, both past and future, should be respected. However, no teacher knows the nature of years to come, so he must teach to cope with constant and inexorable change (118). One who can adapt to change, bring new interpretations to old facts, make different applications of tried principles, and adapt old learnings to new situations and discovery of new facts is truly a scientist.

"Chemistry can make contributions of facts to the building materials of personal philosophy (63)." A knowledge of the structure and behavior of matter is of primary importance in the development of any realistic philosophy or understanding of nature (62). This fact leads to the following statements of definite aims. After completion of an initial course in college chemistry, a student should have concepts of the (1) structure of matter, (2) finiteness of matter, (3) kinds of matter, (4) changes matter can undergo, and (5) an appreciation of the orderliness of nature and the simple laws which govern the infinite proliferation of her works. Day goes so far as to suggest that the initial course be called the "Nature of Matter" rather than "chemistry."

Learning by doing sometimes is given as an aim for chemistry, but this does not tell what is learned or should be learned. Weaver (126) suggests that the ideal chemistry course should teach to (1) observe cause and effect, (2) discriminate significant from unimportant events, (3) make accurate reports, i.e., report things as they actually happen or seem to happen, (4) teach practical safety, and (5) make printed matter real. These aims do not apply to all of chemistry but only to a portion--the laboratory.

Rogers (67) answered the question, "What should be the aims and objectives of science in general education?," thus:

In general education we need not start the training of professional students ... we need not to try to equip everyone with a lot of scientific knowledge ... but we do need to give an understanding of science and its contributions to the intellectual, spiritual and physical aspects of our lives.

McGrath (44--p. 12) summarized his findings on the aims of science in general education in these general terms:

Though many institutions have a list of eight or ten objectives, they can be classified under a relatively few heads, the most common of which is the cultivation of the scientific method and the ability to use it. ... Another common objective has to do with the facts of science. ... The third most common objective is concerned with the impact of science on modern life. A few institutions, but an increasing number, have as a fourth objective acquainting the student with the historical development of science to reveal how the cooperative efforts of succeeding generations of scientists have been responsible for our present knowledge and to indicate the evolution of scientific thought.

President Truman's Commission on Higher Education (110--p. 2) reported that the real difference between general and higher (specialized) education is not so much materials as attitudes. How facts contribute to the solution of a problem is more important than merely more facts. Then the importance of content is a direct function of its use in understanding a problem. If a course is to be counted as a part of general education, it should provide profit and understanding to all students in all major fields (32--p. 49). A Coalgate Committee (32--p. 11) was unable to set down in black and white the objectives of a chemistry course, but the committee members did agree on the following broad aims: (1) to give the student experience in accurate and critical thinking and jolt him out of authoritarian learning, (2) to give him an appreciation and understanding of how natural science has functioned and does function to gain its results, and (3) to provide him with a grasp of some of the more important laws and principles of science. These aims would correspond to the fundamental general aim of general education--"better understanding and ways of thinking." However, objectives are only good if realized (32--p. 390). The above aims are like so many of those previously mentioned in that they are not defined or limited and are too general to be used as specific, measurable aims.

French (32--p. 87) suggested these two aims for a physical science: (1) direct into college work the natural curiosity of the student and (2) motivate the student, i.e., arouse a desire to learn more about the subject. These are modest statements. They possibly reduce the aims from the heroic to the merely human, but at least they are more definite and point toward definite things. Nash (32--p. 97) says that the objective of any science course is to present science as a part of civilization--a rich part of cultural heritage and one of the intensely creative aspects of human endeavor. Scientific facts and theories should be taught not for their own sake, but as a means toward the end of understanding science. It cannot be hoped that the persistent characteristics of scientific enterprise can be taught in a pat, capsulated form under the name "scientific method." In line with the above, a stated aim might be to give the student a concept of the centuries of interplay of influences that led to some particular pronouncement or discovery such as Boyle's statement that the volumes of gases vary inversely as pressure exerted upon them or Lavoisier's theory of oxygenation or the Curies' discovery of radium.

It is possible that "scientific method" is so stressed because it gives a meeting of minds on a high place of abstraction (43--p. 103). Often better teaching can be done by working from empirical evidence rather than traditional dogma. Dalton arrived at his all important and often quoted four points of the atomic theory not by any exact scientific methods but from following erroneous reasoning. Yet these four points, none of which is exactly true, are religiously stressed by today's chemistry teachers. Why not then make one aim of chemistry to give some grasp of the varieties of scientific experience, the erroneous as well as the correct (43--p. 103)?

Science should be viewed from a number of relevant influences--scientific, philosophical, economic, and social.

All four influences have played important roles in today's scientific achievements, and no picture of achievement is complete without being viewed from all four angles. The above facts point to still other aims that have different connotations, such as: point out that science is not a miracle worker nor does it make all things possible; show that science is not a thing apart from the culture of the times; stress the importance of social surroundings on scientific undertaking; teach that economic surroundings have a preponderant effect upon scientific enterprise; show that growth of science has been an organized social activity and always has been in the framework of all human physical endeavor; and emphasize the integration and some of the interrelations between the various fields of science. This latter point is particularly important due to the contributions of all the sciences to the areas of human need such as consumer knowledge, physical health, civic relations ranging from family relations to international relations, and communication.

Goodman (75) contended that one of the great educational problems of modern times in the teaching of science is the tendency to lean toward facts rather than principles and concepts. A select collection of facts about science and technology is necessary but secondary to a mastery of a scientific way of thinking. Students will gain professional stature, Goodman continued, in science and engineering not through rote learning but through an orientation of mind and habit. Ideally, the conditioning should begin in early childhood and follow continuously through high school and college. The process of conditioning is divided three ways by Goodman as follows: (1) reduction of detailed content, (2) emphasis upon fundamentals, and (3) development of judgment and discrimination in both formulating and applying the fundamentals. Apparently, then, the basic difference between the professional scientist and the layman is a matter of extent of training rather than the foundation or beginning studies.

The textbook stated aims are generally too broad in scope and not sufficiently specific enough to be clear-cut in meaning.

The various expressed aims for an initial course in college chemistry have a wide range. Alyea (52) thinks that a chemistry course is primarily to be used as a means of selecting those capable of research and encouraging them to continue training to become specialists in the field. Larrabee (94), on the other hand, thinks that the social values and implications of chemistry should be stressed most strongly in an initial course.

Scores of opinions have been expressed as to desirable aims and objectives for an initial course in college chemistry. The inventory made as a part of this study enumerates those mentioned in available literature. However, no general consensus has been available until this time.

Aims from Textbooks in General Chemistry

Most of the aims, goals, or objectives, as stated in the prefaces of the majority of present day chemistry texts, are very broad. This fault of stating aims in terms too general for definite evaluation is not uncommon.

The aims of various authors of chemistry texts may be gathered from their statements concerning their various works. Their aims are not always stated plainly but are often only implied. Some representative examples of these are as follows:

Text 1 (24):

1. Develop an appreciation of the scientific procedure.
2. Teach how the results of research are published, abstracted, tabulated and brought together.
3. Give a knowledge of the application of theories to development of natural resources, to the problems of industry, and to those of daily life of the individual.
4. Treat the development of the theory from a historical point of view as far as is consistent with a presentation of the subject matter which is pedagogically sound.

Text 2 (25):

1. Bring the scientific method into proper perspective and provide a basis for at least a reasonable amount of laboratory work.
2. Present a course terminal in nature leaving out much of the traditional facts and material.
3. Make the course primarily descriptive and terminal in nature.

Text 3 (13):

1. Instruct in scientific method.
2. Instruct in the principles of chemistry.
3. Instruct in the experimental methods of chemistry.
4. Present facts that are necessary to illustrate the principles of the subject. These principles are the ones likely to be of value to the student in the future.

Text 4 (20):

1. Teach principles and theories of chemistry.
2. Show the applications of these principles and theories in industrial, agricultural, and medical fields.

Text 5 (14):

1. Emphasize the practical and industrial aspects of the science with differences in laboratory and commercial techniques stressed.

2. Teach how to solve problems.
3. Teach how to reason.
4. Give grounding for subsequent courses.
5. Unify laws and theories.
6. Teach facts in the light of theory.

Text 6 (7):

1. Teach for continuity of chemistry leaving out (or allowing to be left out) terminal ideas.
2. Teach principles rather than stressing industrial applications.
3. Arouse the interest of the student.

Text 7 (2):

1. Present the essential concepts on which chemistry rests, unencumbered by a vast amount of collateral material.
2. Teach behavior of matter by presenting atomic structure, configurations of the electrons, and periodic classification.

Text 8 (12):

1. Teach fundamentals (basic principles) of chemistry for agriculture, home economics, engineering, pre-veterinarian, pre-medical, pharmacy, advanced science, and the arts.
2. Teach to attain new knowledge, i.e., acquire facts through observation and experimentation and form theories for explaining the relationships between observed facts and the

application of organized facts or reasoned principles to human behavior.

Text 9 (11):

1. Give foundational course.
2. Enable students to apply a principle to a new situation.
3. Teach to reason from a known fact to an analogous setting.
4. Solve problems based on chemical principles.

Text 10 (22):

1. Arouse student interest (presumably in chemistry).
2. Have a student to so master given exercises that "one may say he has mastered the course."

Text 11 (29):

1. Ground the student thoroughly in the use of the basic principles in a manner that will enable him to continue in any specialized branches of the science.
2. Furnish modern cultural background necessary for all college courses.
3. Guide to reasoning by reasoning from detailed application and understanding of subject matter without overburdening the student with reference book data.
4. Minimize the historical considerations.

Text 12 (27):

1. Direct toward understanding of environment.
2. Teach the method of science.
3. Apply chemistry to life situations of the average citizen.
4. Teach the importance of experimental evidence rather than theory. Theory is only incidental.
5. Show the importance of chemistry in an international aspect.
6. Show interdependence of nations and individuals upon each other's discoveries in the development of modern technology.

Text 13 (12):

1. "Expose" students to more than they can assimilate. This stimulates (supposedly) the more brilliant student.
2. Require less than the maximum for the less brilliant students so that they may pass the course.

Text 14 (3):

1. Afford an understanding of the scientific method of thought by coordinating the facts, theories, and laws of chemistry in an orderly manner.

2. Develop a rational basis for an appreciation of the true significance of chemistry in the modern world.

Text 15 (15):

1. Ground student in background of chemistry for future studies in chemistry and in other science fields.
2. Teach: (a) scientific method, (b) fundamental laws and theories, (c) atomic structure, valences, and relationships.
3. Place emphasis on the quantitative aspects of chemistry.

Text 16 (8):

1. Give knowledge of the evolutionary processes that have altered the organic and inorganic world over the eras of time.
2. Give the student knowledge of the organic and physical world around him.
3. Give the student an awareness of the impact of the new scientific development upon social, economic, and political problems.
4. Allow the student to gain experience in the way science solves problems and training in the use of the scientific method.
5. Give the student a perspective on what can be expected of science in the future.

6. Acquaint the student with some of the world's great scientific ideas.
7. Teach not only the power but the limitations of science.

In addition to the above list, the author stated that outside reading is desirable and that an attempt is made to weave subject matter and method into a pattern of observation, classification, hypotheses, experimentation, and theory.

Text 17 (5):

1. Teach "all the theories, laws, and discussions generally associated with the first year course in chemistry."
2. Form habit of using previously stated principles.
3. Emphasize the physical structure of molecules and complex ions.
4. Stress the role played by the size of the particles involved in reaction.
5. Give precise definitions of terms.
6. Teach how to refer to tables giving chemical properties of groups of elements for easy reference.
7. Give concepts of acids and bases.
8. Teach the newer I.U.C. scientific terminology.

Text 18 (23):

1. Offer a "fuller understanding and a keener appreciation of the more recent developments in chemistry."
2. Give "statistical, illustrative, and industrial material used to add information, interest, and fullness."
3. Give facts first, and then draw generalizations and conclusions.
4. Present the fundamental concepts of chemistry.

Text 19 (21):

1. Avoid historical approach because fundamentals usually were discovered after the facts.
2. Give only essential information for the beginning chemist, and explain this information as thoroughly as possible.
3. Give those facts (necessarily memorized) that will aid understanding for "true learning is both memorization and understanding ... ."

Text 20 (6):

1. Give greater emphasis to fundamental principles.
2. Establish a more rigorous course of study with particular emphasis on quantitative aspects of the subject.

Text 21 (2):

1. Teach the chemistry of elements and their compounds, chemical reactions and the equations expressing the mechanisms of the changes, the qualitative relations between elements and compounds, and the explanation of the why and how of chemical reactions.

Text 22 (16):

1. Present more organic chemistry than is normally offered in an elementary course.
2. Present more exact and concrete material concerning the fundamental ideas behind various theories.
3. To present experimental facts including those of recent development.

As will be noted, most of the above aims are rather broad and, if restricted, have more meaning, but as specific objectives they have little meaning. As an example of this vagueness, some of the past statements of the characterizations of science may be quoted (44--p. 14).

Pearson: Classification of facts.

Mill: Knowledge of antecedent--consequent relations.

Bernard: Knowledge of sufficient and necessary causes.

Kelvin: Precise measurement.

Newton: Knowledge of forces as causes of phenomena.

There are many other statements found in literature just as vague as the above in both current and past publications. Each of the above is partially correct, just as each aim or objective stated by authors of various texts is partially correct. However, in both instances the statements may be found to be incomplete or too general for evaluation. Statements (44--p. 131) such as "presenting a course terminal in nature leaving out much of the tradition, facts, and materials," or "instruction in scientific method," or "unify laws and theories" are all too general in nature. "Encouragement of critical thinking" is another phrase that sometimes is used to imply that contact with a book is an automatic "open Sesame" for understanding. Many such statements as these made by chemists and other scientists seem to indicate that science is the only place these objectives can be obtained. No one phase of any science is necessary to successful, creative living of all persons (44--p. 132). Science can do no more than contribute to all of the above, working in and with the arts, humanities, and social sciences.

Inventory of Aims and Objectives

In listing specific aims and objectives of an initial college experience in chemistry, certain criteria must be set up. Apparently the two words, "aim" and "objective," are used synonymously in the literature with the word "purpose." The aims used for the formulation of the questionnaire for this study were taken from literature and books other than textbooks. Most of the aims had to be restated to meet the requirements of the criteria. There are many general aims stated in the literature surveyed. This does not mean that these aims are not desirable, but it means only that they are not specific enough to be pinned down to meet the criteria. For example, the statement, "the object of a course in chemistry is to teach scientific method," is a perfectly legitimate objective, but it needs clarification and limitation before it is of great use as a specific objective.

Heiss (40--p. 47) says that a person who is scientific should have some attitudes that are not necessarily universal. He should (1) be curious about his environment, (2) believe that every effect has a natural cause, (3) be open-minded, (4) be critical minded, (5) not believe in superstitions, (6) be unwilling to accept as facts any statements not supported by convincing proof, (7) be willing to change his beliefs upon the presentation of sufficient evidence, (8) respect another person's point of view, and (9) maintain such ideals as honesty, patience, persistence, fairness, and thoroughness. These attitudes must be possessed by all successful scientists; however, before a definitive list of aims and objectives can be formulated, some criteria must be devised.

Heis (40--p. 25) sets up these criteria for objectives: (1) the statement must be practical and usable, leading from one step to the next, and should result in progress, (2) the statement of objectives should be psychologically sound, i.e., based on psychological principles of learning, (3) the objectives should be possible of attainment under favorable circumstances, (4) the objectives should be universal in a democratic society, and (5) the statements should indicate directly or by clear implication the relationship of classroom activity to desired changes in human behavior. In addition to these criteria, stated objectives should (1) be directed toward the general purposes of education in a democracy, (2) consider the needs and the interests of the learner, (3) be attainable at a given level of instruction, (4) serve as guides to the organization of learning materials, (5) serve as guides to the selection of learning materials, (6) direct learning toward the modification of the behavior of the learner, i.e., they should be functional, and (7) serve to suggest ways of evaluation of progress toward their attainment.

The final criteria of the aims and objectives selected for this study were as follows:

Dewey (38--p. 193) gives the following three criteria for an educational aim.

1. An educational aim must be founded upon the intrinsic activities of the individual to be educated.

2. An aim must be capable of translation into a method of cooperating with the activity of those undergoing instruction.

3. An aim must suggest the kind of environment needed to liberate and to organize their (students) capacities.

The following criteria for aims of an "initial" experience in college chemistry were added to those given by Dewey.

1. An aim must be a clear statement of a process or an interaction.

2. An aim must be capable of illustration so as to gain conviction.

3. The statement of a specific aim must not be ambiguous.

4. Aims must imply or include interaction of chemistry with other fields of learning.

5. An aim must be stated in terms of recognizable evidence for changes desired.

McGrath (44--p. 12) thinks that all aims and objectives for any science course designed for general education may fall under one of four headings: (1) teach scientific method and develop ability to use it, (2) teach the facts of science, (3) show the impacts of science on modern life of both the individual and society, and (4) show the evolution of science.

An attempt was made to catalogue the aims found in literature other than textbooks under the four headings or categories given by McGrath. Some of the aims possibly might come under two of the headings. Where used once, they are not repeated. Some of the aims show similarity but, due to different wording, they have different connotations. Most of the statements as listed are summaries of the original statements.

Since the aims as stated in literature are from the writings of teachers, they are stated as teaching aims; however, as will be shown in the final questionnaire, these aims have been reworded to indicate that they are aims for the student himself and will furnish goals for student progress and accomplishment.

I. Teach Scientific Method and Develop Ability to Use It.

1. Teach interrelations between theory and practice (119; 39--p. 245; 61--p. 245).
2. Show that we know only individual things, but we can generalize from these individual knowledges (39--p. 245; 61--p. 245).
3. Lay little stress on facts except as means of producing communication concerning concepts (74).
4. Stress principles as concepts (74).
5. Teach students to recognize and identify a problem (90).
6. Make accurate reports of observations taken of laboratory reactions (126).

7. Develop self reliance in experimenting (90 and 64).
8. Teach how to find and use some source material outside of textbook (132).
9. Teach the value of inquiry into the whats, whys, and wheres of observed happenings (88, 90, and 119).
10. Teach student to approach problems objectively removing self from the situation (79 and 90).
11. Teach personal frame of reference approach where the view of the individual involved is considered (90).
12. Use a shifting point of reference approach in which the student recognizes, chooses, and makes explicit his position in a situation and then varies that position as changes in point of reference would make it seem advantageous (88 and 90).
13. Instruct in how to set up and test a hypothesis (76, 86, 88, 90, and 118).
14. Instruct in dispassionate investigation as a general method that may be used in other real life and community investigations (48).
15. Facts simply verify supposed truths. Design experiments to discover probable truths (73).

16. Teach that true chemists do not believe in the absolute and unalterable truth of any of their working hypotheses, but they work them none the less (73).
17. Present relative truth as better than no truth at all and relative truth as a starting point for approaching absolute truth (73).
18. Teach that there is no <u>one</u> scientific method (35--p. 15).
19. Teach that even if "scientific method" cannot be defined exactly, it still can be used (35--p. 15).
20. Stress the fact that there is no pat series of scientific steps to take in problem solving (35--p. 24).
21. Show that the best method to use in "problematic" situations is the one the individual is best fitted to use (35--p. 24; 52--p. 24).
22. Discourage slovenly habits of thought and work (100).
23. Teach some steps to take in fact finding (52).
24. Encourage "thoughtful" disagreement.
25. Encourage the prediction of possible new data using the facts, theories, or principles known (116 and 148).
26. Teach differences in fact and interpretations of fact (58).

27. Stress need for correct observations before arriving at conclusions (58).
28. Instruct in action based upon critical thinking rather than that based upon intolerances, prejudices, traditions, superstitions, and misconceptions (79).
29. Observe cause and effect relationships (88 and 126).
30. Teach that it is scientific to accept "tested" truth provided the thoroughness of the test is known (119).
31. Develop the ability to suspend judgment when data are inadequate. Learn to judge when data are inadequate (119).
32. Train the ability to make sound inductions (119).
33. Develop ability to interpret data (119).
34. Develop (by use) familiarity with dependable sources of data (119).
35. Develop abilities to make sound deductions or predict outcomes (119).
36. Teach how to collect and organize facts for study (119).
37. Show that science is experimental in nature (126).

38. Instruct in some methods that may be used in making investigations of phenomena or problems (52).

II. Teach the Facts of Science.

1. Show some of the relationships between matter and life (39--p. 245).
2. Give some familiarity with the language of the chemist (39--p. 244).
3. Teach to give some idea or concept of the structure of the atom. Keep this teaching by word and action simplified, i.e., on the student's level of thinking (64).
4. Teach that matter is finite (64).
5. Teach the part that energy plays in holding matter either together or apart (126).
6. By using a select portion of chemistry for intensive study, special attention should be paid to the logical structure of the theory or principle involved. This may serve as an example of the logical structure of science as a whole and its expressed method of dispassionate investigation (126).
7. Teach some organic chemistry concepts as to the differences in structure of organic and inorganic compounds (83).
8. Aim to supplement the textbook with outside material, readings, and projects (92).

9. Stress principles rather than facts (74).
10. Show unity and interdependence that various fields of chemistry may have (55).
11. Show how facts of chemistry interrelate with all other fields of natural science (62).
12. Where and when theories are taught, unify them with facts (84).
13. Teach a simplified theory concerning units of matter (106).
14. Teach a simplified theory concerning atomic structure (106).
15. Teach some of the values of and how to use at least one periodic arrangement of elements (106).
16. Emphasize and use the kinetic theory of matter in explaining common and familiar phenomena (106).
17. Explain reactions as means of reaching energy equilibrium (111).
18. Teach the basic nature of a chemical bond (57 and 111).
19. Give comprehensive ideas of the sizes of atoms, ions, and molecules and the significance of size (64).
20. Teach oxidation states of elements including transition elements (116).

21. Teach to balance equations and to make formulas (116).
22. Teach the value of accurate measurements (62).
23. Teach facts only as they illuminate principles (119).
24. Teach some mechanical techniques (97).
25. Stimulate interest in facts (52, 56, 61, and 88).

III. Impacts of Science on Modern Life--Both the Individual and Society.

1. Show that knowledge of chemistry per se is not so important as the fact that it is a tool for accomplishment (63).
2. Inspire investigative curiosity. Allow the student to answer some of his own questions by literature or laboratory research (39--p. 245).
3. Teach for skepticism of too authoritarian statements by book or teacher (39--p. 245).
4. Teach for respective consideration of the ideas, theories, and work of others (33--p. 22).
5. Teach science (chemistry) as a tool for better living (59 and 93).
6. Show the value of and teach respect for theories (62).

7. Teach first aid procedures for the type of accidents likely to happen around the laboratory (126).
8. Bring about a realization of the importance of man's physical needs in the search for innovations and inventions made possible by science (85).
9. Instruct in communication for clarification (73).
10. Teach by illustration that truth comes by seeking not by attack upon others (73 and 88).
11. Show the differences in pure and applied science (57).
12. Emphasize that science is incompatible with a static view of any theory (53).
13. Sell chemistry by using words and phrases and illustrations already known and understood by the student in introducing any new words, theories, phrases, or principles (121 and 122).
14. Where two or more experiments may illustrate the same principle, use the one with which the students are more likely to come into contact in everyday living (121).
15. Allow student individuality to express itself. "Character cannot be taught; it must be acquired, caught, or developed." (82)

16. Make student safety conscious (66).
17. Encourage critical thinking in solving individual problems (66).
18. Give student occupational and vocational perspective (66 and 119).
19. Attempt to arouse recreational interests (66 and 119).
20. Give a partial picture of the importance of chemistry to the social world (66).
21. Give a partial picture of the part that chemistry plays in the economic world (66).
22. Indicate the part that chemistry plays in agriculture (soils, fertilizers, etc.) (62 and 76).
23. Indicate the part that chemistry plays in manufacturing and other industries (62 and 76).
24. Indicate the importance of chemistry in medicine (62 and 76).
25. Bring about a realization of the part chemistry plays in preservatives and decoration (paints, varnishes, etc.) (76).
26. Arouse curiosity about chemistry and its concepts and principles (88 and 52).
27. Instruct in evaluation of consumer problems (evaluation of advertisements, materials,

foods, and other consumer goods) (50--p. 201).

28. Awaken intellectual curiosity of the role of science in modern living (54).

29. Present some of the limitations of chemistry (what it can and cannot do (70 and 132).

30. Teach to attack problems individually. Develop self-confidence (82).

31. Develop habit of inquiry (62).

32. Develop habit of work (62).

33. Develop habit of observation (62).

34. Develop system, order, and neatness in work (62).

35. Teach to keep methodical and accurate note-books (62).

36. Help student to discover and evaluate his own aptitudes and abilities (62).

37. Teach how some conditions under which one lives may be improved (28).

38. Teach some of the contributions that science has made to the religious aspects of life (51).

39. As any principle is studied, make application and transfer the principle to some environmental factor familiar to the student (51 and 88).

40. Teach chemistry (and science in general) as cooperative and universal in nature (88).
41. Teach social concern for others (88).
42. Teach student why science is valuable to all (122).
43. Teach that theories and principles serve not to provide dogma to be taught but questions to be answered by further research (123).
44. Develop ability in student to work with others or alone (123).
45. Teach for conquering blind fear of those things not understood (68).
46. Bring about realization of a need for facts before presenting the facts themselves (90).
47. Develop skill in reading and understanding of everyday news reports as well as elementary scientific material (39--p. 245).
48. Develop better civic behavior by teaching some concepts of individual responsibility for conservation, sanitation, and health practices (107).
49. Develop some concepts that will aid in the interpretation of some of the phenomena of nature (39--p. 246).

IV. Evolution of Science.

1. Teach that progress is but the stepping stone for further advancements. "What we do today may be obsolescent tomorrow; nevertheless, today's work must be done (27)."
2. Show the unity of nature by teaching of interdependence and interrelations of the natural sciences (39--p. 245).
3. Teach that chemistry is man-made, therefore limited by man and man's knowledge (85 and 96).
4. Design problems for the present and illustrate from problems in the past that show that different ideas of the same thing can contribute to a more fully understood product (73).
5. Show that arguments stand or fall on the strength of evidence--not the qualities of men--supporting them (73).
6. Show how chemistry has contributed to social problems in the past by helping man make the most of his heritage (73).
7. Present comprehensive explanations about some of the underlying philosophies about chemistry (125).
8. Attempt to give an elementary knowledge of the historical background for science (59).

CHAPTER IV

SELECTION OF THE JURIES AND DEVELOPMENT OF THE QUESTIONNAIRE

It is unrealistic to confuse the accumulation of opinion data by means of a questionnaire with scientific fact gathering, although an instrument of this sort may be used to collect quantitative facts directly or indirectly concerning such things as the health and morals of a nation's people (49--p. 28). The subsequent usefulness of such accumulated data depends upon how well the simple rules of common sense have been followed in assembling and presenting the results, as well as the selection and cooperation of the jurors.

Selection of Sample Populations of Respondents

In the planning of a sample survey, a stage always is reached at which some decision must be made about the size of the sample (41--p. 50). Too large a sample implies a waste of resources, and too small a sample diminishes the utility of the results. With any sample population, it is impossible to guarantee absolute accuracy, but there can be calculations made that will show the level of confidence in the results provided there is some advanced approximate knowledge of the total population and its distribution.

To determine the sample size, the following line of reasoning was chosen. There are approximately 1,300 accredited senior colleges listed in the <u>Blue-Book of American Colleges and Universities</u>. If returns could be obtained from sixty-five of these, there would be a 5 per cent, or one-twentieth, representation of all these colleges.

There is no safe general rule as to how large a sample population (n) must be for use of the normal approximation in computing confidence limits. However, an estimate of sample size necessary for a 90 per cent level of confidence with a 10 per cent variation may be computed as follows (41--p. 52):

If the percentage (p) of the sample population lies within a range of 10 per cent of the percentage (P) of the total population, p will be distributed normally about P within $\pm$ 1.64 p where 1.64 is the normal deviate corresponding to a 90 per cent confidence level. Standard Deviation (σ) = $\frac{PQ}{n}$ where Q = 100 - P and n = the sample number. Hence, 1.64 x $\frac{PQ}{n}$ = 10, and n = 2.7 $\frac{PQ}{(10)^2}$.

From the preliminary sample groups, approximately 80 per cent of the answers were "yes." Using the percentages P = 80 and Q = 20,

$$n = \frac{2.7\ (80 \times 20)}{100} = 43.$$

This is less than 5 per cent of the total colleges. Therefore, no finite population correction need be used (41--p. 55). Two juries of 100 teachers each selected for this study apparently offered an adequate margin of safety.

Sampling may be of two basic varieties: (1) that based completely upon the laws of chance and (2) that in which the units of the sample are determined by the personal judgment of the enumerator. The latter method has several designations, the most common of which are purposive or non-random methods. It may produce good results with a small sample, but it is not amenable to the development of a theory, because it contains no element of random selection.

The method used for the present study was non-random in that the populations sampled had the following restrictions. First, all persons chosen were employed by some recognized four-year college or university at the time the questionnaire was presented. Second, the names of the colleges or universities had to be listed in the _Blue-Book of American Colleges and Universities_. Third, the selection of the professor from each college was chosen from a college catalogue description or list of names of professors working in the field of beginning college chemistry or professional education curriculum. Fourth, the names of every third college and university listed in the _Blue-Book of American Colleges and Universities_ were divided into two groups, those having an enrollment of 2,000 and under and those having an enrollment of over 2,000.

The method was random in the following respects. The colleges and universities selected from the Blue-Book of American Colleges and Universities were given numbers. These numbers were placed in two separate boxes. The small college numbers were in one box, and the large college numbers were in another box. Fifty numbers were drawn from each of the two groups with an extra ten drawn as alternates from each. These numbers were matched with the corresponding names of the institutions, and a list was made for the choosing of the jury of chemistry professors. The numbers then were returned to the boxes where they were mixed, and the process was repeated for the selection of the jury of education professors.

A search for catalogues from the institutions whose names were drawn was made in the libraries of Oklahoma State University in Stillwater, Oklahoma; East Texas Baptist College, Marshall, Texas; Stephen F. Austin State Teachers College, Nacogdoches, Texas; and Centenary College, Shreveport, Louisiana. No catalogues were available for six of the names drawn, and alternates were used. In the education group, the names of five colleges were technical schools or schools with no departments of teacher training or education, and these were substituted again by alternate names.

There was a total of thirty-three states represented in the total jury of chemists, and twenty-nine states were represented in the total jury of education professors.

Critique of the Questionnaire

The questionnaire has many disadvantages. In the first place, the method is often unreliable (41--p. 3) in that questions may be too suggestive of a certain answer and lead to a bias. In the second place, sampling techniques often may not give an accurate picture of the entire population (31--p. 34; 47--p. 34). Even if the sample of the population is adequate and representative, there are still chances (31--p. 292) of errors. These are (1) non-respondents may disturb or bias the representative group; (2) statements within the instrument may be ambiguous; (3) respondents may be biased or have inaccurate information; and (4) errors could be made in editing and tabulating results. In the third place, questionnaires are quite time consuming for the respondents (41--p. 4).

An opinion survey, however, is a source of data often unavailable by any other method. The oral questionnaire is preferable to the written questionnaire (41--p. 17), but, again, circumstances are frequently such as to prohibit the oral method. The written questionnaire has been used extensively in administrative and curriculum studies, with varying degrees of success, and generally is considered as an acceptable method (41--p. 35). It is one of the very few methods that adapts itself to an analysis of a course outline or text, although the questionnaire itself is fundamentally a source of data rather than a method of treating data.

The instrument used in this study was designed to secure opinions in regard to suggested objectives for an initial experience in college chemistry where the course is planned for non-science majors, for those lacking in scientific background, and for those undecided as to a major field of study. The assumption was made that the ability of the chosen test population was satisfactory since all jurors were experienced and active college professors. The willingness of the respondents may be judged by the number of answers received and the freedom used in making comments (41--p. 99). There is normally little effort made to validate opinion polls or questionnaires (41--p. 138). However, this study did attempt to find similarities and differences within and between the groups surveyed.

Development of the Questionnaire

Since the results of a questionnaire poll are so very dependent upon the instrument itself, there are certain fundamental rules to be followed in its preparation (49--p. 51).

1. The interest of the recipients of the questionnaire must be aroused or cooperation obtained by some means.

2. The questionnaire should be as short as possible, consistent with the scope of information sought.

3. The various items and statements of the questionnaire should be free of ambiguity.

4. Individual questions should be arranged so that replies may be brief. Preferably, the respondent should be able to answer the question with a simple check mark.

5. The letter of transmittal should be brief but should "sell" the idea to the informants.

6. After a questionnaire has been prepared, it should be tried on some questionnaire recipients.

7. A self-addressed, stamped, return envelope should always be included.

To determine the present day aims and objectives, a study was made of some twenty-five of the accepted textbooks used in colleges today, and an attempt was made to arrive at the over-all outcomes desired by the authors. In addition, a search was made of literature--scientific journals, current popular magazines, educational and teachers' periodicals, committee reports, bulletins, science workshop results, and opinion polls--in order to obtain a list of desired outcomes for an initial course in college chemistry designed especially for those who are either non-science majors or are undecided as to a major academic program. In all, nearly three hundred sources were used. These aims and objectives then were broken down and reworded to eliminate ambiguities and clarify the statements. There were 119 different aims and objectives used in the first questionnaire prepared. Each of the 119 individual statements was grouped under one of four general headings as suggested by McGrath (44--p. 12).

Each item had five possible answers with values ranging from +2 through zero to -2, with the +2 indicating strongest approval and -2 indicating strongest disapproval. Additional space was provided for comments, criticisms, and corrections. A sample from the first questionnaire follows. For the complete questionnaire, see Appendix IV.

Questionnaire Number 1

Using a check mark ( ), please indicate in the proper blank your opinion of each item. The greatest plus (+) value indicates strongest approval, and the greatest minus (-2) indicates strongest disfavor, with the zero (0) blank representing no opinion. Mark through, change, or add to any or all items if you so desire. Mark items that are ambiguous or not clear to you with an X.

I. After a year of college chemistry, a student should be able to demonstrate his understanding of scientific method and show his ability to use it by how well he can meet the following outcomes. A student should or should have:

	+2	+1	0	-1	-2
1. Comprehend that facts are useful in illustrating principles and aiding communication.	___	___	___	___	___

The questionnaire then was presented for study and scoring to twenty-five graduate students enrolled in Oklahoma State University. Of this number, fifteen were completed. For the preparation of a revised questionnaire, a study of these returns then was made, and any discovered ambiguities and errors were removed and corrected. For example, in Questionnaire Number 1, item 25 states as an aim "accept accepted truth." In Questionnaire Number 2, this item is number 30 and reads: "Accept tested truth according to the stringency of the test." Other changes may be noted by comparing the Number 1 and Number 2 questionnaires as found in the Appendices.

The first revision of the questionnaire was tried out with a heterogeneous group of thirty-one college instructors in a laboratory workshop held in Baylor-Belton College, Belton, Texas, in the fall of 1955. Of this group, twenty-seven were returned completed, and three were partially answered. Again a tabulation of the answers was made.

A study of the results and comments showed a need for shortening the questionnaire, which was revised completely by combining statements and rewording to give a greater clarification. The items this time were placed under these categories: (1) skills, attitudes, and understandings, (2) concepts and facts, and (3) history. The revised instrument contained fifty-seven items. The response patterns were changed to read so that check marks could be placed under "yes" if the juror thought the stated aim or objective a desirable outcome that should be consciously striven for; "no" if no conscious effort should be made by the teacher to see that the student reached the stated outcome; "indifferent" if the juror was undecided or did not know; and "do not understand" if the statement was not clear to the individual juror. Again a request for comments and suggestions was made, and space was provided in which these could be written.

This third draft was presented to a group of nineteen teachers of high school chemistry in a National Science Foundation School held in Stephen F. Austin College, Nacogdoches, Texas, in the summer of 1957. Of these nineteen, fifteen returned completed copies.

Some of the suggestions to change Questionnaire Number 3 were: (1) Item 12: "Scientists are only human" should be omitted; (2) Item 14: combining of the three sentences into one might simplify the statement; and (3) Item 15: not clear as stated. Minor changes may be found by comparison of questionnaires number 3 and number 4 as found in the Appendices.

The final revision contained fifty-eight separate items listed under these two categories: (1) skills, attitudes, and understandings and (2) concepts and facts. The response patterns were revised to include the following choices: "yes," "no," and "undecided."

The fourth revision was approved to be sent out with a letter of transmittal to the final juries in May, 1958.

A sample of the heading and first item of the final revised questionnaire and a sample letter of transmittal follow:

Questionnaire Number 4

I. An initial course in college chemistry should develop within a student certain skills, attitudes, and understandings. After completion of the course, the student should:

	Yes	No	Undecided
1. Have learned that principles, theories, and facts are most useful to the layman when applied as an aid to understanding and communication.	___	___	___

Letter of Transmittal

Dr. John Doe
Professor of Chemistry
University of ________

Dear Sir:

What is a professor to do? Through the years we professors of a beginning course in college chemistry have been so bombarded with "do's and don't's" that many of us are in doubt as to where the emphasis should be placed in our teaching methods and materials. The professional education group tells us that teaching should be concerned with brining about desirable changes in student behavior, while many of our chemistry group tell us that the ideal goal is to get over the facts--period! Now, what are we to do to get the most desirable results in, to, or from our students?

Here is how you can help immeasurably. Enclosed is a list of so-called desirable aims and objectives for an initial course in college chemistry designed for the non-majors and those who are uncertain of their future course of study, as well as for those who think they might major in one of the natural sciences. This list was gleaned from over 300 sources and seems to be relatively complete. There are three choice-opinion answers to each statement. If, as a professional chemistry professor, you think the chemistry teacher should consciously and conscientiously attempt to bring about the stated goal or aim, answer "yes." If the aim or goal is to you far-fetched or irrelevant, answer "no." If the aim is one about which you have misgivings, answer by marking "undecided."

Your answers will be included with those of a representative group of professors of chemistry, and an attempt will be made to ascertain whether or not a consensus exists among you. If you so desire, the results of this study will be sent to you as soon as it is completed.

Sincerely yours,

Frank Stinson
Professor of Chemistry

CHAPTER V

RESULTS OF THE STUDY

Response to Letters of Transmittal

On June 25, 1958, a questionnaire (Appendix IV, Questionnaire 4), with a letter of transmittal (Appendix III) and a self-addressed return envelope, was sent to each juror of two different juries (Chapter IV, page 81). The first jury consisted of one hundred college teachers of education, and the second jury consisted of one hundred teachers of college chemistry at the freshman level. This latter jury was divided evenly into two sub-juries. One of the sub-juries consisted of fifty teachers of chemistry from small colleges, and the other consisted of fifty teachers of chemistry from large colleges.

A follow-up letter (Appendix III) was sent to each of twenty-five non-respondents within each of the two larger juries on August 1, 1958. The returns immediately following these letters were almost negligible and were considered in the final totals of returns as being answers to the correspondence of June 25. The failure to obtain appreciable response to this second letter may be explained by the fact that most college teachers take vacations during the month of August.

In September a second follow-up letter (Appendix III) and a questionnaire were sent to each of fifty non-respondents with twenty-five going to members of each of the two larger juries.

There was a total of twenty-eight returns from the sub-jury of chemistry teachers in small colleges, a total of thirty-three returns from the sub-jury of chemistry teachers from large colleges, and a total of fifty-three returns from education teachers. A grand total of one hundred and fourteen returns was received. Of this number, one was too late to use in the results of the study, and four were incomplete. A summary of the returns used in the study is shown in Table I.

Of the forty-nine returns from the jury of education teachers, twenty-four were from jurors representing ten states east of the Mississippi River, and twenty-five were from jurors representing fifteen states west of the Mississippi River. Of the sixty returns from the jury of chemistry teachers, twenty-three were from jurors representing eleven states east of the Mississippi River, and thirty-three were from jurors representing sixteen states west of the Mississippi River.

TABLE I

RESPONSES TO QUESTIONNAIRE

	Small College Chemistry Teachers	Large College Chemistry Teachers	Education Teachers	Total
First Letter of Transmittal				
Number sent	50	50	100	200
Returns	24	25	43	92
Third Letter of Transmittal				
Number sent	12	13	25	50
Returns	3	8	6	17
Total returns	27	33	49	109
Per cent returns	54%	66%	49%	55%

The following scheme was used for the tabulation of results. A card was prepared for each juror. The face of the card had the name and address of the juror, a code number to match a like number on the questionnaire sent to the particular juror, and blanks for dates of correspondence either sent or received. The back of the card had numbers from one through fifty-eight with places provided for each answer given to any item of the questionnaire. The cards with names of the teachers of education were arranged alphabetically and code-marked E-1 through E-100. In like manner, cards for the fifty teachers of chemistry in large colleges were arranged and code-marked C-101 through C-150. The cards with the names of the teachers of chemistry in small colleges were arranged alphabetically and code-marked C-151 through C-200. As each questionnaire was received, the various opinion answers were recorded upon the proper card and double checked for accuracy in recording.

The total "yes," "no," and "undecided" answers were counted by the use of tally sheets, and the results were made into a table as follows:

TABLE II

TOTALS OF OPINIONS OF RESPONDENTS

	Chemistry						Education Large and Small Colleges Group D		
	Small Colleges Group A			Large Colleges Group B					
Item	Yes	No	Undecided	Yes	No	Undecided	Yes	No	Undecided
1.	20	1	6	21	3	9	43	1	5
2.	21	2	4	20	4	9	41	1	7
3.	23	2	2	24	2	7	43	2	4
4.	19	4	4	20	7	6	41	5	3
5.	27	0	0	31	1	1	46	1	2
6.	21	1	5	22	2	9	43	1	5
7.	23	1	3	22	6	5	41	0	8
8.	25	1	1	30	1	2	47	0	2
9.	17	3	7	22	5	6	37	3	9
10.	14	6	7	8	13	12	36	8	5
11.	22	2	3	16	9	8	30	6	13
12.	20	4	3	22	5	6	41	3	5
13.	24	0	3	28	2	3	47	1	1
14.	20	5	2	16	6	11	31	8	10
15.	21	1	5	17	4	12	38	5	6
16.	25	0	2	26	2	5	44	1	4
17.	26	0	1	29	1	3	42	2	5
18.	25	1	1	16	6	11	37	6	6
19.	24	0	3	28	2	3	45	0	4
20.	24	2	1	26	3	4	41	1	7
21.	17	7	3	17	8	8	33	9	7
22.	24	1	2	23	2	8	40	2	7
23.	26	0	1	26	1	6	43	1	5
24.	23	1	3	26	2	5	40	2	7
25.	15	7	5	16	7	10	29	9	11
26.	6	12	9	3	19	11	25	15	9
27.	15	1	11	15	9	9	26	13	10
28.	20	3	4	15	3	15	29	5	15
29.	15	8	4	13	11	9	18	15	16
30.	25	1	1	23	2	8	40	5	4
31.	26	0	1	24	3	6	41	2	6
32.	22	0	5	15	4	14	35	2	12
33.	6	9	12	7	15	11	22	13	14
34.	17	4	6	17	4	12	25	9	15
35.	18	1	8	14	7	12	38	5	6

TABLE II--Continued

Item	Chemistry						Education		
	Small Colleges Group A			Large Colleges Group B			Large and Small Colleges Group D		
	Yes	No	Undecided	Yes	No	Undecided	Yes	No	Undecided
36.	11	6	10	5	13	15	25	14	10
37.	25	0	2	21	7	5	34	10	5
38.	13	7	7	5	14	14	35	9	5
39.	25	1	1	26	2	5	36	6	7
40.	25	1	1	23	2	8	41	4	4
41.	27	0	0	33	0	0	47	0	2
42.	27	0	0	33	0	0	48	0	1
43.	24	0	3	26	1	6	44	0	5
44.	24	1	2	30	0	3	41	0	8
45.	25	1	1	26	1	6	45	0	4
46.	23	2	2	23	2	8	37	3	9
47.	21	2	4	25	3	5	44	0	5
48.	27	0	0	27	1	5	46	2	1
49.	26	0	1	27	1	5	34	6	9
50.	26	1	0	27	2	4	40	2	7
51.	23	0	4	26	2	5	41	2	6
52.	13	3	11	12	13	8	27	6	16
53.	8	7	12	11	13	9	39	4	6
54.	21	2	4	19	5	9	40	2	7
55.	25	1	1	24	5	4	43	2	4
56.	10	6	11	7	14	12	23	7	19
57.	23	0	4	21	4	8	35	6	8
58.	10	5	12	11	9	13	28	5	16

A survey of the above table shows the predominance of the "yes" answers on most of the items, as well as the few items, such as item 53, for which the relative number of "no" and "undecided" answers was relatively high.

Procedures for Group Comparisons

Two procedures were used in this study to obtain an over-all picture of the instrument investigated. The first procedure was to use the tabulated totals of all answers from each jury polled (Table II) and calculate a weighted score (Appendix tables B and E_3) for each item listed. Scores were weighted with a value of two for each "yes" answer, one for each "undecided" answer, and zero for each "no" answer. The totals obtained by this weighting process then were converted to a base maximum of one hundred (Table E_3). For example, using item number 1 of Table II, there were twenty "yes" answers, one "no" answer, and six "undecided" answers. The total score was calculated thus: $20 \times 2 + 6 \times 1 = 46$. The number 46 then was converted to a base of 100 by the method described in Appendix V, Table E_3.

An examination of the weighted score values (Appendix V, Table B) will show that the juries voted a relatively high value for most of the items listed. This was to be expected because of the method of scoring. The "no" answers were given a zero value; therefore, they did not detract from the total score. In addition, the nature of the instrument was such that there was relative assurance that each item was favored in some measure by some people before the poll was taken.

A series of weighted scores, such as those shown in Table B, Appendix V, may not be as important for item comparison by statistical analysis as some other methods, but they were revealing as a means for making quick and simple comparisons between the opinions of the various juries.

The accumulated scores (Table B) show that with the exception of items 39, 41, 42, and 49, the jury of education teachers rated every item higher than the jury of chemistry teachers from large colleges. Item 39 states that a student having finished an initial course in college chemistry should "have learned that all sciences are related; that there are no sharp lines of demarcation." Item 49 states that the student should have "gained some mathematical (arithmetical) efficiency." The other two items (41 and 42) differed by only two "undecided" votes for the former and one "undecided" vote for the latter. No variance between juries on any one of these four is significant by the Chi-Square test (Table D).

A comparison of score values (Table B) between the chemistry teachers in small colleges and the education teachers shows that the scores of the small college jury were above those of the education jury on twenty-eight items or approximately one-half of the total instrument. Three of the items have Chi-Square values indicating significant variance (Appendix V, Table D).

The chemistry teachers in small colleges scored only one item, item 44, lower than the chemistry teachers in large colleges. On this lone item there was a difference of less than three points.

Comparing the opinions of the various juries by mean scores (Appendix V, Table C) shows that the mean score of the teachers of chemistry in large colleges was 72.2, while that of the teachers of chemistry in small colleges was 83.8. That of teachers of education was 83.6.

The second procedure of group comparison resulted in a mean rank value for each item (Appendix V, Table A) using the weighted scores as a basis for each rank determination. Spearman coefficients of rank correlations (Rho) were determined using the mean rank values of each item (Tables A and E_2).

Rho values of 0.85 between the jury of small college chemistry teachers and the jury of large college chemistry teachers; 0.67 between the chemistry teachers in small colleges and the jury of education teachers; 0.80 between chemistry teachers in large colleges and education teachers; and 0.77 between the combined juries of chemistry teachers and the jury of education teachers indicated an appreciable degree of agreement concerning the relative importance of the aims and objectives as listed in the questionnaire.

The rank coefficients were of little importance in determining the relative agreement between any two juries upon any given aim or objective. For example, comparing scores (Table A) within the jury of chemistry teachers from small colleges will show item 41 was given a score of 100 and a mean rank of 2.5, while item 44 was given a score of 92.6 and a mean rank of 23.5. A difference of only 7.4 score points made a difference of 21 points in rank. On the other hand, these same two items were ranked as 1.5 and 3.5, respectively, by the chemistry teachers in large colleges, and they were scored with values of 100 and 95.5. A difference of 4.5 score points changed the rank value by only two points.

Item Classification and Comparison

An aid was needed in judging which of the items voted on by any given jury were to be classified as acceptable, doubtful, or rejected. The method chosen to obtain this aid was as follows: Upon each item within a separate jury's opinions, the "no" and "undecided" answers were grouped together (Table II), and the "no" plus the "undecided" total was compared with the total of "yes" answers. The null hypothesis was assumed (Appendix V, Table E_5), i.e., the assumption was made that all answers were independent and random. Then, to find the number of "yes" answers that would indicate agreement or disagreement, the Chi-Square value of 3.84, i.e., the value at the 95 per cent level of confidence, was used to calculate the limits of the numbers of "yes" answers that would classify each item in each jury's total answers (Table II) as acceptable, rejected, or doubtful. For example, the results of the above calculation gave the following limits for the jury of teachers from small colleges. Under thirteen "yes" answers for an item placed it in the "rejected" category; from thirteen to seventeen "yes" answers placed the item in the "doubtful" category; and seventeen or more "yes" answers placed the item in the "accepted" category. All items in this last group were considered as the aims that the particular jury agreed upon as being acceptable for an initial course in college chemistry designed for the non-science major. For details of calculations of the above limits and the limits set for the other juries, see Appendix V, Table E_5.

To determine whether or not there were significant disagreements between the opinions of any two juries upon any item, Chi-Square again was used. Using the null hypothesis for each test, i.e., using the hypothesis that there was no difference of opinion between two juries upon a given item, the Chi-Square value was calculated (Appendix V, Table E_6). A table (Appendix IV, Table D) of the results of the Chi-Square tests indicates the agreement between various juries. The table shows Chi-Square values between the teachers of chemistry in small colleges and the teachers of chemistry in large colleges; between the teachers of chemistry in small colleges and the teachers of education; and between the teachers of chemistry in large colleges and the teachers of education.

In the following tables, the items from the questionnaire (Appendix IV) sent to the juries are separated into the various categories of agreement and disagreement as shown, using the Chi-Square determination as an aid to separation and interpretation.

Although Chi-Square values (Appendix Table D) indicate that the null hypothesis may be rejected upon these items (Table III), the method of classification allowed items 27 and 29 to be placed within the same category. There was a high degree of agreement between these two juries.

TABLE III

ITEMS INDICATED BY CHI-SQUARE VALUES TO HAVE LITTLE SIGNIFICANT AGREEMENT BETWEEN JURIES OF CHEMISTRY TEACHERS IN SMALL COLLEGES (A) AND EDUCATION TEACHERS (C)

		Jury	
		A	C
After completion of an initial course in college chemistry designed for the non-science major, a student should:			
27.*	Have developed occupational perspective.	d	d
49.	Gained some mathematical (arithmetical) efficiency.	a	a
53.	Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world in ages past.	r	a

* Numbers represent item numbers (Appendix IV, Questionnaire 4).

A represents teachers of chemistry in small colleges.

C represents teachers of education.

a represents acceptable.

d represents doubtful.

r represents rejected.

Table IV illustrates the variance between the indicated juries. The method of accepting, rejecting, or classifying each item as doubtful allowed items 52 and 58 to be placed in the same category.

TABLE IV

ITEMS SHOWN BY CHI-SQUARE TO HAVE LITTLE SIGNIFICANT AGREEMENT BETWEEN JURIES OF CHEMISTRY TEACHERS IN LARGE COLLEGES AND EDUCATION TEACHERS

		Jury	
		B	C
After completion of an initial course in college chemistry designed for the non-science major, a student should:			
10.*	Have developed skill in locating, evaluating, and using source material and data in predicting new data or developing new hypotheses.	r	d
18.	Be able to substitute results of critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions.	d	a
26.	Have developed recreational interests.	r	d
35.	Respect the habit of research and have developed ability to channel curiosity.	d	a
36.	Apply scientific principles to human behavior.	r	d
38.	Have developed concepts of the value of cooperation and social concern for community conservation, sanitation, and health.	r	a

* Numbers represent item numbers (Appendix IV, Questionnaire 4).

B represents teachers of chemistry in large colleges.

C represents teachers of education.

a represents acceptable.

d represents doubtful.

r represents rejected.

TABLE IV--Continued

		Jury	
		B	C
52.	Be able to illustrate the scientific attitude by citing some case histories.	d	d
53.	Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world in ages past.	d	a
56.	Be able to design problems for the present and illustrate from problems in the past so as to show that different ideas of the same thing can contribute to a more complete understanding.	r	d
58.	Be able to give a comprehensive explanation about some of the underlying philosophies of chemistry.	d	d

Table V shows the items with Chi-Square values greater than that in the .05 column of a Chi-Square table. Therefore, the null hypothesis may be rejected on these items. The method of classification did not place any item within the same category by both juries.

TABLE V

ITEMS SHOWN BY CHI-SQUARE TO HAVE LITTLE SIGNIFICANT AGREEMENT BETWEEN JURIES OF CHEMISTRY TEACHERS IN SMALL COLLEGES AND CHEMISTRY TEACHERS IN LARGE COLLEGES

	Jury	
	A	B
After completion of an initial course in college chemistry designed for the non-science major, a student should:		
18.* Be able to substitute results of critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions.	a	d
28. Conceive of progress as generally depending upon directed effort rather than genius.	a	d
32. Have learned interrelations between theories and practices.	a	d
37. Have developed self-reliance, the ability to learn for self, and the ability to work with others as well as alone.	a	d
54. Have learned how chemistry has contributed to the solution of social and economic problems in the past, and have an awareness of its prospective roll in the future.	a	d

* Numbers represent item numbers (Appendix IV, Questionnaire 4).

A represents chemistry teachers in small colleges.

B represents chemistry teachers in large colleges.

a represents acceptable.

d represents doubtful.

r represents rejected.

TABLE V--Continued

	Jury A	Jury B
58. Be able to give a comprehensive explanation about some of the underlying philosophies of chemistry.	r	d

Table VI shows those items rejected by the method used (Appendix V, Table E_5) by either the combined jury of chemistry teachers or by the jury of education teachers. Education teachers did not completely reject any item; however, of the seven rejected by the combined jury of chemistry teachers, all but item 53 were classed as doubtful by the teachers of education. There is relatively good agreement that these aims could or should be omitted from a list for an initial course in college chemistry designed for the non-science major.

TABLE VI

REJECTED AIMS AND OBJECTIVES

	Juries			
	A	B	AB	C
After completion of an initial course in college chemistry designed for the non-science major, a student should:				
26.* Have developed recreational interests.	r	r	r	d
33. Have learned that sensory stimulation usually comes before reasoning mental processes.	r	r	r	d
36. Be able to apply scientific principles to human behavior.	r	r	r	d
38. Have developed concepts of the value of cooperation and social concern for community conservation, sanitation, and health.	d	r	r	d
53. Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world in ages past.	r	d	r	a

* Numbers represent item numbers (Appendix IV, Questionnaire 4).

A represents chemistry teachers in small colleges.

B represents chemistry teachers in large colleges.

AB represents the combined jury of chemistry teachers.

C represents teachers of education.

a represents acceptable.

d represents doubtful.

r represents rejected.

TABLE VI--Continued

	Juries A	B	AB	C
56. Be able to design problems for the present and illustrate from problems in the past so as to show that different ideas of the same thing can contribute to a more complete understanding.	r	r	r	d
58. Be able to give a comprehensive explanation about some of the underlying philosophies of chemistry.	r	d	r	d

There were twelve items that either jury AB or jury C classed as doubtful. Some of the differences in jury opinions are worthy of note. Jury C showed favor for item 10, while Jury B rejected it altogether. Jury A classed it as doubtful. Jury A showed noticeable favor for these aims (items 11, 14, 21, 28, 32, and 34) which implied application of facts to practical use. See Table VII.

TABLE VII

DOUBTFUL AIMS AND OBJECTIVES

	Juries			
	A	B	AB	C
After completion of an initial course in college chemistry designed for the non-science major, a student should:				
10.* Have developed skill in locating, evaluating, and using source material and data in predicting new data or developing new hypotheses.	d	r	d	a
11. Be proficient in communication, i.e., skillful in reading, writing, speaking, and listening.	a	d	a	d
14. Conceive of science as a word referring to method rather than subject matter, i.e., the scientific method is any logically organized procedure using the instruments and factors available.	a	d	d	a
21. Have learned the difference between pure and applied research (i.e., seeking knowledge for the sake of knowledge and seeking knowledge with a particular end in view); between science and technology.	a	d	d	a

* Numbers represent item numbers (Appendix IV, Questionnaire 4).

A represents chemistry teachers in small colleges.

B represents chemistry teachers in large colleges.

AB represents the combined jury of chemistry teachers.

C represents teachers of education.

a represents acceptable.

d represents doubtful.

r represents rejected.

TABLE VII--Continued

		Juries			
		A	B	AB	C
25.	Feel that authenticated printed matter is significant, i.e., recorded phenomena may be experienced by anyone, and the explanations of these phenomena may be made by anyone.	d	d	d	d
27.	Have developed occupational perspective.	d	d	d	d
28.	Conceive of progress as generally depending upon directed effort rather than genius.	a	d	d	d
29.	Have learned to evaluate advertising.	d	d	d	d
32.	Have learned interrelations between theories and practices.	a	d	d	a
34.	Have learned that we can know only individual things, but we can generalize from those individual knowledges.	a	d	d	d
35.	Respect the habit of research and have developed ability to channel curiosity into action.	d	d	d	d
52.	Be able to illustrate the scientific attitude by citing some case histories.	d	d	d	d

Table VIII lists thirty-nine aims that both the combined juries of chemistry teachers and the jury of education teachers classed as acceptable aims for an initial course in college chemistry designed for the non-science major. Almost all of these aims imply those skills, attitudes, and understandings that have been favored by advocates of certain background or general education courses designed for all college students.

A brief summary of all the suggested aims (Appendix IV, Questionnaire 4) shows that the jury of teachers of chemistry from small colleges rejected six aims, placed six aims in the doubtful class, and accepted forty-six aims. The jury of teachers of chemistry from large colleges rejected six aims, placed nineteen aims in the doubtful category, and accepted thirty-three aims. The jury from the small colleges was strongly in favor of some of those aims classed as doubtful by the jury of teachers of chemistry from large colleges; therefore, it was possible for some of these to be accepted by the combined jury. The jury of teachers of education placed twelve aims within the doubtful class and accepted forty-six aims.

TABLE VIII

AIMS AND OBJECTIVES ACCEPTABLE TO THE COMBINED JURIES OF CHEMISTRY TEACHERS AND EDUCATION TEACHERS

After completion of an initial course in college chemistry designed for the non-science major, a student should:

1. Have learned that principles, theories, and facts are most useful to the layman when applied as an aid to understanding and communication.

2. Be able to recognize what constitutes a problem and to approach a solution to the problems objectively from a shifting point of reference.

3. Be able to use both deductive and inductive reasoning processes in planning possible steps of procedure in problem solving.

4. Be able to arrive at and state hypotheses which may be tested by planned experiments and problems.

5. Be able to analyze and interpret data from correct observations so as to reach tentative, simple, and reasonable conclusions.

6. Understand that knowledges of interrelated facts may be arranged and combined to make new knowledge.

7. Have learned to employ critical thinking and judgment in distinguishing between facts and interpretation of facts.

8. Have learned that chemistry is not isolated from life, but is a tool which can and should contribute to personal, social, and political aspects of society.

9. Understand that principles are concepts to be applied to new situations in solving daily problems and that the facts simply define the principles.

10. Have developed an interest in chemistry as a man-made and man-limited field.

11. Have developed respect and appreciation for methods, aspirations, and limitations of studies of science.

TABLE VIII--Continued

12. Have formed habit of observing cause and effect and of inquiring as to the what, how, and why of observed happenings.

13. Have developed curiosity about and interest in factual knowledge.

14. Be able to substitute results of critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions.

15. Recognize the need for objectivity and open-mindedness in interpreting phenomena, i.e., exhibit intellectual honesty.

16. Have attained a background of knowledges that will make possible further study after formal schooling is finished.

17. Recognize the fact that the chemist does not believe in the unalterable truth of any of his hypotheses but that he makes use of them just the same; i.e., that the scientific mind values relative truth as better than no truth.

18. Develop proper laboratory techniques through "practical accuracy" in making and using measurements and "practical safety" in laboratory procedures.

19. Have developed an appreciation of the orderliness of nature.

20. Have discovered that doing is one of the best ways of learning.

21. Have formed habits of order and neatness in making reports, thinking, and observing.

22. Apply scientific principles to human behavior.

23. Have developed self-reliance, the ability to learn for self, and the ability to work with others as well as alone.

24. Have learned that all sciences are related; that there are no sharp lines of demarcation.

25. Have developed the habit of suspended judgment until sufficient data have been accumulated, but recognize the tentative value of consistent results.

TABLE VIII--Continued

26. Gained some idea of kinds (classes and state), structure, nature, and finiteness of matter.

27. Gained some idea of the chemical and physical changes matter can undergo and learned to express the more simple reactions of matter in symbol and word form.

28. Learned some of the interrelations between facts, theories, and techniques pertaining to the forces of nature.

29. Acquired concepts of theoretical atomic structure, atomic sizes, and importance of size.

30. Acquired concepts of the nature of energy and the importance of energy in holding matter together or apart.

31. Developed an understanding of the nature of ionic and oxidation-reduction reactions as being attempts to reach energy equilibrium.

32. Developed an understanding of some industrial and some practical aspects of chemistry such as certain common industrial processes and the uses of synthetics, detergents, fertilizers, dyes, etc., around the home.

33. Acquired a usable scientific vocabulary.

34. Gained some mathematical (arithmetical) efficiency.

35. Learned how to read charts, graphs, and tables.

36. Know how scientists work and become acquainted with some of the world's great scientific ideas.

37. Have learned how chemistry has contributed to the solution of social and economic problems in the past, and have an awareness of its prospective roll in the future.

38. Have conceived of progress made up to the present time as but a stepping stone for further advancements of science in the future.

39. Have learned that the validity of arguments depends on the strength of the evidence and not on the qualities of the men supporting them.

CHAPTER VI

CONCLUSIONS AND EDUCATIONAL IMPLICATIONS

This study was concerned with the problem of identifying the aims and objectives for an initial course in college chemistry designed for the non-science major. It was proposed as hypotheses that a consensus of the desired aims and objectives could be identified; that there would be differences as well as similarities of opinion about the aims of an initial course in college chemistry between populations of teachers of education and teachers of chemistry; and that there would be likenesses and differences between teachers of chemistry in small colleges and teachers of chemistry in large colleges.

The procedure for proving these hypotheses included an item inventory of aims and objectives in natural science and chemistry in a first year college course; the development of an instrument of inquiry; the selection of juries from the fields of education and chemistry; and comparisons of opinions received from the respondents.

Conclusions

The following conclusions were drawn:

1. There is a consensus between teachers of chemistry and teachers of education that certain student behavior-centered aims for an initial course in college chemistry should be taken into consideration when designing a course for the non-science major. In this study only seven items of a compilation of fifty-eight student-centered aims were rejected by a jury of sixty teachers of chemistry from a wide geographical distribution of colleges. Of these seven items, six were classified as doubtful by a jury of forty-nine education teachers.
2. There are some differences of opinion between the teachers of chemistry in small colleges and the teachers of chemistry in large colleges. Within the population limits of the findings of this study, the former jury significantly favored some behavior-centered aims for an initial course of chemistry more than the latter jury. The jury of teachers from small colleges rejected six of the compiled aims and placed six in the doubtful category, whereas the jury of teachers from large colleges rejected six aims but placed nineteen in the doubtful category.

Educational Implications

The conclusions drawn from the findings of fact in this study lead to certain educational implications. They are:

1. Teachers of chemistry in small colleges appear to have more personal interest in the student's development than do teachers of chemistry in large institutions. This implication may help to explain previous studies which showed that over sixty per cent of the chemistry students taking graduate work in universities came from small colleges, while only forty per cent of the total undergraduate majors in chemistry came from the small colleges. It may be that teachers in the larger colleges are more interested in teaching chemistry majors only and do not recognize or accept their responsibilities in a science training program for all students.
2. The teachers of chemistry in the larger colleges often seem to think that to stress the factual content of a course is the sole responsibility of the chemistry teacher rather than the stressing of social and humanistic aims.
3. A course in chemistry can be used to fulfill the needs for natural science in a general education program provided a course is designed on a different basis from the present classical course. This

new course should be organized and should be presented around the consensus identified in this study.

4. An initial course in college chemistry must not be used solely in an attempt to teach all of the facts necessary to technologists in the field of chemistry.
5. Textbook writers should make a critical survey of the present material, organization, and presentations of their texts used in the present initial courses of college chemistry.

Weaknesses of the Study

1. A possible weakness of this study is the selection of items. In the multitude of aims which have been proposed, there must have been some which were overlooked.
2. Another weakness is in the statements of objectives. These objectives were restatements and summaries of original writings as interpreted by the author of this study.
3. The weighted scale of the study was one arbitrarily chosen for convenience of handling. There may be a better method of weighting the item.
4. No attempt was made to test the reliability of this study by the retest method upon the same or different juries.

5. The written questionnaire has several inherent weaknesses since it depends upon the willingness, training, and interpretations of the respondents.

Recommendations for Further Study

The recommendations given here are offered in the hope that they may contribute to the elimination of the present day dilemma as to what to offer in an initial course in college chemistry designed for the non-chemistry major. Additional problems that need investigation are:

1. Which of the aims and objectives classified as doubtful or omitted in this study should be accepted or rejected?
2. What kind of testing instruments should be developed to determine whether or not the aims and objectives classified as acceptable in this study have been reached for an initial course in college chemistry?
3. If the aims and objectives classified as acceptable in this study are striven for and reached to a greater or less degree, will their attainment help bring an increase or decrease in well trained and qualified chemistry majors?
4. Can the other basic natural sciences serve as background courses of science and fulfill the need for

science in a general education program as well as chemistry?

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APPENDICES

APPENDIX I

EDUCATION PROFESSORS

(Respondents)

Robert Clark Aden
Bethel College
McKenzie, Tennessee

Dr. H. B. Alberty
Ohio State University
Columbus, Ohio

Arnold DeWald Albright
University of Kentucky
Lexington, Kentucky

Dr. R. B. Allen
University of Arkansas
Fayetteville, Arkansas

Dr. Harold Anderson
University of Colorado
Boulder, Colorado

Dr. C. K. Arey
University of Alabama
University, Alabama

Dr. W. D. Armentrout
Colorado State College of Education
Greeley, Colorado

Marshall Arnold
East Central State College
Ada, Oklahoma

Dr. Ray M. Berry
University of Idaho
Moscow, Idaho

Adelaide Bohstedt
Bob Jones University
Greenville, South Carolina

Dr. J. A. Bond
University of California
Los Angeles, California

Dr. G. R. Boyd
State Teachers College
Troy, Alabama

Dr. E. M. Bowman
Texas Wesleyan College
Ft. Worth, Texas

Mary Bacon Brooks
Georgia State College for Women
Milledgeville, Georgia

Roscoe V. Buckland
Berea College
Berea, Kentucky

Dr. John Winder Carr
Duke University
Durham, North Carolina

Dr. Don E. Davis
Kansas State Teachers College
Emporia, Kansas

Dr. E. C. Denney
Iowa State Teachers College
Cedar Falls, Iowa

Dr. H. W. Distad
University of Akron
Akron, Ohio

Dr. J. A. Dotson
University of Georgia
Athens, Georgia

Dr. J. G. Fowlkes
University of Wisconsin
Madison, Wisconsin

Dr. Mildred Franks
Montana State College
Bozeman, Montana

Dr. H. L. Frick
Florida State University
Tallahassee, Florida

Dr. Homer L. Garrett
Louisiana State University
Baton Rouge, Louisiana

Prof. Warren E. Gauerke
Emory University
Emory, Georgia

John Baker Gentry
Clemson Agricultural College
Clemson, South Carolina

Dr. V. W. Gillenwater
Arizona State College
Flagstaff, Arizona

Prof. T. D. Graham
Ohio Wesleyan University
Delaware, Ohio

Ernest Clifford Hall
Central State College
Edmond, Oklahoma

Arthur William Hartung
Catawba College
Salisbury, North Carolina

Dr. W. L. Howard
Butler University
Indianapolis, Indiana

J. Calvin Koonts
Erskine College
Due West, South Carolina

Kenneth George Kuehner
Coker College
Hartsville, South Carolina

Dr. D. E. Lawson
Southern Illinois University
Carbondale, Illinois

Dr. J. M. Lee
State College of Washington
Pullman, Washington

Dr. Hal G. Lewis
University of Florida
Gainesville, Florida

Normand W. Madore
West Texas State College
Canyon, Texas

Dr. Irving A. Mather
Santa Barbara College
Santa Barbara, California

Dr. G. D. McGrath
Arizona State College
Tempe, Arizona

Dr. J. C. Parker
University of California
Berkeley, California

Dr. R. B. Patrick
Pennsylvania State University
State College, Pennsylvania

Dr. Emma Reinhardt
Eastern Illinois State College
Charleston, Illinois

Dr. N. O. Reppen
Wisconsin State College
Stevens Point, Wisconsin

Dr. George Ernest Schdesser
Colgate University
Hamilton, New York

E. Boyd Shannon
Pasadena College
Pasadena, California

Dr. W. B. Spalding
University of Illinois
Urbana, Illinois

Dr. D. F. Votaw
Southwest Texas State Teachers College
San Marcus, Texas

Dr. C. L. Wisseman
Southern Methodist University
Dallas, Texas

Dr. J. B. Woodley
Southeastern Louisiana State College
Hammond, Louisiana

CHEMISTRY PROFESSORS

(Respondents)

Dr. Agnes M. Allen
Arizona State College
Flagstaff, Arizona

Prof. Carl T. Bahner
Carson-Newman College
Jefferson City, Tennessee

Dr. H. E. Bent
University of Missouri
Columbia, Missouri

Dr. Melvern H. Berry
Florida Southern College
Lakeland, Florida

Dr. E. L. Bickerdike
Santa Barbara College
Santa Barbara, California

Dr. Francis E. Blacet
University of California
Los Angeles, California

Dr. J. W. Bouknight
University of South Carolina
Columbia, South Carolina

Dr. B. P. Broadbent
Idaho State College
Pocatello, Idaho

Alfred Seely Brown
Colgate University
Hamilton, New York

Duane Brown
Arizona State College
Tempe, Arizona

Paul M. Brown
Bob Jones University
Greenville, South Carolina

Dr. R. D. Brown
University of Alabama
University, Alabama

Colonel Ralph Milledge Byrd
Citadel-Military College
Charleston, South Carolina

Dr. J. G. Calvert
Ohio State University
Columbus, Ohio

Dr. E. C. Colin
Chicago Teachers College
Chicago, Illinois

Dr. Paul E. Cross
University of Washington
Seattle, Washington

Dr. J. L. Culbertson
State College of Washington
Pullman, Washington

Dr. Willis I. Decker
East Central State College
Ada, Oklahoma

Dr. L. I. Diuguid
A & M Normal College
Pine Bluff, Arkansas

Dr. R. H. Eastman
Stanford University
Palo Alto, California

Dr. J. B. Entrikin
Centenary College
Shreveport, Louisiana

Prof. H. C. Eshelman
Southwestern Louisiana Institute
Lafayette, Louisiana

Dr. L. P. Eslin
Ohio University
Athens, Ohio

Dr. P. C. Gaines
Montana State College
Bozeman, Montana

Dr. B. E. Ginsbury
University of Chicago
Chicago, Illinois

Dr. H. F. Glidden
Colorado State College of Education
Greeley, Colorado

Dr. J. C. Godbey
Georgetown University
Georgetown, Texas

Dr. C. A. Goetz
Iowa State College
Ames, Iowa

Dr. R. U. Gooding
Illinois State Normal University
Normal, Illinois

Dr. H. W. Gould
Northern Illinois State Teachers College
DeKalb, Illinois

Kenneth Milton Gordon
Birmingham-Southern College
Birmingham, Alabama

Dr. Norman Hackerman
University of Texas
Austin, Texas

Dr. Henry B. Hardt
Texas Christian University
Ft. Worth, Texas

Lowell V. Heisey
Bridgewater College
Bridgewater, Virginia

Dr. J. W. Howard
Montana State University
Missoula, Montana

Dr. J. I. Jolly
University of Idaho
Moscow, Idaho

Dr. Myron N. Jorgensen
University of Kansas City
Kansas City, Missouri

Dr. James W. Kercheval
Iowa State Teachers College
Cedar Falls, Iowa

Dr. Carroll L. Key
Southwest Texas State Teachers College
San Marcus, Texas

Harold W. Lucien
Dillard University
New Orleans, Louisiana

Dr. W. A. Manual
Ohio Wesleyan University
Delaware, Ohio

Dr. E. C. Markham
University of North Carolina
Chapel Hill, North Carolina

Dr. E. G. Meyer
New Mexico Highlands University
Las Vegas, New Mexico

Dr. M. C. Nielson
University of Missouri
Columbia, Missouri

Dr. H. E. Phipps
Eastern Illinois State College
Charleston, Illinois

Dr. R. E. Powell
University of California
Berkeley, California

Prof. R. T. Pursley
Southeastern Louisiana State College
Hammond, Louisiana

Dr. W. M. Rieger
Northeast Missouri State College
Kirksville, Missouri

George E. Rouse
Bethel College
McKenzie, Tennessee

Richard Irwin Rush
Centre College of Kentucky
Danville, Kentucky

Dr. John R. Sampey
Furman University
Greenville, South Carolina

Dr. E. R. Schieza
University of Wyoming
Laramie, Wyoming

Dr. A. W. School
Marshall College
Huntington, West Virginia

Alfred S. Spriggs
Clark College
Atlanta, Georgia

Edward Emerson Towell
College of Charleston
Charleston, South Carolina

Dr. R. A. Trytten
Wisconsin State College
Stevens Point, Wisconsin

Dr. W. E. Ward
Texas Wesleyan College
Ft. Worth, Texas

APPENDIX II

FIRST LETTER OF TRANSMITTAL
TO EDUCATION PROFESSORS

Dr. John Doe
Professor of Education
University of ________

Dear Sir:

What is a professor to do? Through the years we professors of a beginning course in college chemistry have been so bombarded with "do's and don't's" that many of us are in doubt as to where the emphasis should be placed in our teaching methods and materials. The professional education group tells us that teaching should be concerned with bringing about desirable changes in student behavior, while many of our chemistry group tell us that the ideal goal is to get over the facts--period! Now, what are we to do to get the most desirable results in, to, or from our students?

Here is how you can help immeasurably. Enclosed is a list of so-called desirable aims and objectives for an initial course in college chemistry designed for the non-majors and those who are uncertain of their future course of study, as well as for those who think they might major in one of the natural sciences. This list was gleaned from over 300 sources and seems to be relatively complete. There are three choice-opinion answers to each statement. If, as a professional education professor, you think the chemistry teacher should consciously and conscientiously attempt to bring about the stated goal or aim, answer "yes." If the aim or goal is to you far-fetched or irrelevant, answer "no." If the aim is one about which you have misgivings, answer by marking "undecided."

Your answers will be included with those of a representative group of professors of education, and an attempt will be made to ascertain whether or not a consensus exists among you. If you so desire, the results of this study will be sent to you as soon as it is completed.

Sincerely yours,

Frank Stinson
Professor of Chemistry

FIRST LETTER OF TRANSMITTAL
TO CHEMISTRY PROFESSORS

Dr. John Doe
Professor of Chemistry
University of ________

Dear Sir:

What is a professor to do? Through the years we professors of a beginning course in college chemistry have been so bombarded with "do's and don't's" that many of us are in doubt as to where the emphasis should be placed in our teaching methods and materials. The professional education group tells us that teaching should be concerned with bringing about desirable changes in student behavior, while many of our chemistry group tell us that the ideal goal is to get over the facts--period! Now, what are we to do to get the most desirable results in, to, or from our students?

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Your answers will be included with those of a representative group of professors of chemistry, and an attempt will be made to ascertain whether or not a consensus exists among you. If you so desire, the results of this study will be sent to you as soon as it is completed.

Sincerely yours,

Frank Stinson
Professor of Chemistry

SECOND LETTER OF TRANSMITTAL
TO EDUCATION PROFESSORS

Dr. John Doe
Professor of Education
University of ________

Dear Sir:

If you are like the rest of us, the days seem all too short to take care of all the odds and ends that seem to stack up at this time of year. In some of that stacked up mail, you will possibly find a questionnaire that I sent to you about July 1st. To have been sent out at this time of the year, the number of responses to the questionnaire has been very gratifying, but I would still like very much to have your opinions to incorporate in an October report.

It might interest you to know that the pattern of responses has taken some quirks that I was not exactly anticipating, but this will only make the results more interesting.

If the instrument has been misplaced, I will send another within the next two or three weeks.

Sincerely yours,

Frank Stinson
Professor of Chemistry

SECOND LETTER OF TRANSMITTAL
TO CHEMISTRY PROFESSORS

Dr. John Doe
Professor of Chemistry
University of ________

Dear Sir:

If you are like the rest of us, the days seem all too short to take care of all the odds and ends that seem to stack up at this time of year. In some of that stacked up mail, you will possibly find a questionnaire that I sent to you about July 1st. To have been sent out at this time of the year, the number of responses to the questionnaire has been very gratifying, but I would still like very much to have your opinions to incorporate in an October report.

It might interest you to know that the pattern of responses has taken some quirks that I was not exactly anticipating, but this will only make the results more interesting.

If the instrument has been misplaced, I will send another within the next two or three weeks.

Sincerely yours,

Frank Stinson
Professor of Chemistry

THIRD LETTER OF TRANSMITTAL
TO EDUCATION PROFESSORS

Dr. John Doe
Professor of Education
University of _______

Dear Sir:

A few weeks ago you received a questionnaire relating to the various attitudes, aptitudes, skills, etc., that various professors have listed as being of prime importance as ideal goals for an initial course in college chemistry. Probably this was misplaced during the summer vacation. However, I would still like very much to have your opinions to incorporate in an early spring report as to what a chemistry teacher should consciously and conscientiously strive for as worthy aims.

You will be interested to know that the responses to this instrument have been very gratifying. Respondents have been divided about equally between professional teachers of education and teachers of chemistry. The similarities and differences of opinions are proving rather interesting.

Enclosed you will find an extra copy of the questionnaire with a return envelope in case yours was lost.

Sincerely yours,

Frank Stinson, Chairman
Math-Science Division

THIRD LETTER OF TRANSMITTAL
TO CHEMISTRY PROFESSORS

Dr. John Doe
Professor of Chemistry
University of ________

Dear Sir:

A few weeks ago you received a questionnaire relating to the various attitudes, aptitudes, skills, etc., that various professors have listed as being of prime importance as ideal goals for an initial course in college chemistry. Probably this was misplaced during the summer vacation. However, I would still like very much to have your opinions to incorporate in an early spring report as to what a chemistry teacher should consciously and conscientiously strive for as worthy aims.

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Enclosed you will find an extra copy of the questionnaire with a return envelope in case yours was lost.

Sincerely yours,

Frank Stinson, Chairman
Math-Science Division

APPENDIX III

EXCERPTS FROM NOTES AND LETTERS RECEIVED FROM THE JURY OF EDUCATORS

West Texas State College

"... let me state how pleased I am to see someone undertake the task of bringing the professional educator and the academic professor closer together."

Michigan State University

"... I doubt that anyone could answer the questionnaire with any considerable confidence in the answer... ."

University of Arkansas

"No single course will develop skill, etc., except as are peculiar to a certain field. The ability of a student at this level of training is the perspectus from which I am checking the questions."

University of Alabama

"Goals and objectives of this sort do not represent some kind of finish line which some students reach while others do not. Rather, they represent directions or vectors along which we attempt to move students, and some students progress farther in these directions than do others."

Colorado State College of Education

"With the exception of items 4, 12, 23, the first 39 questions apply to any well taught subject."

Florida State University

"Every course which he (the student) takes from chemistry to poetry should make a contribution to most of these ends. ... if you claim these as unique values for the first course in college chemistry and can prove that the course achieves the values, I would argue that we might just as well eliminate all work previous to this course except perhaps the first three or four grades in school. After all, the one course in chemistry will provide all the student needs in general education."

Louisiana State University

"... I would like to suggest that you send copies of this to the following of my colleagues... ."

Butler University

"It would be worthwhile if you could do all of these in a chemistry course."

Southern Illinois University

"This is an excellent list for such a questionnaire."

State College of Washington

"... most of the objectives are developmental. In many cases I placed my mark 'D' under the 'yes' check to indicate in my opinion that they should receive special attention."

University of Florida

"... I would make a distinction of sorts but the central purposes of the courses (factors of chemistry) and the accompanying purposes (skills, attitudes, etc.)... ."

University of California

"... I would like to see the results on this study. All are significant in my opinion, but some are more significant than others."

Eastern Illinois State College

"... most of the aims that you list are highly desirable but could be obtained in courses other than chemistry. ... the courses (in chemistry) for non-majors should be less detailed than a course for majors."

Duke University

"... those questions checked (as 'yes') are those for which chemistry is only partially responsible."

Kansas State Teachers College

"If you succeed in accomplishing them (the objectives) all in one beginning course of chemistry, or in a chemistry major for that matter, please advise me. I am not too old to profit from such a course!!!"

Ohio Wesleyan University

"'The essence of things hoped for' ... . Any of these are most desirable things which took me more than one chemistry course to appreciate. In fact, half a lifetime of experience."

Georgia State College for Women

"... if you do the above well (stated aims), I imagine the student will learn some chemistry."

Bridgewater College

"... I was extremely pleased that you sent me one of your questionnaires... . ... thank you for letting me know that this study is going on."

Stanford University

"... I am not able or qualified to respond to the questionnaire..."

University of Idaho

"Most of these may well be answered yes. Certainly they are desirable. The only question is can they reasonably be expected to be realized."

University of California

"It is hard to disagree with very many of these objectives, but it would take the 'world's best course' to accomplish all of them to any great extent within the amount of time available for the average Chem IA course. I would very much like having a copy of this questionnaire. I believe it would be very helpful to all teachers of chemistry."

University of Colorado

"Some of the objectives checked must be brought in as secondary objectives. These objectives could be checked as primary or secondary."

Iowa State Teachers College

"I regard these items (18, 19, 36, 38, 47, 51, 54, and 57) as of the foremost importance."

University of Akron (Ohio)

"I would be interested to know the results of your study."

University of Georgia

"I ... I have not studied Chemistry. It is my opinion that the first objective of Chemistry I is to teach Chemistry ... ."

University of Wisconsin

"These statements cannot be denied as to value... ."

Central State College (Oklahoma)

"I should say to STRESS the subject matter in your general Chemistry--methods should be incidental."

EXCERPTS FROM NOTES AND LETTERS RECEIVED FROM THE JURY OF CHEMISTS

Southern Methodist University

"Most of these items could be debated... ."

Arizona State College

"... on some (of the items) I entered qualified entries which may be of interest to you. ... I would be pleased to receive the results... ."

University of Missouri

"I have read with interest the questionnaire with regard to a beginning course in Chemistry. This reflects what seems to me almost an hysterical attitude on the part of much of the public with regard to what can be accomplished in a course of Chemistry... ."

University of California

"Many (of these items) refer to accomplishing which in our opinion (four professors quoted) lay outside ... this chemistry course."

Chicago Teachers College

"Many of these outcomes seem to be too much to ask of a single course. I believe we would do better in chemistry to limit our objectives and do a few of them well."

University of Washington

"All are noble objectives but applicable to a Ph.D. course rather than an introductory course... ."

State College of Washington

"The brilliant student will do all of these to a greater or lesser degree. The duller will do none. The hope that the average student will attain a significant confidence along these lines is a utopian dream."

Iowa State College

"... only on item 17 do I find the old curiosity which is the key to success or failure."

Southwest Texas State Teachers College

"I am not convinced that the above (questionnaire) covers what should be accomplished in a first year chemistry course."

University of Missouri

"... all ... are goals or hopes to achieve in any chemistry course... . We differ ... only with respect to the relative emphasis placed on each and the combined abilities of ... students to achieve the goals."

Marshall College (West Virginia)

"... these objectives are quite good ... most of these would apply to our students after two years of chemistry."

Arizona State College

"I only wish these were possible."

Santa Barbara College

"I would like another copy of the questionnaire for it lists all of the things one should get from college chemistry."

Kansas State Teachers College

"We cannot hope to attain all goals in a beginning course!"

Centenary College

"Certainly any great increase in all of these 'abilities' should be expected from a first year course in college chemistry."

Ohio Wesleyan University

"... do not expect perfection."

Southeastern Louisiana State College

"... remember this student is only a freshman."

Texas Wesleyan College

"... I feel that the teacher could aim toward these goals and at least develop them to some degree. ... the concepts under #2 heading should be first while the others should be secondary."

Borea College (Kentucky)

"... This appears to be merely a typical research project from someone working toward a higher degree in education rather than going to the trouble of research of basic scientific knowledge and value. In the end it is of little value when finished. The fact that a similar questionnaire was sent to our education department lends weight to this theory."

Coker College (South Carolina)

"... an unusually intelligent student may be able to reach for some of your goals, but the vast margin will not dream of them."

APPENDIX IV

QUESTIONNAIRE NUMBER 1

Using a check mark ( ), please indicate in the proper blank your opinion of each item. The greatest plus (+) value indicates strongest approval, and the greatest minus (-2) indicates strongest disfavor, with the zero (0) blank representing no opinion. Mark through, change, or add to any or all items if you so desire. Mark items that are ambiguous or not clear to you with an X.

I. After a year of college chemistry, a student should be able to demonstrate his understanding of scientific method and show his ability to use it by how well he can meet the following outcomes. A student should or should have:

	+2	+1	0	-1	-2
1. Comprehend that facts are useful in illustrating principles and aiding communication.	___	___	___	___	___
2. Understand that knowledges may be interrelated that they may be combined to make new knowledges.	___	___	___	___	___
3. Be able to recognize and state problems.	___	___	___	___	___
4. Approach problems objectively without bias.	___	___	___	___	___
5. Be able to use personal frame of reference approach to problems where individual involved is considered, i.e., person's own abilities and limitations are recognized.	___	___	___	___	___
6. Be able to use a shifting point of reference approach to problems in which choice and recognition determine the method of attack.	___	___	___	___	___

7. Learned some possible step of procedure in problem solving. There is no pat series of steps. ___ ___ ___ ___ ___

8. Learned how to arrive at hypotheses. ___ ___ ___ ___ ___

9. Learned that experiments may test hypotheses. ___ ___ ___ ___ ___

10. Learned that data are taken to be analyzed and interpreted. ___ ___ ___ ___ ___

11. Learned to classify and evaluate statements of others, i.e., have critical judgment. ___ ___ ___ ___ ___

12. Learned that chemistry is a "tool" for better living, not a religion. ___ ___ ___ ___ ___

13. Learned how to apply principles to new situations in the solving of daily problems. ___ ___ ___ ___ ___

14. Learned to predict new data. ___ ___ ___ ___ ___

15. Learned to judge the differences between facts and the interpretation of facts. ___ ___ ___ ___ ___

16. Learned the importance of making correct observations before arriving at conclusions. ___ ___ ___ ___ ___

17. Formed habits of system, order, and neatness in making reports, thinking, and observing. ___ ___ ___ ___ ___

18. Learn the leaning of "practical accuracy" in making and using measurements. ___ ___ ___ ___ ___

19. Gained concept of "scientific method" as any logical organized procedure using the instruments and facts available. ___ ___ ___ ___ ___

20. Critical thinking is scientific. Substitute critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions. __ __ __ __ __

21. Recognize the need of objectivity in interpreting phenomena. __ __ __ __ __

22. Learned interrelations between operations and theories. __ __ __ __ __

23. Learned interrelations between facts and words. __ __ __ __ __

24. Learned that sense stimulation comes before mental processes. __ __ __ __ __

25. Accept tested truth. __ __ __ __ __

26. Developed ability to plan experiments and problems. __ __ __ __ __

27. Realize some of the limitations of science. __ __ __ __ __

28. Learned that principles, theories, and facts are only useful when applied. __ __ __ __ __

29. Understand deductive-inductive reasoning processes. __ __ __ __ __

30. Be able to locate and use source material. __ __ __ __ __

31. Be able to reach tentative simple conclusions from facts available. __ __ __ __ __

32. Learned that we know individual things, but we can generalize from these individual knowledges. __ __ __ __ __

33. Understand principles as concepts. __ __ __ __ __

34. Understand that even if "scientific method" cannot be defined, it may still be used.	___	___	___	___	___
35. Conceive of science as experimental in nature.	___	___	___	___	___
36. Conceive of science as method not subject.	___	___	___	___	___
37. Develop manual skills in obtaining data.	___	___	___	___	___
38. Be able to communicate definitions clearly and exactly.	___	___	___	___	___

II. Impacts that an initial course in chemistry may have upon an individual and society. The student should or should have:

	+2	+1	0	-1	-2
39. Perceive that chemistry functions in later life.	___	___	___	___	___
40. Learned that principles are of general use and are explained by facts.	___	___	___	___	___
41. Learned that chemistry can and should contribute to personal philosophy.	___	___	___	___	___
42. Developed an appreciation of orderliness of nature.	___	___	___	___	___
43. Observe cause and effect.	___	___	___	___	___
44. Be able to discriminate significant from unimportant events.	___	___	___	___	___
45. Practice practical safety and become safety conscious.	___	___	___	___	___
46. Feel that printed matter is real.	___	___	___	___	___

47. Prepare for further study in chemistry.	___	___	___	___	___
48. Developed a desirable attitude toward science.	___	___	___	___	___
49. Cultivated appreciation of the methods of science.	___	___	___	___	___
50. Developed appreciation of the aspirations of science.	___	___	___	___	___
51. Acquired an appreciation of the limitations of science.	___	___	___	___	___
52. Learned to draw reasonable conclusions.	___	___	___	___	___
53. Respect value of inquiry and use inquiry as to what, how, and why of observed happenings.	___	___	___	___	___
54. Learned to evaluate and use source material.	___	___	___	___	___
55. Become proficient in communication for clarification--language development.	___	___	___	___	___
56. Learned that truth comes by seeking, not by attack upon others.	___	___	___	___	___
57. Discovered meaning of truth. Facts simply verify truth.	___	___	___	___	___
58. Increased ability in communication.	___	___	___	___	___
59. Conceive of progress as depending upon directed effort rather than genius.	___	___	___	___	___
60. Recognize the fact that the chemist does not believe in the unalterable truth of any of his hypotheses, but he works them just the same.	___	___	___	___	___

61. Realize that relative truth is better than no truth. ___ ___ ___ ___ ___

62. Gained an appreciation of the role of chemistry in our national economy. ___ ___ ___ ___ ___

63. Gained appreciation of the role of chemistry in our social and political life. ___ ___ ___ ___ ___

64. Developed an interest in chemistry. ___ ___ ___ ___ ___

65. Learned the difference in pure and applied research. ___ ___ ___ ___ ___

66. Learned the difference in science and technology. ___ ___ ___ ___ ___

67. Learned to evaluate advertising. ___ ___ ___ ___ ___

68. Discovered that "doing" is one of the best ways of "learning." ___ ___ ___ ___ ___

69. Developed ability to observe cause and effect relations. ___ ___ ___ ___ ___

70. Gained occupational perspective. ___ ___ ___ ___ ___

71. Developed recreational interests. ___ ___ ___ ___ ___

72. Conceive of chemistry as man-made. ___ ___ ___ ___ ___

73. Developed curiosity about and interest in facts. ___ ___ ___ ___ ___

74. Respect the habit of research. ___ ___ ___ ___ ___

75. Developed an interest in facts. ___ ___ ___ ___ ___

76. Developed self-reliance. ___ ___ ___ ___ ___

77. Eliminated superstitions. ___ ___ ___ ___ ___

78. Learned the value of cooperation and social concern. __ __ __ __ __

79. Apply principles to human behavior. __ __ __ __ __

80. Developed reading skill. __ __ __ __ __

81. Learned that chemistry is not isolated from life but that its processes are going on around us at all times. __ __ __ __ __

82. Reached conclusion that scientists are only human. __ __ __ __ __

83. Conceive of science as ethical. __ __ __ __ __

84. Conceive of science as reverent. __ __ __ __ __

85. Developed ability to channel curiosity. __ __ __ __ __

86. Developed ability to work with others or alone. __ __ __ __ __

87. Developed ability to learn for self; self-reliance. __ __ __ __ __

88. Developed a feeling of responsibility for community conservation, sanitation, and health. __ __ __ __ __

89. Learned that all sciences are related; there are no sharp lines of demarcation. __ __ __ __ __

90. Developed habit of intellectual honesty. __ __ __ __ __

91. Developed habit of open-mindedness. __ __ __ __ __

92. Developed habit of suspended judgment until sufficient data have been accumulated but recognize authority of consistent results. __ __ __ __ __

93. Be able to continue to educate self after formal schooling is finished. ___ ___ ___ ___ ___

III. Generalized facts that an initial course in chemistry should give after completion of the course. The student should or should have:

	+2	+1	0	-1	-2
94. Gained some idea of structure of matter.	___	___	___	___	___
95. Gained some idea of finiteness of matter.	___	___	___	___	___
96. Gained some idea of classes, states, and kinds of matter.	___	___	___	___	___
97. Gained some ideal of chemical and physical changes matter can undergo.	___	___	___	___	___
98. Learned some of the interrelations between facts, theories, and techniques.	___	___	___	___	___
99. Acquired concepts of theoretical atomic structure.	___	___	___	___	___
100. Acquired concepts of atomic sizes and the importance of size.	___	___	___	___	___
101. Acquired concepts of the nature of energy.	___	___	___	___	___
102. Acquired concepts of the importance of energy in holding matter together or apart (kinetics).	___	___	___	___	___
103. Know something of the nature of reactions as being attempts to reach energy equilibrium.	___	___	___	___	___

		+2	+1	0	-1	-2
104.	Developed concepts of the practical and industrial aspects of chemistry by studying some industrial practices.	___	___	___	___	___
105.	Acquired information of use in home and daily life such as: nature of synthetics, detergents, fertilizers, dyes, bactericides, etc.	___	___	___	___	___
106.	Acquired a select usable scientific vocabulary.	___	___	___	___	___
107.	Gained some mathematical (arithmetical) efficiency.	___	___	___	___	___
108.	Learned how to read charts, graphs, and tables.	___	___	___	___	___
109.	Be able to express the more simple types of reactions of matter in symbol and word form.	___	___	___	___	___

IV. Enough history of the evolution of science should be included in an initial course in chemistry that upon completion the student should:

		+2	+1	0	-1	-2
110.	Know how scientists work.	___	___	___	___	___
111.	Become acquainted with some of the world's great scientific ideas.	___	___	___	___	___
112.	Be able to illustrate scientific attitude by citing some case histories.	___	___	___	___	___
113.	Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world over the eras of time.	___	___	___	___	___

114. Have an awareness of the prospective role of science in the future. _ _ _ _ _

115. Have learned how chemistry has contributed to social and economical problems in the past. _ _ _ _ _

116. Have conceived of progress as but a stepping stone for further advancements. _ _ _ _ _

117. Be able to design problems for the present and illustrate from problems in the past to show that different ideas of the same thing can contribute to a more fully understood product. _ _ _ _ _

118. Have learned that arguments have stood or fallen on the strength of evidence--not on the qualities of the men--supporting them. _ _ _ _ _

119. Be able to give a comprehensive explanation about some of the underlying philosophies about chemistry. _ _ _ _ _

Additional aims and comments:

114. Have an awareness of the prospective role of science in the future.

115. Have learned how chemistry has contributed to social and economical problems in the past.

116. Have conceived of progress as but a stepping stone for further advancements.

117. Be able to design problems for the present and illustrate from problems in the past to show that different ideas of the same thing can contribute to a more fully understood product.

118. Have learned that arguments have stood or fallen on the strength of evidence--not on the qualities of the men--supporting them.

119. Be able to give a comprehensive explanation about some of the underlying philosophies about chemistry.

Additional aims and comments:

QUESTIONNAIRE NUMBER 2

Using a check mark ( ), please indicate in the proper blank your opinion of each item. The greatest plus (+) value indicates strongest approval, and the greatest minus (-2) indicates strongest disfavor, with the zero (0) blank representing no opinion. Mark through, change, or add to any or all items if you so desire. Mark items that are ambiguous or not clear to you with an X.

I. After a year of college chemistry, a student should be able to demonstrate his understanding of scientific method and show his ability to use it by how well he can meet the following outcomes. A student should or should have:

	+2	+1	0	-1	-2
1. Comprehend that facts are more useful in illustrating principles and aiding communication.	___	___	___	___	___
2. Learned that principles, theories, and facts are only useful when applied.	___	___	___	___	___
3. Understand that knowledges may be so interrelated that they may be combined to make new knowledges.	___	___	___	___	___
4. Be able to recognize and state problems.	___	___	___	___	___
5. Approach problems objectively without bias.	___	___	___	___	___
6. Be able to use a personal frame of reference approach to problems where individual involved is considered, i.e., person's own abilities and limitations are recognized.	___	___	___	___	___

7. Be able to use a shifting point of reference approach to problems in which choice of data and recognition of validity of data determine the method of attack. ___ ___ ___ ___ ___

8. Learned some possible steps of procedure in problem solving. There is no pat series of steps. ___ ___ ___ ___ ___

9. Understand deductive-inductive reasoning processes. ___ ___ ___ ___ ___

10. Learned how to arrive at and state hypotheses. ___ ___ ___ ___ ___

11. Learned that experiments may test hypotheses. ___ ___ ___ ___ ___

12. Developed ability to plan experiments and make problems. ___ ___ ___ ___ ___

13. Learned that data are taken to be analyzed and interpreted. ___ ___ ___ ___ ___

14. Learned to judge the differences between facts and the interpretation of facts. ___ ___ ___ ___ ___

15. Learned interrelations between facts and words. ___ ___ ___ ___ ___

16. Be able to reach tentative simple conclusions from facts available. ___ ___ ___ ___ ___

17. Learned to classify and evaluate statements of others, i.e., have critical judgment of logical validity of statements. ___ ___ ___ ___ ___

18. Learned that chemistry is a "tool" for better living, not a religion. ___ ___ ___ ___ ___

19. Learned how to apply principles to new situations in the solving of daily problems. ___ ___ ___ ___ ___

20. Understand principles as concepts. ___ ___ ___ ___ ___

21. Learned to predict new data. ___ ___ ___ ___ ___

22. Learned to judge the differences between facts and the interpretation of facts. ___ ___ ___ ___ ___

23. Formed habits of system, order, and neatness in making reports, thinking, and observing. ___ ___ ___ ___ ___

24. Learn the meaning of "practical accuracy" in making and using measurements. ___ ___ ___ ___ ___

25. Gained concept of "scientific method" as any logical organized procedure using the instruments and facts available. ___ ___ ___ ___ ___

26. Be able to substitute critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions. ___ ___ ___ ___ ___

27. Recognize the need of objectivity in interpreting phenomena. ___ ___ ___ ___ ___

28. Learned interrelations between operations and theories. ___ ___ ___ ___ ___

29. Learned that sense stimulation comes before mental processes. ___ ___ ___ ___ ___

30. Accept tested truth according to the stringency of the test. ___ ___ ___ ___ ___

31. Realize some of the limitations of science. ___ ___ ___ ___ ___

32. Be able to locate and use source material. ___ ___ ___ ___ ___

33. Learned that we know only individual things, but we can generalize from these individual knowledges. ___ ___ ___ ___ ___

34. Understand that even if "scientific method" cannot be defined, it may still be used. ___ ___ ___ ___ ___

35. Conceive of science as experimental in nature. ___ ___ ___ ___ ___

36. Conceive of science as method not subject. ___ ___ ___ ___ ___

37. Develop manual skills in obtaining data. ___ ___ ___ ___ ___

38. Be able to communicate definitions clearly and exactly. ___ ___ ___ ___ ___

II. Impacts that an initial course in chemistry may have upon an individual and society. The student should or should have:

	+2	+1	0	-1	-2
39. Perceive an understanding of how chemistry may function in later life.	___	___	___	___	___
40. Learned that principles are of general use and that facts define principles.	___	___	___	___	___
41. Learned that chemistry can and should contribute to personal philosophy.	___	___	___	___	___
42. Developed an appreciation of orderliness of nature.	___	___	___	___	___
43. Formed habit of observing cause and effect.	___	___	___	___	___
44. Be able to discriminate significant from unimportant events.	___	___	___	___	___

45. Practice practical safety and become safety conscious.

46. Feel that printed matter is real; i.e., recorded phenomena and the explanations may actually happen to or be needed by anyone.

47. Prepare for further study, self-directed or under guidance.

48. Developed a desirable attitude toward science, i.e., respect and appreciations for science.

49. Cultivated appreciation of the methods of science.

50. Developed appreciation of the aspirations of science.

51. Acquired an appreciation of the limitations of science.

52. Learned to draw reasonable conclusions.

53. Respect value of inquiry and use inquiry as to what, how, and why of observed happenings.

54. Learned to evaluate and use source material.

55. Become proficient in communication for clarification--language development.

56. Learned that truth comes by seeking, not by attack upon others.

57. Discovered meaning of truth. Facts simply verify truth.

58. Increased ability in communication.

59. Conceive of progress as depending upon directed effort rather than genius. ___ ___ ___ ___ ___

60. Recognize the fact that the chemist does not believe in the unalterable truth of any of his hypotheses, but he works them just the same. ___ ___ ___ ___ ___

61. Realize that relative truth is better than no truth. ___ ___ ___ ___ ___

62. Gained an appreciation of the role of chemistry in our national economy. ___ ___ ___ ___ ___

63. Gained appreciation of the role of chemistry in our social and political life. ___ ___ ___ ___ ___

64. Developed an interest in chemistry. ___ ___ ___ ___ ___

65. Learned the difference in pure and applied research. ___ ___ ___ ___ ___

66. Learned the difference in science and technology. ___ ___ ___ ___ ___

67. Learned to evaluate advertising. ___ ___ ___ ___ ___

68. Discovered that "doing" is one of the best ways of "learning." ___ ___ ___ ___ ___

69. Developed ability to observe cause and effect relations. ___ ___ ___ ___ ___

70. Gained occupational perspective. ___ ___ ___ ___ ___

71. Developed recreational interests. ___ ___ ___ ___ ___

72. Conceive of chemistry as man-made. ___ ___ ___ ___ ___

73. Developed curiosity about and interest in facts. ___ ___ ___ ___ ___

74. Respect the habit of research. ___ ___ ___ ___ ___

75. Developed an interest in facts. ___ ___ ___ ___ ___

76. Developed self-reliance. ___ ___ ___ ___ ___

77. Eliminated superstitions. ___ ___ ___ ___ ___

78. Learned the value of cooperation and social concern. ___ ___ ___ ___ ___

79. Apply principles to human behavior. ___ ___ ___ ___ ___

80. Developed reading skill. ___ ___ ___ ___ ___

81. Learned that chemistry is not isolated from life, but that its processes are going on around us at all times. ___ ___ ___ ___ ___

82. Reached conclusion that scientists are only human. ___ ___ ___ ___ ___

83. Conceive of science as ethical. ___ ___ ___ ___ ___

84. Conceive of science as reverent. ___ ___ ___ ___ ___

85. Developed ability to channel curiosity. ___ ___ ___ ___ ___

86. Developed ability to work with others or alone. ___ ___ ___ ___ ___

87. Developed self-reliance. ___ ___ ___ ___ ___

88. Developed a feeling of responsibility for community conservation, sanitation, and health. ___ ___ ___ ___ ___

89. Learned that all sciences are related; there are no sharp lines of demarcation. ___ ___ ___ ___ ___

90. Developed habit of intellectual honesty. ___ ___ ___ ___ ___

91. Developed habit of open-mindedness. ___ ___ ___ ___ ___

92. Developed habit of suspended judgment until sufficient data have been accumulated, but recognize authority of consistent results. ___ ___ ___ ___ ___

93. Be able to continue to educate self after formal schooling is finished. ___ ___ ___ ___ ___

III. Generalized facts that an initial course in chemistry should give. After completion of the course, the student should or should have:

	+2	+1	0	-1	-2
94. Gained some idea of structure and nature of matter.	___	___	___	___	___
95. Gained some idea of finiteness of matter.	___	___	___	___	___
96. Gained some idea of kinds (classes and states) of matter.	___	___	___	___	___
97. Gained some idea of the chemical and physical changes matter can undergo.	___	___	___	___	___
98. Learned some of the interrelations between facts, theories, and techniques concerning the forces of nature.	___	___	___	___	___
99. Acquired concepts of theoretical atomic structure.	___	___	___	___	___
100. Acquired concepts of atomic sizes and the importance of size.	___	___	___	___	___
101. Acquired concepts of the nature of energy.	___	___	___	___	___
102. Acquired concepts of the importance of energy in holding matter together or apart (kinetics).	___	___	___	___	___

103.	Know something of the nature of ionic and oxidation reduction reactions as being attempts to reach energy equilibrium.	___	___	___	___	___
104.	Developed concepts of the practical and industrial aspects of chemistry by studying some industrial practices.	___	___	___	___	___
105.	Acquired information of use in home and daily life such as: nature of synthetics, detergents, fertilizers, dyes, bactericides, etc.	___	___	___	___	___
106.	Acquired a select usable scientific vocabulary.	___	___	___	___	___
107.	Gained some mathematical (arithmetical) efficiency.	___	___	___	___	___
108.	Learned how to read charts, graphs, and tables.	___	___	___	___	___
109.	Be able to express the more simple types of reactions of matter in symbol and word form.	___	___	___	___	___

IV. Enough history of the evolution of science should be included in an initial course in chemistry that upon completion the student should:

		+2	+1	0	-1	-2
110.	Know how scientists work.	___	___	___	___	___
111.	Become acquainted with some of the world's great scientific ideas.	___	___	___	___	___
112.	Be able to illustrate scientific attitude by citing some case histories.	___	___	___	___	___

113. Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world over the eras of time. ___ ___ ___ ___ ___

114. Have an awareness of the prospective role of science in the future. ___ ___ ___ ___ ___

115. Have learned how chemistry has contributed to social and economical problems in the past. ___ ___ ___ ___ ___

116. Have conceived of progress as but a stepping stone for further advancements. ___ ___ ___ ___ ___

117. Be able to design problems for the present and illustrate from problems in the past to show that different ideas of the same thing can contribute to a more fully understood product. ___ ___ ___ ___ ___

118. Have learned that arguments have stood or fallen on the strength of evidence--not on the qualities of the men --supporting them. ___ ___ ___ ___ ___

119. Be able to give a comprehensive explanation about some of the underlying philosophies about chemistry. ___ ___ ___ ___ ___

Additional aims and comments:

QUESTIONNAIRE NUMBER 3

Abbreviations: Ind--indifferent
DNU--do not understand

I. An initial course in college chemistry should develop within the student certain skills, attitudes, and understandings. After completion of the course, the student should:

	Yes	No	Ind	DNU
1. Have learned that principles, theories, and facts are more useful to the layman when applied as an aid to understanding and communication.	___	___	___	___
2. Be able to recognize what constitutes a problem and approach a solution to the problem objectively from a shifting point of reference.	___	___	___	___
3. Be able to use both deductive and inductive reasoning processes in planning possible steps of procedure in problem solving.	___	___	___	___
4. Be able to arrive at and state hypotheses which may be tested by planned experiments and problems.	___	___	___	___
5. Be able to make correct observations; then analyze and interpret data from observations to reach tentative, simple, and reasonable conclusions.	___	___	___	___

6. Understand that knowledges of interrelated facts may be rearranged and combined to make new knowledges. ___ ___ ___ ___

7. Have learned to employ critical thinking and judgment in evaluating statements of others and in distinguishing between facts and interpretation of facts. ___ ___ ___ ___

8. Have learned that chemistry is not isolated from life, but is a tool which can and should contribute to personal, social, and political phases of society. ___ ___ ___ ___

9. Understand principles as concepts to be applied to new situations in solving daily problems and that facts define principles. ___ ___ ___ ___

10. Have developed skill in locating, evaluating, and using source material and data in predicting new data or developing new hypotheses. ___ ___ ___ ___

11. Be proficient in communicating clearly and exactly and develop skills in reading, writing, speaking, and listening. ___ ___ ___ ___

12. Have developed an interest in chemistry with the concept that chemistry is man-made and that scientists are only human. ___ ___ ___ ___

13. Have developed respect and appreciations for methods, aspirations, and limitations of science. ___ ___ ___ ___

14. Conceive of science as experimental in nature. As a word it refers to method rather than subject matter. Scientific method is any logically organized procedure using the instruments and factors available. ___ ___ ___ ___

15. Realize that truth comes by seeking; facts verify; and testing truth may be accepted according to the stringency of the test. ___ ___ ___ ___

16. Have formed habit of observing cause and effect and inquiring as to the what, how, and why of observed happenings. ___ ___ ___ ___

17. Have developed curiosity about and interest in facts. ___ ___ ___ ___

18. Be able to substitute critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions. ___ ___ ___ ___

19. Recognize the need for objectivity and open-mindedness in interpreting phenomena. Exhibit intellectual honesty. ___ ___ ___ ___

20. Have attained a background of knowledges that will make possible further study after formal schooling is finished. ___ ___ ___ ___

21. Have learned the difference between pure and applied research; between science and technology. ___ ___ ___ ___

22. Recognize the fact that the chemist does not believe in the unalterable truth of any of his hypotheses, but he works them just the same; i.e., the scientific mind values relative truth as better than no truth. ___ ___ ___ ___

23. Develop proper lab technique through "practical accuracy" in making and using measurements and "practical safety" in laboratory procedures. ___ ___ ___ ___

24. Have developed an appreciation of orderliness of nature. ___ ___ ___ ___

25. Feel that printed matter is real; i.e., recorded phenomena and the explanations of these phenomena may actually happen to or be needed by anyone. ___ ___ ___ ___

26. Have developed recreational interests, occupational perspective. ___ ___ ___ ___

27. Conceive of progress as depending upon directed effort rather than genius. ___ ___ ___ ___

28. Have learned to evaluate advertising. ___ ___ ___ ___

29. Have discovered that "doing" is one of the best ways of "learning." ___ ___ ___ ___

30. Have formed habits of order and neatness in making reports, thinking, and observing. ___ ___ ___ ___

31. Have learned interrelations between theories and practices. ___ ___ ___ ___

32. Have learned that sensory stimulation comes before mental processes. ___ ___ ___ ___

33. Have learned that we know only individual things, but we can generalize from these individual knowledges. ___ ___ ___ ___

34. Respect the habit of research and have developed ability to channel curiosity. ___ ___ ___ ___

35. Apply principles to human behavior. ___ ___ ___ ___

36. Develop self-reliance, the ability to learn for self, and the ability to work with others as well as alone. ___ ___ ___ ___

37. Develop the value of cooperation and social concern for community conservation, sanitation, and health. ___ ___ ___ ___

38. Learn that all sciences are related; there are no sharp lines of demarcation. ___ ___ ___ ___

39. Conceive of science as ethical. ___ ___ ___ ___

40. Have developed habit of suspended judgment until sufficient data have been accumulated but recognize authority of consistent results. ___ ___ ___ ___

II. Concepts: At the conclusion of an initial course in chemistry, the student should have gained certain generalized facts. To some extent he should or should have:

	Yes	No	Ind	DNU
41. Gained some idea of kinds (classes and states), structure, nature, and finiteness of matter.	___	___	___	___
42. Gained some idea of the chemical and physical changes matter can undergo and be able to express more simple reactions of matter in symbol and word form.	___	___	___	___
43. Learned some of the interrelations between facts, theories, and techniques concerning the forces of nature.	___	___	___	___
44. Acquired concepts of theoretical atomic structure, atomic sizes, and importance of size.	___	___	___	___
45. Acquired concepts of the nature of energy and the importance of energy in holding matter together or apart (kinetics).	___	___	___	___
46. Understand the nature of ionic and oxidation-reduction reactions as being attempts to reach energy equilibrium.	___	___	___	___
47. Understand industrial and practical aspects of chemistry; i.e., studying some industrial practices as well as uses in home and daily life such as: nature of synthetics, detergents, fertilizers, dyes, etc.	___	___	___	___

48. Acquired a usable scientific vocabulary and gained some mathematical (arithmetical) efficiency. ___ ___ ___ ___

49. Learned how to read charts, graphs, and tables. ___ ___ ___ ___

III. Enough history of the evolution of science should be included in an initial course in chemistry that upon completion the student should:

	Yes	No	Ind	DNU
50. Know how scientists work and become acquainted with some of the world's great scientific ideas.	___	___	___	___
51. Be able to illustrate the scientific attitude by citing some case histories.	___	___	___	___
52. Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world in ages past.	___	___	___	___
53. Have learned how chemistry has contributed to social and economical problems in the past and have an awareness of its prospective role in the future.	___	___	___	___
54. Have conceived of progress as but a stepping stone for further advancements of science in the future.	___	___	___	___
55. Be able to design problems for the present and illustrate from problems in the past to show that different ideas of the same thing can contribute to a more fully understood product.	___	___	___	___

56. Have learned that the validity of arguments depends on the strength of the evidence and not on the qualities of the men supporting them. ___ ___ ___ ___

57. Be able to give a comprehensive explanation about some of the underlying philosophies of chemistry. ___ ___ ___ ___

QUESTIONNAIRE NUMBER 4

This is the final form of the questionnaire as sent to the final juries.

The sum totals of all answers from all jurors are under the "yes," "no," and "undecided" headings. Under "classification" are the final decisions of each jury as determined by the Chi-Square limits of confidence (Table E_5 and Table III, Chapter V.

The following symbols are used:

A - jury of small college chemistry teachers

B - jury of large college chemistry teachers

AB - both large and small college chemistry teachers

C - education teachers

a - accepted

r - rejected

d - doubtful

QUESTIONNAIRE NUMBER 4 AND THE RESPONSES OF ALL JURIES

	Yes	No	Unde-cided	Jury Classification A	B	AB	C
I. An initial course in college chemistry should develop within a student certain skills, attitudes, and understandings. After completion of the course the student should:							
1. Have learned that principles, theories, and facts are most useful to the layman when applied as an aid to understanding and communication.	84	5	20	a	d	a	a
2. Be able to recognize what constitutes a problem and to approach a solution to the problems objectively from a shifting point of reference.	82	7	20	a	d	a	a
3. Be able to use both deductive and inductive reasoning processes in planning possible steps of procedure in problem solving.	90	6	13	a	a	a	a
4. Be able to arrive at and state hypotheses which may be tested by planned experiments and problems.	80	16	13	a	d	a	a
5. Be able to analyze and interpret data from correct observations so as to reach tentative, simple, and reasonable conclusions.	104	2	3	a	a	a	a

		Yes	No	Unde-cided	Jury Classification A	B	AB	C
6.	Understand that knowledges of interrelated facts may be rearranged and combined to make new knowledge.	86	4	19	a	a	a	a
7.	Have learned to employ critical thinking and judgment in distinguishing between facts and interpretation of facts.	86	7	16	a	a	a	a
8.	Have learned that chemistry is not isolated from life but is a tool which can and should contribute to personal, social, and political aspects of society.	102	2	5	a	a	a	a
9.	Understand that principles are concepts to be applied to new situations in solving daily problems and that the facts simply define the principles.	76	11	22	a	a	a	a
10.	Have developed skill in locating, evaluating, and using source material and data in predicting new data or developing new hypotheses.	58	27	24	d	r	d	a
11.	Be proficient in communication, i.e., skillful in reading, writing, speaking, and listening.	68	17	24	a	d	a	d
12.	Have developed an interest in chemistry as a man-made and man-limited field.	83	12	14	a	a	a	a

		Yes	No	Unde-cided	Jury Classification A	B	AB	C
13.	Have developed respect and appreciation for methods, aspirations, and limitations of studies of science.	99	3	7	a	a	a	a
14.	Conceive of science as a word referring to method rather than subject matter, i.e., the scientific method is any logically organized procedure using the instruments and factors available.	67	19	23	a	d	d	a
15.	Realize that truth comes by seeking, facts verify a hypothesis, and tested truth may be accepted according to the stringency of the test.	76	10	23	a	d	d	a
16.	Have formed habit of observing cause and effect and of inquiring as to the what, how, and why of observed happenings.	95	3	11	a	a	a	a
17.	Have developed curiosity about and interest in factual knowledge.	97	3	9	a	a	a	a
18.	Be able to substitute results of critical thinking for intolerances, prejudices, traditions, superstitions, and misconceptions.	78	13	18	a	d	a	a
19.	Recognize the need for objectivity and open-mindedness in interpreting phenomena, i.e., exhibit intellectual honesty.	97	2	10	a	a	a	a

		Yes	No	Unde-cided	Jury Classification A	B	AB	C
20.	Have attained a background of knowledges that will make possible further study after formal schooling is finished.	91	6	12	a	a	a	a
21.	Have learned the difference between pure and applied research (i.e., seeking knowledge for the sake of knowledge and seeking knowledge with a particular end in view); between science and technology.	67	24	18	a	d	d	a
22.	Recognize the fact that the chemist does not believe in the unalterable truth of any of his hypotheses but that he makes use of them just the same; i.e., that the scientific mind values relative truth as better than no truth.	87	5	17	a	a	a	a
23.	Develop proper laboratory techniques through "practical accuracy" in making and using measurements and "practical safety" in laboratory procedures.	95	2	12	a	a	a	a
24.	Have developed an appreciation of the orderliness of nature.	89	5	15	a	a	a	a
25.	Feel that authenticated printed matter is significant, i.e., recorded phenomena may be explained by anyone, and the explanations of these phenomena may be made by anyone.	60	23	26	d	d	d	d

		Yes	No	Unde-cided	Jury Classification A	B	AB	C
26.	Have developed recreational interests.	34	46	29	r	r	r	d
27.	Have developed occupational perspective.	56	23	30	d	d	d	d
28.	Conceive of progress as generally depending upon directed effort rather than genius.	64	11	34	a	d	d	d
29.	Have learned to evaluate advertising.	46	34	29	d	d	d	d
30.	Have discovered that doing is one of the best ways of learning.	88	8	13	a	a	a	a
31.	Have formed habits of order and neatness in making reports, thinking, and observing.	91	5	13	a	a	a	a
32.	Have learned interrelations between theories and practices.	72	6	31	a	d	d	a
33.	Have learned that sensory stimulation usually comes before reasoning mental processes.	35	37	37	r	r	r	d
34.	Have learned that we can know only individual things, but we can generalize from these individual knowledges.	59	17	33	a	d	d	d
35.	Respect the habit of research and have developed ability to channel curiosity.	70	13	26	a	d	d	a

	Yes	No	Unde- cided	Jury Classification A	B	AB	C
36. Be able to apply scientific principles to human behavior.	41	33	35	r	r	r	d
37. Have developed self-reliance, the ability to learn for self, and the ability to work with others as well as alone.	80	17	12	a	a	a	a
38. Have developed concepts of the value of cooperation and social concern for community conservation, sanitation, and health.	53	30	26	d	r	r	a
39. Have learned that all sciences are related; there are no sharp lines of demarcation.	87	9	13	a	a	a	a
40. Have developed the habit of suspended judgment until sufficient data have been accumulated but recognize the tentative value of consistent results.	89	7	13	a	a	a	a
II. Concepts: At the conclusion of an initial course in chemistry, the student should have gained certain generalized facts. To some extent he should have:							
41. Gained some idea of kinds (classes and states), structure, nature, and finiteness of matter.	107	0	2	a	a	a	a

	Yes	No	Undecided	Jury Classification A	B	AB	C
42. Gained some idea of the chemical and physical changes matter can undergo and learned to express the more simple reactions of matter in symbol and word form.	108	0	1	a	a	a	a
43. Learned some of the interrelations between facts, theories, and techniques pertaining to the forces of nature.	94	1	14	a	a	a	a
44. Acquired concepts of theoretical atomic structure, atomic sizes, and importance of size.	95	1	13	a	a	a	a
45. Acquired concepts of the nature of energy and the importance of energy in holding matter together or apart.	96	2	11	a	a	a	a
46. Developed an understanding of the nature of ionic and oxidation-reduction reactions as being attempts to reach energy equilibrium.	83	7	19	a	a	a	a
47. Developed an understanding of some industrial and some practical aspects of chemistry such as certain common industrial processes and the uses of synthetics, detergents, fertilizers, dyes, etc., around the home.	90	5	14	a	a	a	a

	Yes	No	Unde- cided	Jury Classification A	B	AB	C
48. Acquired a usable scientific vocabulary.	100	3	6	a	a	a	a
49. Gained some mathematical (arithmetical) efficiency.	87	7	15	a	a	a	a
50. Learned how to read charts, graphs, and tables.	93	5	11	a	a	a	a
51. Know how scientists work and become acquainted with some of the world's great scientific ideas.	90	4	15	a	a	a	a
52. Be able to illustrate the scientific attitude by citing some case histories.	52	22	35	d	d	d	d
53. Have an awareness and knowledge of the evolutionary processes that have altered the organic and inorganic world in ages past.	58	24	27	r	d	r	a
54. Have learned how chemistry has contributed to the solution of social and economic problems in the past and have an awareness of its prospective role in the future.	80	9	20	a	d	a	a
55. Have conceived of progress made up to the present time as but a stepping stone for further advancements of science in the future.	92	8	9	a	a	a	a

	Yes	No	Undecided	Jury Classification A	B	AB	C
56. Be able to design problems for the present and illustrate from problems in the past so as to show that different ideas of the same thing can contribute to a more complete understanding.	40	27	42	r	r	r	d
57. Have learned that the validity of arguments depends on the strength of the evidence and not on the qualities of the men supporting them.	79	10	20	a	a	a	a
58. Be able to give a comprehensive explanation about some of the underlying philosophies of chemistry.	49	19	41	r	d	r	d

APPENDIX V

TABLE A

RANK VALUES OF THE JURY RESPONSES

Item	A	B	AB	C
1.	36.5	29.0	32.0	13.5
2.	36.5	33.5	33.0	20.0
3.	30.5	20.5	24.5	16.5
4.	42.5	37.0	40.0	30.0
5.	2.5	3.5	3.0	7.0
6.	33.0	27.0	28.5	4.5
7.	27.5	33.5	31.0	16.5
8.	16.5	5.0	6.0	2.5
9.	44.5	31.0	38.0	33.5
10.	49.5	51.0	51.0	41.0
11.	33.0	45.5	41.0	44.5
12.	41.0	31.0	36.0	26.0
13.	16.5	9.5	12.0	4.5
14.	42.5	41.5	43.0	47.5
15.	33.0	37.0	36.0	36.0
16.	10.0	16.5	14.5	12.0
17.	6.5	6.0	4.0	20.0
18.	16.5	41.5	34.0	38.0
19.	16.5	9.5	12.0	7.0
20.	27.5	19.0	21.0	20.0
21.	47.5	43.5	46.0	44.5
22.	23.5	24.0	23.0	26.0
23.	6.5	13.0	9.5	13.5
24.	27.5	16.5	19.0	26.0
25.	50.0	48.5	47.0	51.0
26.	58.0	58.0	58.0	56.0
27.	44.5	47.0	45.0	54.0
28.	39.5	39.0	39.0	44.5
29.	51.0	48.0	49.5	58.0
30.	16.5	24.0	21.0	31.5

A = chemistry teachers in small colleges

B = chemistry teachers in large colleges

AB = chemistry teachers in both small and large colleges

C = education teachers

TABLE A--Continued

Item	A	B	AB	C
31.	6.5	24.0	17.5	22.5
32.	27.5	40.0	36.0	36.0
33.	57.0	56.5	57.0	57.0
34.	46.0	37.0	42.0	52.5
35.	39.5	45.5	44.0	36.0
36.	53.5	55.0	54.5	55.0
37.	10.0	35.0	30.0	44.5
38.	52.0	57.0	54.5	42.0
39.	16.5	16.5	16.0	39.0
40.	16.5	24.0	21.0	29.0
41.	2.5	1.5	1.5	2.5
42.	2.5	1.5	1.5	1.0
43.	16.5	13.0	14.5	10.0
44.	23.5	3.5	6.0	16.5
45.	16.5	7.0	9.5	7.0
46.	30.5	24.0	26.0	33.5
47.	36.5	20.5	27.0	10.0
48.	2.5	9.5	6.0	10.0
49.	6.5	9.5	8.0	49.0
50.	10.0	13.0	12.0	26.0
51.	23.5	16.5	17.5	22.5
52.	47.5	49.0	49.5	50.0
53.	55.0	50.0	52.0	31.5
54.	36.5	52.0	48.0	26.0
55.	16.5	28.0	24.5	16.5
56.	55.0	53.0	54.5	52.5
57.	23.5	31.0	28.5	40.0
58.	53.5	55.0	54.5	47.5

TABLE B

ITEM SCORES OF THE JURY RESPONSES

Item	A	B	AB	C
1.	85.2	77.3	80.8	92.8
2.	85.2	74.3	79.2	90.8
3.	88.9	83.3	85.9	91.8
4.	77.8	69.7	73.3	86.7
5.	100.0	95.5	97.5	96.0
6.	87.0	80.3	83.3	93.0
7.	90.8	74.3	81.6	91.8
8.	94.5	94.0	94.1	98.0
9.	76.0	75.8	75.8	84.7
10.	64.8	42.4	52.5	78.5
11.	87.0	60.7	72.5	74.5
12.	79.6	75.8	77.4	88.8
13.	94.5	89.0	91.6	97.0
14.	77.8	50.0	70.8	73.5
15.	87.0	69.7	77.4	83.6
16.	91.4	86.4	90.7	93.8
17.	98.2	92.5	94.9	90.8
18.	94.5	65.2	78.3	81.6
19.	94.5	89.5	91.6	95.8
20.	90.8	85.0	87.5	90.8
21.	68.5	63.7	65.8	74.5
22.	92.6	81.9	86.4	88.8
23.	98.2	87.9	92.5	92.8
24.	90.8	86.4	88.3	88.8
25.	64.8	63.7	64.2	70.4
26.	38.9	25.8	31.6	60.2
27.	76.0	59.2	66.6	63.3
28.	81.5	68.2	74.2	74.5
29.	63.0	53.1	57.5	53.1
30.	94.5	81.9	87.5	85.7

A = chemistry teachers in small colleges

B = chemistry teachers in large colleges

AB = chemistry teachers in both small and large colleges

C = education teachers

TABLE B--Continued

Item	A	B	AB	C
31.	98.2	81.9	89.1	89.8
32.	90.8	66.7	77.5	83.6
33.	44.4	39.9	40.8	59.2
34.	74.2	69.7	71.6	66.3
35.	81.5	60.6	70.0	83.7
36.	59.3	37.9	48.0	61.2
37.	96.4	71.3	82.5	74.5
38.	61.2	36.6	47.5	76.5
39.	94.5	85.9	90.0	80.6
40.	94.5	81.9	87.5	87.8
41.	100.0	100.0	100.0	98.0
42.	100.0	100.0	100.0	99.0
43.	94.5	87.9	90.8	94.8
44.	92.6	95.5	94.1	91.8
45.	94.5	88.0	92.5	95.8
46.	88.9	81.9	85.0	84.7
47.	85.2	83.3	84.1	94.9
48.	100.0	89.5	94.1	94.9
49.	98.2	89.5	93.4	72.4
50.	96.4	87.9	91.6	88.8
51.	92.6	81.9	88.2	89.8
52.	68.5	48.5	57.5	71.5
53.	51.8	47.0	49.2	85.7
54.	85.2	40.9	60.8	88.8
55.	94.5	78.8	85.8	91.8
56.	57.4	39.4	47.5	66.3
57.	92.6	75.8	83.3	79.5
58.	59.3	37.9	47.5	73.5

TABLE C

MISCELLANEOUS VALUES

(1) Coefficients of rank correlations (Rho)

Juries A and B: Rho = 0.85

Juries A and C: Rho = 0.67

Juries B and C: Rho = 0.80

Juries AB and D: Rho = 0.77

(2) Standard deviations (s) of scores

Jury A: s = 13.9

Jury B: s = 18.6

Jury AB: s = 16.4

Jury C: s = 11.3

(3) Mean (M) of jury scores

Jury A: M = 83.8

Jury B: M = 72.2

Jury AB: M = 77.6

Jury C: M = 83.6

(4) Mean deviations (d) of jury scores

Jury A: d = 11.9

Jury B: d = 15.4

Jury AB: d = 13.3

Jury C: d = 9.4

TABLE D

CHI-SQUARE (X^2) VALUES BETWEEN THE INDICATED JURIES

Item	X^2_{A-B}	X^2_{A-C}	X^2_{B-C}
1.	1.06	2.15	5.82
2.	1.70	1.32	6.40
3.	2.40	.20	3.26
4.	2.27	2.26	5.64
5.	.23	1.50	0.14
6.	.93	2.23	5.15
7.	3.55	2.06	9.80
8.	.99	.85	1.70
9.	1.81	1.37	1.89
10.	5.33	4.22	16.93
11.	4.99	3.40	3.08
12.	.59	1.73	3.31
13.	1.61	3.43	3.14
14.	5.93	2.42	2.09
15.	4.77	1.48	6.40
16.	2.65	.95	0.94
17.	1.43	2.23	0.09
18.	13.80	3.41	11.64
19.	3.27	.73	3.99
20.	1.61	3.21	2.12
21.	1.63	.63	2.15
22.	2.94	.79	4.35
23.	4.04	1.55	1.24
24.	.48	0.24	2.98
25.	1.10	0.60	0.43
26.	2.14	6.38	14.96
27.	6.05	11.08	0.58
28.	6.42	1.51	1.89
29.	2.27	5.47	0.68
30.	2.83	1.69	4.24
31.	5.98	2.56	1.52
32.	9.90	1.83	5.64
33.	1.03	4.05	5.41
34.	1.51	1.03	0.67
35.	5.14	4.02	12.91

TABLE D--Continued

Item	X^2_{A-B}	X^2_{A-C}	X^2_{B-C}
36.	5.33	2.48	11.85
37.	8.16	6.96	0.13
38.	7.54	3.07	25.53
39.	2.38	4.16	3.39
40.	5.37	1.15	4.16
41.	0.00	1.09	1.18
42.	0.00	0.55	0.67
43.	1.91	0.36	2.55
44.	1.80	1.77	0.87
45.	4.28	0.71	2.33
46.	3.01	1.66	0.42
47.	0.06	4.43	5.40
48.	6.45	1.68	5.52
49.	3.29	9.48	2.34
50.	3.71	4.30	0.31
51.	1.70	1.16	0.85
52.	6.01	0.49	7.51
53.	2.05	16.51	18.37
54.	9.38	0.38	6.35
55.	2.39	0.54	3.68
56.	3.12	0.88	9.80
57.	4.91	3.84	0.84
58.	7.82	2.93	10.33

TABLE E

METHODS OF CALCULATIONS

1. Grouped rank determination using Table B.

All items with the same score are grouped together, and the mean rank of all is given to each item within the group.

Example: From Jury A

Item	Score	Rank	Mean Rank
5	100	1	2.5
41	100	2	2.5
42	100	3	2.5
48	100	4	2.5

$$\text{Mean rank} = \frac{\text{Rank values}}{\text{No. of items in group}}$$

$$= \frac{1 + 2 + 3 + 4}{4} = \frac{10}{4} = 2.5$$

2. Rank correlations by rank difference using rank values in Table B.

Step 1. List all item numbers with rank values of the two juries to be compared.

Step 2. Obtain differences in rank values.

Step 3. Square the differences.

Step 4. Use formula $P = 1 - \frac{6 \quad d^2}{N(N^2-1)}$

N = number of items

Example:

Item	Rank Jury A	Rank Jury B	d	d^2
1.	36.5	29	7.5	56.25
2.	36.5	33.5	3.0	9.00
3.	30.5	20.5	10.0	100.00

Calculate and tabulate like values for all fifty-eight items.

Letting P represent Rho, coefficient of correlation, substitute the sum of d^2 in the formula and solve.

3. The score for each item as given in Table B was found thus: A "yes" answer was valued as 2, and an undecided was valued as 1.

No. of "yes" answers x 2 + No. of undecided answers x 1 x 100 divided by total No. of answers x 2 = Score with base 100

4. Means and deviations

The following formulas were used for determining the mean score and the standard deviation of scores within each jury.

$$\text{Mean} = \frac{\sum' \text{scores}}{\text{No. of items}} \qquad \sigma = \frac{\sum d^2}{N-1}$$

5. Method of determining the limits of "yes" answers for classification of the aims.

(1) Assume there is no significance between the answers and the respondents; that is, the answers

are random. To increase confidence assume all "undecided" votes are "no" votes.

(2) By the short form formula for finding chi-square (X^2) find the maximum and minimum limits of the number of "yes" answers that would disprove the null-hypothesis.

Example: Use Jury A

Formula: $$X^2 = \frac{2(f_o - f_e)^2}{f_e}$$

Let y = fo (frequency observed)

Let ½ of number of jury members = $_e$ (frequency expected)

Substitute into formula using $X^2 = 3.84$, the value given at the 95 per cent level of confidence in a chi-square table with 1 degree of freedom

$$3.84 = \frac{2(Y - 27/2)^2}{27/2}$$

$$3.84 = \frac{2(y - 13.5)^2}{13.5}$$

Solve: y = 16½ and 13½ or approximately 17 and 13

Therefore,

17 or more answers of "yes" for an item in Jury A means "accept."

13 to 17 "yes" answers means "doubtful."

Under 13 "yes" answers are interpreted to mean "reject" the item.

In like manner, the limits of the other juries or combinations may be found:

	Accept	Doubtful	Reject
Limits of B =	22-33	11-21	Under 11
Limits of AB =	38-60	22-37	Under 22
Limits of C =	31-49	18-30	Under 18

Chi-Square: Use item 30 between Jury A and Jury B.

1. Set up contingency table assuming null hypothesis.

	(23.75)	(2.13)	(1.78)	Totals
	25	1	1	27
	(41.25)	(3.87)	(3.23)	
	40	5	4	49
Totals	65	6	5	76

2. Calculate independence values.

$$\frac{65 \times 27}{76} = \frac{1775}{76} = 23.75 \qquad \frac{65 \times 49}{76} = \frac{3185}{76} = 41.25$$

$$\frac{6 \times 27}{76} = \frac{162}{76} = 2.13 \qquad \frac{6 \times 49}{76} = \frac{294}{76} = 3.87$$

$$\frac{5 \times 27}{76} = \frac{135}{76} = 1.78 \qquad \frac{5 \times 49}{76} = \frac{245}{76} = 3.22$$

3. Calculate chi-square (X^2) by squaring the difference in observed frequency and the independence value; divide by the independent value. Perform this calculation for each of the six entries, and add results.

$$\frac{(1.25)^2}{2.35} + \frac{(-1.25)^2}{41.25} + \frac{(4.13)^2}{2.13} + \frac{(1.13)^2}{3.87} + \frac{(-.78)^2}{1.78} + \frac{(.78)^2}{3.23}$$

$= 2.83$ or X^2

There are two degrees of freedom; therefore, X^2 is well below the value of 5.99 given in the .05 column in a X^2 table, and the hypothesis that there is no difference, other than random differences, between the two juries is not rejected, i.e., there is no significant disagreement between the opinions of the two juries.

VITA

Edgar Franklin Stinson

Candidate for the Degree of

Doctor of Education

Thesis: AIMS AND OBJECTIVES FOR AN INITIAL COURSE IN COLLEGE CHEMISTRY DESIGNED FOR THE NON-SCIENCE MAJOR

Major Field: Higher Education

Biographical:

Personal Data: Born in Winfield, Texas, July 6, 1914, the son of Edgar F. and Effie Cody Stinson.

Education: Attended public school in Winfield, Texas; graduated from Winfield High School in 1931; received the Bachelor of Arts degree from East Texas State Teachers College, Commerce, Texas, with a science major in 1935; received the Master of Arts degree from East Texas State Teachers College with a major in Education--The Art of Teaching, in 1943; completed residence requirements for the doctorate in chemistry in Duke University, Durham, North Carolina, in 1949; completed requirements for the Doctor of Education degree at Oklahoma State University in 1959.

Professional experience: Taught science in Mt. Vernon High School from 1935 to 1941; Head of Science Program in Mt. Pleasant High School from 1941 to 1942; Assistant Professor of Chemistry in the College of Marshall, Marshall, Texas, from 1942 to 1944, during which time duties included teaching in ground school of the Naval Air Corps; from 1944 to the present time employed by East Texas Baptist College, Marshall, Texas. During this latter period, duties have included Professor of Chemistry, Student Dean, Chairman of the Mathematics-Science Division, and Executive Vice-President.

Organization Memberships: Texas State Teachers Association, East Texas School Men's Club, Texas Association of Student Personnel Administrators, American Chemical Society, American Association of University Professors, Phi Delta Kappa, Rotary International, and Masonic Lodge.