

South Dakota State University
**Open PRAIRIE: Open Public Research Access Institutional
Repository and Information Exchange**

Electronic Theses and Dissertations

1966

An Analysis and Evaluation of Chemical Education Selected South Dakota Secondary Schools

Bernal A. Kiser

Follow this and additional works at: <https://openprairie.sdstate.edu/etd>

Recommended Citation

Kiser, Bernal A., "An Analysis and Evaluation of Chemical Education Selected South Dakota Secondary Schools" (1966). *Electronic Theses and Dissertations*. 3210.
<https://openprairie.sdstate.edu/etd/3210>

This Thesis - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.

AN ANALYSIS AND EVALUATION OF CHEMICAL EDUCATION IN SELECTED
SOUTH DAKOTA SECONDARY SCHOOLS

BERNAL A. KISER

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Education, South Dakota
State University

1966

AN ANALYSIS AND EVALUATION OF CHEMICAL EDUCATION IN SELECTED
SOUTH DAKOTA SECONDARY SCHOOLS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Date

Head, Education Department

Date

CONTENTS

CHAPTER	PAGE
I. INTRODUCTION.....	1
Statement of the problem.....	2
Delimitation of the problem.....	3
Significance of the problem.....	3
Methods of study.....	4
II. SURVEY OF THE RECENT LITERATURE.....	8
A SURVEY OF THE RECENT LITERATURE PERTAINING TO THE CHEMICAL EDUCATION MATERIAL STUDY...	8
History of Chemical Education Material Study.....	8
Purpose of the Materials.....	9
The Role of the Laboratory in the CHEM Study Program.....	11
Laboratory Materials Required.....	13
Role of the Teacher.....	14
Cost of the Program.....	14
A SURVEY OF THE RECENT LITERATURE PERTAINING TO THE CHEMICAL BOND APPROACH PROJECT.....	15
History of the Chemical Bond Approach Project.....	15
Purpose of the Approach.....	17

CHAPTER	PAGE
Role of the Laboratory in the Chemical Bond Approach Project.....	18
Laboratory Materials Required.....	20
Role of the Teacher.....	21
Cost of the Program.....	21
III. THE RECORDING OF INFORMATION GAINED FROM THE STUDY.....	22
WHAT ARE THE OPINIONS OF EXPERTS IN THE FIELD OF CHEMICAL EDUCATION IN REGARD TO TRADITIONAL COURSES AND TO THE NEW TEACHING APPROACHES?.....	22
WHAT IS THE NATURE OF CHEMISTRY PROGRAMS CURRENTLY BEING USED IN SOUTH DAKOTA SECONDARY SCHOOLS?.....	29
Teacher Preparation.....	29
Recency of Instructional Materials....	32
Use of Class Time.....	34
Financial Support of Chemistry Programs.....	34
Opportunities for Individual Study....	34
Teacher Evaluation of Students.....	35
Factors Limiting the Effectiveness of Laboratory Instruction.....	35

WHAT FACTORS ARE INVOLVED IN CHANGING FROM TRADITIONAL CHEMISTRY PROGRAMS TO THE "NEW PROGRAMS," SPECIFICALLY CHEM- ICAL EDUCATION MATERIAL STUDY, AND THE CHEMICAL BOND APPROACH PROJECT?.....	36
Adapting the Physical Plant.....	37
Stocking and Preparation of Reagents..	38
Glassware and Hardware.....	38
Development of a Healthy Student Philosophy.....	39
HOW CAN CHEMICAL EDUCATION BE IMPROVED IN SOUTH DAKOTA SCHOOLS?.....	39
IV SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.....	45
SUMMARY.....	45
Purpose of the Investigation.....	45
Procedures Used.....	45
Problems of the Study.....	46
CONCLUSIONS.....	48
RECOMMENDATIONS.....	49
SELECTED REFERENCES.....	50
APPENDIX.....	52

TABLES

TABLE	PAGE
I. GEOGRAPHIC LOCATIONS OF TOWNS FROM WHICH DATA WERE RETURNED, AND THE NUMBER OF CHEMISTRY STUDENTS ENROLLED IN THE SCHOOLS DURING 1965-1966.....	5
II. DEGREES HELD BY TEACHERS OF SECONDARY SCHOOL CHEMISTRY IN SOUTH DAKOTA IN 1965-1966.....	30
III. UNDERGRADUATE MAJORS HELD BY TEACHERS OF SECONDARY SCHOOL CHEMISTRY IN SOUTH DAKOTA IN 1965-1966.....	31
IV. COURSE WORK HELD IN CHEMISTRY BY TEACHERS OF SECONDARY SCHOOL CHEMISTRY IN SOUTH DAKOTA DURING 1965-1966.....	32
V. TEXTBOOKS USED BY TEACHERS OF SECONDARY SCHOOL CHEMISTRY IN SOUTH DAKOTA.....	33

CHAPTER I
INTRODUCTION

In the past fifty years, numerous achievements have been made in the science of chemistry. Such achievements have required changes, both in industrial chemistry and in the teaching of chemistry.

Traditionally, beginning chemistry has been taught as a descriptive science. Even presently, many secondary schools, colleges, and universities, offer a factual course emphasizing factual data rather than basic principles.

Although teaching chemistry descriptively has appeared adequate in the past, because of the extensive volume of knowledge available today, such a method of instruction seems questionable.

More than ever before there seems to be a need for a logical and effective means of teaching secondary school chemistry. There also seems to be a need for a course which will present the modern nature and the methods of present day science.

Within the last decade, two introductory high school chemistry courses have been introduced. They are the Chemical Education Material Study and the Chemical Bond Approach Project. It is one of the objectives of this study to examine the role of the chemistry laboratory, with special reference to the Chemical Bond Approach Project

and the Chemical Education Material Study.

Statement of the problem. Whenever change is introduced, many questions seem to arise. Perhaps this is healthy for education. Too frequently, however, people oppose only for the sake of opposition. It is the sincere desire of the investigator that this study might contribute to the improvement of science education in South Dakota.

One of the purposes of this study is to examine and evaluate methods currently used in teaching chemistry in the secondary schools of South Dakota. Questions such as the following will be considered in this study:

1. What are the opinions of experts in the field of chemical education concerning traditional programs and the new chemistry approaches?
2. What is the nature of chemistry programs currently being used in South Dakota secondary schools?
3. What are the factors involved in changing from traditional chemistry programs to the "new approaches," namely Chemical Education Material Study, and Chemical Bond Approach Project, in high schools of the size of Brookings, Watertown, Huron, and Yankton?
4. How can chemical education be improved in South Dakota?

These are but a few of the many questions concerned within this study. Answers to these questions are likely to be tentative ones, for the new approaches to teaching high school chemistry in South Dakota are very vulnerable to change.

Delimitation of the problem. A comprehensive study of high school chemistry programs would necessarily include teacher training, audio-visual materials, examination of laboratory facilities, and many other factors. Such a study would seem excessive for a single thesis. This study, therefore, will be limited to the analysis and evaluation of methods used in teaching chemistry in selected secondary schools in South Dakota, with special emphasis upon the implications of the Chemical Education Material Study and the Chemical Bond Approach Project.

Significance of the problem. There has been a nation wide concern with the validity of chemical education in secondary schools. According to members of the CHEM Study project, among the weaknesses studied by the Chemical Education Material Study steering committee was a lack of correlation between science as understood by scientists and science as presented in the secondary schools.¹

¹Robert L. Silber, "Resources for improving instruction in chemistry," School Life, 45:16, October, 1962.

Certainly if this is true in South Dakota, recommendations for improving science education are needed.

A second concern of this study is to determine how well our students are prepared for chemistry courses offered in colleges and universities. It seems true that institutions of higher learning are becoming increasingly selective. It appears logical, therefore, that South Dakota students must be adequately prepared to meet rising demands.

Few educators would ignore the apparent implications of the above paragraphs. Indeed, such conditions were one of several factors which led to the "new programs" to be discussed in later chapters. The present study is meant to be a search into the possibilities of improving such conditions.

Methods of study. The data for this study were compiled in two ways: (1) a questionnaire was sent to each of 75 high schools randomly selected from the Educational Directory of South Dakota Schools, 1964-1965, and (2) the investigator observed four high school chemistry laboratory programs, two of which offered the traditional chemistry, one of which offered Chemical Education Material Study, and one of which offered Chemical Bond Approach.

Schools were randomly selected so that the data would be impartial to any given section of the state. Table I

indicates the name of each school, the number of students enrolled in the 1965-1966 chemistry program of the school and its geographic location.

TABLE I

GEOGRAPHIC LOCATIONS OF TOWNS FROM WHICH DATA WERE RETURNED, AND THE NUMBER OF CHEMISTRY STUDENTS ENROLLED IN THE SCHOOLS DURING 1965-1966

Name of Town	Number of Students in the Chemistry Program	County in which the town is located
Burke	28	Gregory
Pickstown	8	Charles Mix
Hurley	21	Turner
Dell Rapids	21	Minnehaha
Milbank	51	Grant
Elkton	18	Brookings
Spearfish	47	Lawrence
Chester	17	Lake
Miller	60	Hand
Ellsworth	60	Pennington
Yankton	96	Yankton
Lake Preston	18	Kingsbury
Chamberlain	45	Brule
Pierre	114	Hughes
Colton	20	Minnehaha
Huron	145	Beadle
Timber Lake	26	Dewey
Lemmon	34	Perkins
Estelline	30	Hamlin
Custer	20	Custer
Isabel	21	Dewey
Alpena	17	Jerauld
Sisseton	63	Roberts
Redfield	40	Spink
Gayville	6	Yankton
Canton	37	Lincoln
Bonesteel	13	Gregory
Flandreau	27	Moody
Rapid City	325	Pennington
Sturgis	88	Meade
Hill City	20	Pennington
Faith	20	Meade

TABLE I (continued)

Name of Town	Number of Students in the Chemistry Program	County in which the town is located
Belle Fourche	41	Butte
Mitchell	96	Davison
Brandon	30	Minnehaha
Marion	32	Turner
Parkston	22	Hutchinson
Madison	65	Lake
Rutland	13	Lake
Faulkton	33	Faulk
Brookings	125	Brookings
White	27	Brookings
Mobridge	7	Walworth
Raymond	13	Clark
Deadwood	36	Lawrence
Onida	24	Sully
Groton	18	Brown
Provo	13	Fall River
Lane	15	Jerauld
Bridgewater	17	McCook

Data were also compiled from the writing committees of both Chemical Bond Approach Project and Chemical Education Material Study.

Much help was given from the staff of the University of California, Berkeley, in regard to the Chemical Education Material Study. Information gained from such correspondence is entered in Chapter III of this study.

Chapter I of this study outlines the scope of the problem. Chapter II is a review of the literature pertaining to Chemical Education Material Study and Chemical Bond Approach Project. Chapter III represents material

gained via personal correspondence with writers of the Chemical Bond Approach Project, Chemical Education Material Study, and high school educators using the materials of the new approaches. Chapter IV contains the conclusions and implications of this study.

CHAPTER II
SURVEY OF THE RECENT LITERATURE

Much has been written concerning instruction of traditional chemistry. Therefore, the present section will be limited to the following:

1. A survey of the recent literature pertaining to Chemical Education Material Study
2. A survey of the recent literature pertaining to the Chemical Bond Approach Project

A SURVEY OF THE RECENT LITERATURE PERTAINING
TO THE CHEMICAL EDUCATION MATERIAL STUDY

History of Chemical Education Material Study

The Chemical Education Material Study, commonly called CHEM Study, resulted from suggestions made by a committee headed by A. B. Garrett of the Ohio State University. In 1960, Nobel laureate, Glenn T. Seaborg, obtained a grant from the National Science Foundation, and assembled a steering committee composed of the nation's most able teachers and scientists from a variety of chemical fields. This steering committee then selected whom they considered the most able people, of high schools, colleges, and universities, to participate in writing the CHEM Study materials.¹

¹J. Arthur Campbell, "Chemistry--An Experimental Science," School Review, 70:52-53, Spring, 1962.

The first edition of the textbook and laboratory manual was written at Harvey Mudd College in Claremont, California, during the summer of 1960. During the 1960-1961 academic year, the materials were used by one junior college and 23 high schools, involving approximately 1300 students. Weekly contact was maintained between the staff of CHEM Study and the pioneering teachers.²

During the summer of 1961, the CHEM Study materials underwent revision at the University of California, Berkeley. At this writing conference, a complete teacher's guide was written. These new materials were used by three colleges and 123 high schools throughout the United States, and involved approximately 13,000 students.³ Again, close contact was maintained between staff members of CHEM Study and the teachers using the materials.

Purpose of the Materials

Several purposes have been stated for the development of the CHEM Study materials. Among these has been, according to Dr. J. Arthur Campbell,⁴ the existence of

²George C. Pimentel, Editor, Chemistry--An Experimental Science. San Francisco: W. H. Freeman and Company, 1960, p. vii.

³Ibid.

⁴Campbell, op. cit., p. 51.

widespread discontent among secondary school chemistry teachers. Such discontent, Campbell feels, may be due to the following:

1. Historical approaches to teaching chemistry which terminate in a period foreign to students.
2. Memorization of data rather than understanding of concepts behind such data.
3. Laboratory exercises demonstrating to the student that which he has already read.

Because Campbell, and other noted science educators, felt such deficiencies to be detrimental to satisfactory instruction, it was decided that a national effort was needed to deal directly with such problems. Such a national effort resulted in the Chemical Education Material Study.

A second purpose of the study is to create among high school students an awareness of the significance and capabilities of scientific activities that will help the future citizen assess wisely the growing impact of technology on his social environment.⁵

Thirdly, the writers of CHEM Study have attempted to provide the best possible high school chemistry course for those students planning to go to colleges and

⁵Pimentel, op. cit., p. viii.

universities. The course is, however, within the grasp of the average high school chemistry student.⁶

Finally, the constant effort of the Chemical Education Material Study staff is to experiment with all possible means of providing the most comprehensive and effective high school chemistry course possible.⁷

The Role of the Laboratory in the CHEM Study Program

The title of the CHEM Study textbook, Chemistry--An Experimental Science, suggests the importance of the laboratory. The Laboratory Manual refers to the course as laboratory-centered.⁸ The importance of the laboratory in the CHEM Study program may be illustrated in several ways. One is that the student is sent to the laboratory the first day he enters chemistry, and he works there for about the next seven chemistry periods. Furthermore, the student is not given a textbook until the fourth day of school.

A second example illustrating the prominent role of the laboratory is that the student generally performs an experiment prior to reading about the material, or before

⁶Ibid.

⁷Campbell, op. cit., p. 62.

⁸Lloyd E. Malm, Editor, Laboratory Manual for Chemistry--An Experimental Science. San Francisco: W. H. Freeman and Company, 1960, p. v.

the material is discussed in class.⁹ Dr. J. Arthur Campbell states, "He realizes that chemistry is indeed a laboratory science, not a subject that can be only read about in a book or talked about in class."¹⁰

A third illustration of the importance of the laboratory may be cited from the Laboratory Manual:¹¹

The CHEM Study course approaches the study of chemistry as an experimental science. It is a laboratory-centered course which:

1. features experiments which will permit you to make your own discoveries of the regularities and principles which unify chemistry and make it easier to understand,
2. emphasizes the making of careful observations and quantitative measurements under controlled experimental conditions,
3. stresses the preparation of well-organized tables for recording data and the results of calculations so that you can more readily make deductions and recognize the regularities which exist,
4. use challenging discussion questions which will help you to apply the principles observed in the experiments to new situations.

The Laboratory Manual is organized into five major divisions, and terminates with an appendix. The five divisions are as follows:

Part 1. Observation and Interpretation. Precision of Measurement. (6 experiments)

⁹Campbell, op. cit., p. 55.

¹⁰Ibid.

¹¹Pimentel, op. cit., p. v.

- Part 2. An Introduction to Chemistry. The Mole Concept. Avogadro's Hypothesis. Gases. Solutions. (8 experiments)
- Part 3. Investigations of Chemical Reactions Illustrating Important Principles. (13 experiments)
- Part 4. Theoretical Concepts. Atomic Structure. Chemical Bonds. Structure and Properties. (4 experiments)
- Part 5. Application of Chemical Principles to Descriptive Chemistry. (15 experiments)¹²

No experiment of the CHEM Study materials involves the use of hazardous materials which characterized many of the traditional experiments. About three-fourths of the experiments are quantitative in nature, but involve only freshman level mathematics. The experiments are structured in procedure, but quite open-ended in regard to expected results.¹³

Kenneth V. Fast comments, "Using this method, centering the course about the laboratory, one learns chemistry rather than learning about chemistry."¹⁴

Laboratory Materials Required

One distinct advantage of the laboratory program as set-up by the Chemical Education Material Study is that

¹²Ibid.

¹³Kenneth V. Fast, "The Role of Laboratory Experiences in the CHEM Study Program," School Science and Mathematics, 63:155, February, 1963.

¹⁴Ibid., p. 147.

the equipment requirements are approximately the same as those used in a conventional chemistry course. The equipment required is simple and low in cost. According to Dr. J. Arthur Campbell, "Any school with a reasonable laboratory budget should have no difficulty in introducing these experiments into its program."¹⁵

Richard J. Merrill states that double laboratory periods are a distinct advantage, but are not a necessary requirement.¹⁶

Role of the Teacher

The role of the classroom teacher who changes to CHEM Study is changed considerably. Of greatest contrast to the traditional manner of teaching is that the teacher acts as a consultant rather than a leader. The teacher is primarily a guide for the average chemistry student.¹⁷

Cost of the Program

The cost of laboratory materials was stated to be low previously. Textbooks and the laboratory manuals are also reasonable in cost. Because of the heavy emphasis

¹⁵Campbell, op. cit., p. 56.

¹⁶Richard J. Merrill, "Chemistry--An Experimental Science," The Science Teacher, 30:31, April, 1963.

¹⁷Fast, op. cit., p. 147.

placed on the laboratory, the CHEM Study program can be carried on at a very reasonable cost. If a school is large enough that it can support the added expense of audio-visual materials, CHEM Study films are available at a cost of one hundred dollars per film. The films come in sets of five or more. At present there are over twenty such films available.¹⁸

A SURVEY OF THE RECENT LITERATURE PERTAINING
TO THE CHEMICAL BOND APPROACH PROJECT

History of the Chemical Bond Approach Project

In June of 1957, a conference among high school and college chemistry teachers was held at Reed College in Portland, Oregon. The members of this conference were later recognized as the Chemical Bond Approach Committee.¹⁹ The purpose of this initial conference was to study the existing high school chemistry program. Several conferences later, the group agreed that the approach to teaching high school chemistry had to be changed.²⁰

The members of the committee decided that simply introducing modern terminology to existing courses, and

¹⁸Campbell, op. cit., p. 60.

¹⁹Anonymous, "The Committee's Purpose," CBA Newsletter, 2:1, April, 1963.

²⁰Ibid.

making courses more rigorous was not what was needed. Rather, to present a good up-to-date chemistry, by new organization of materials, was required.²¹

The actual development of written materials for the Chemical Bond Approach Project was begun in the summer of 1959. Involved in this conference were nine college chemistry professors and nine high school chemistry teachers. Since that time, these same people have been the principal representatives of the program.

After the first trial edition of the materials was completed, the materials were distributed to cooperating teachers throughout the nation. On the recommendations received by these teachers, and students, the materials were revised in the summer of 1960. From the CBA Newsletter, April, 1963 issue:²²

All the feedback from users was studied in preparing the textbook and laboratory materials scheduled for the publication in August of 1963. Through the whole period of development much effort has been expended in making the materials understandable, while, at the same time, making no compromise with regard to the facts of chemistry, or the way chemists view their work.

The writing committee of Chemical Bond Approach Project has maintained continuous contact with the teachers employing the materials. A number of the ideas that were

²¹Ibid.

²²Ibid., p. 2.

tested during the development of the program had to be eliminated because of their difficulty. Quite frequently, however, the writing committee was advised that the ability of high school students had been underestimated.²³

In August of 1963, McGraw-Hill Book Company published the textbook, Chemical Systems, and the laboratory manual, Investigating Chemical Systems.²⁴ These materials represented the culmination of the Chemical Bond Approach Project investigation and revision of high school chemistry programs.

Purpose of the Approach

The initial purpose of the Chemical Bond Approach Project was determined during the summer of 1957 at Reed College, Portland, Oregon. The result of this conference was the recommendation that a high school course be developed that would serve as a basis for further study of chemistry in college.

To achieve this purpose, the committee proposed that the new course demonstrate the importance of theory and experiment, and present an accurate story of modern day chemistry. The following entry, taken from the 1963

²³ Ibid.

²⁴ John J. Montean and Others, "An Evaluation of CBA Chemistry for High School Students," Science Education, 47:36, February, 1963.

CBA Newsletter, illustrates the committee's concern:

All too often students have failed to understand why chemistry is a subject which fascinates many different people. To give students a vital and true picture of chemistry, the subject must be organized and presented to explore three key points:

1. Chemists work in the laboratory to obtain data
2. Chemists use their imagination to develop ideas
3. Chemists combine experimental data and imaginative ideas to further their understanding of chemical systems.²⁵

The last point illustrates the aim of the committee, that students come to realize the importance of both experimental data and theory--not as separate, but as complements of one another.

A final, and strongly stressed purpose of the Chemical Bond Approach Project committee, is to encourage students to dismiss the notion of a single correct answer to a problem. CBA teachers judge answers by their logical effectiveness to the situation.²⁶

Role of the Laboratory in the Chemical Bond Approach Project

In the Chemical Bond Approach Project, emphasis is placed upon close correlation of classroom and laboratory work. Problems are developed which require both experimental data and theory. Chemical Bond, therefore, is an

²⁵Ibid., p. 1.

²⁶Ibid., p. 2.

attempt at a laboratory-concepts course. As stated in the 1963 CBA Newsletter:²⁷

The ideas and information presented and developed in both classroom and laboratory programs are interrelated and designed to encourage students and teachers to move freely from theory to observation, from concept to experiment, and from classroom to laboratory.

The laboratory manual, Investigating Chemical Systems, accounts for individual differences by having experiments for all types of students. Experiments are included which all students should complete; others are designed for only those who are more academically able. Independent experimentation is one of the major aims of the laboratory program.²⁸

Experiments included in the laboratory manual encourage the students to work in a manner similar to research chemists. Because the students are, initially, unskilled in laboratory procedure, the first set of experiments gives the student sufficient information to both plan and carry out his experiment. As the course progresses, the amount of given information lessens. Finally, the last experiments simply state the problem. On the basis of this gradual lessening of given information, the experiments are classified into Groups I, II, and III.²⁹

²⁷Ibid., p. 3.

²⁸Ibid., p. 2.

²⁹H. A. Neidig and Others, Investigating Chemical Systems. St. Louis: Webster Division, McGraw-Hill Book Company, 1963, p 2.

A final major role of the laboratory in the CBA program is to teach the student how to record scientific data. Laboratory notes are kept in a blank record, consisting of white and yellow sheets of quarter inch graph paper. The original notes are entered on the white sheets; a carbon copy, made on the yellow sheets, is torn out and handed to the instructor following the laboratory period. The student keeps his original record. Students are encouraged to extend their laboratory investigations whenever possible.³⁰

Laboratory Materials Required

The Chemical Bond Approach and the Chemical Education Material Study are similar in several respects. One is that both programs require approximately the same amount of equipment that is used in a conventional chemistry course. According to Mr. Alfred A. Halsted of Yankton High School, the requirements of physical plant, chemical reagents, and laboratory apparatus vary insignificantly from traditional courses.³¹

³⁰Paul Westmeyer, "The Chemical Bond Approach to Introductory Chemistry," School Science and Mathematics, 61:321, May, 1961.

³¹Alfred A. Halsted, Interview with Bernal Kiser, June 8, 1966.

Role of the Teacher

The role of the teacher is much less authoritarian in the CHEM Bond program than in traditional chemistry courses. The primary task of the teacher is to serve as a resource person to his students. According to Dr. Paul Westmeyer, the teacher must restrain his tendency to give specific directions, yet keep close watch on the methods his students employ in conducting their thinking and experimentation.³²

Cost of the Program

The textbooks, laboratory manuals, and laboratory equipment are all very similar in cost to materials required in a conventional chemistry program. According to Alfred Halsted, any school which can afford a good traditional chemistry program should not hesitate to adopt the CBA materials if cost is the basis of the decision.³³

³²Paul Westmeyer, "Do It Yourself--But Wear Goggles," The Science Teacher, 32:22, September, 1965.

³³Halsted, op. cit., interview.

CHAPTER III

THE RECORDING OF INFORMATION GAINED FROM THE STUDY

This chapter represents an attempt to answer the following four questions:

1. What are the opinions of experts in the field of chemical education in regard to traditional, or descriptive courses, and to the new approaches?
2. What is the nature of chemistry programs currently being used in South Dakota secondary schools?
3. What are the factors involved in changing from traditional, or descriptive, chemistry programs to the new programs, namely Chemical Education Material Study and Chemical Bond Approach?
4. How can chemical education be improved in South Dakota?

Data for this chapter were gathered from material sent to the investigator, from visiting recognized chemistry educators in South Dakota, and from questionnaire returns.

WHAT ARE THE OPINIONS OF EXPERTS IN THE FIELD OF CHEMICAL EDUCATION IN REGARD TO TRADITIONAL COURSES AND TO THE NEW TEACHING APPROACHES?

The investigator has covered the opinions of experts in regard to traditional chemistry courses in foregoing sections of this study. This section will therefore

emphasize the opinions of experts concerning the new approaches, namely CHEM Study and CHEM Bond.

The material for this section was compiled from letters received from prominent chemistry teachers throughout the United States. Following are the names and opinions of these persons.

Robert L. Silber,¹ presently director of the membership activities division, the American Chemical Society, indicated that both the Chemical Bond Approach Project and the Chemical Education Material Study have made significant contributions to chemical education in the United States. Silber states that it is interesting to note that although CHEM Study was supported by a substantial amount of funds from the federal government, all of this will be paid back in a few years. This, Dr. Silber states, is the first such program that has accomplished this.

Wendell H. Taylor,² chairman of the department of science, The Lawrenceville School, Lawrenceville, New Jersey, commented as follows on the Chemical Bond Approach Project: "I do not find that the course suffers overly from presentation of 'too much of the same.'" Continuing, Taylor states, "It is true that it is largely conceptual, and that descriptive chemistry is kept on a minimal level, but the

¹R. L. Silber, Letter to Bernal Kiser, March 18, 1966.

²Wendell H. Taylor, Letter to Bernal Kiser, February 23, 1966.

concepts are many and varied."

Taylor further commented that his experience, however with good students having a physics background prior to entering chemistry, has been that the course "grows on the students and that by mid-year they have become quite enthusiastic about their power to predict properties in terms of structure."³

Saul L. Geffner,⁴ chairman of the department of physical science, Forest Hills High School, Forest Hills, New York, and a member of the writing panel for Chemical Education Material Study, states:

My experience of five years has convinced me that the approach in CHEM Study is proper for a secondary school chemistry class. The reason students experience difficulty is not primarily due to the difficulty of the material presented. Instead, it is the higher reading level (and the proper one for high school juniors or seniors) that represents the major block. In time when the grade schools and intermediate schools reset their sights to provide acceptable reading habits (and writing as well) fewer students will reject CHEM Study. Furthermore, the course puts the major responsibility where it rightfully belongs--on the shoulders of the student, who, up to this time has been spoon fed.

Dr. Robert W. Parry,⁵ Professor of chemistry, the University of Michigan, and contributor to the manuscript

³Ibid.

⁴Saul L. Geffner, Letter to Bernal Kiser, March 8, 1966.

⁵Robert W. Parry, Letter to Bernal Kiser, April 26, 1966.

of Chemical Education Material Study, delivered an address in late October of 1965, entitled "The New High School Programs in Chemistry." Professor Parry was kind enough to have his colleague, Dr. R. M. Fitch of the North Dakota State University, send the investigator one copy of the Proceedings of the First Conference on Undergraduate Chemistry Curriculum in the North Central States Region, which included a copy of Dr. Parry's address. In reference to CBA, Dr. Parry commented as follows:⁶

The CBA people describe their course as "imaginative ideas and facts rolled into one." The problem is to weave facts and concepts into a consistent pattern. They were trying to set up a framework with the chemical bond as the central structural unit, then hang as much chemistry on this framework as time would permit. I believe they were remarkably successful in many ways.

Dr. Parry further stated: "Through some refreshing modifications in approach, the student is introduced to the basic tools needed in the development of chemistry."

Frequently educators are asked, "What are the results of the new programs?" Unfortunately, data are incomplete on course evaluation. Dr. Parry did, however, commit himself to this extent: "I firmly believe that the CHEM

⁶Robert W. Parry, "The New High School Programs in Chemistry," Proceedings of the First Conference on Undergraduate Chemistry Curriculum in the North Central States Region, North Dakota State University, 1:23, April, 1966.

Study students will do better, but belief or prejudice is one thing, while information is something else."⁷

Professor Eugene Roberts,⁸ formerly head of the division of chemistry at Polytechnic High School, San Francisco, California, and presently on the staff of City College of San Francisco, contributed heavily to the investigator's material. In one letter, Professor Roberts commented as follows:

The type of experiment in CHEM Study, as you probably recognize, differs radically from the O, H, H₂O, sequence of the traditional lab manuals. For teachers this is a major attraction, and a major hurdle. An established, traditional course teacher must completely, but completely, revamp his supply of chemicals, solutions, and equipment. It is a major task to "switch over", and requires a lot of gumption on the part of the teacher to do so, since none of the experiments are very interchangeable. The lab prep on a first year's trial is a massive thing. Without student help it is almost impossible to accomplish all that needs to be done to get the course off the ground on a five-classes-a-day schedule. I know of no experienced teacher who would minimize this aspect. The amazing thing is the attraction that the CHEM Study program has for instructors in spite of the task of retooling their lab programs.

Professor Roberts further endorsed the CHEM Study approach by paying special tribute to the Teacher's Guide. It is in his opinion the Teacher's Guide that is the single most important reason for the wide acceptance of

⁷ Ibid., p. 24.

⁸ Eugene Roberts, Letter to Bernal Kiser, March 10, 1966.

the CHEM Study materials. Interestingly, Richard Vitters,⁹ instructor of chemistry at Huron High School, made the same comment in his questionnaire return.

In continuing his letter, Professor Roberts remarked:¹⁰

A real contribution that CHEM Study makes to all lab sciences is the use of the carbon copies of the lab notebook. This ties down the student to the data HE actually gathered in the lab, serves as a check on just what a student did do in the lab during the class period, and lets the student have his notebook at all times, while enabling the instructor to continuously check the lab work of the class--without "collecting notebooks." This technique can be applied to any lab situation, and instructors think it is an excellent idea.

In addition to personal opinions concerning the new programs, Dr. R. L. Silber sent the investigator an article written by Professor P. G. Ashmore which gives a detailed review of CHEM Study and CHEM Bond. In commenting upon the new approaches, Dr. Ashmore writes the following:¹¹

Now it is likely that none of these pedagogic methods are new, but they are rarely found "in extenso", and they are woven so skillfully into the texts that the main impression, after reading these books, is of something new and refreshing. The value of the material is enhanced by the excellent production and layout of the books, with diagrams and tables that

⁹Richard Vitters, Letter to Bernal Kiser, May 18, 1966.

¹⁰Roberts, op. cit., Letter.

¹¹P. G. Ashmore, untitled review, Chemistry, 38:1, 1965.

compel examination and highlight the essential information with extraordinary care. Teaching chemistry is revealed and sustained as a fascinating exploration, jointly conducted by teacher and pupil, and compounded of personal investigation and critical study of the work and ideas of lively minded scientists, rather than the offering of a corpus of unchangeable facts and rigid interpretations for assimilation by passive students.

Professor Ashmore states that the CHEM Study and CHEM Bond approaches differ in both depth and emphasis. Specifically, Dr. Ashmore writes: "The CBA project presents a considerably more advanced and sophisticated approach." Professor Ashmore continues to comment that he feels CHEM Study to be a more genuinely beginner's approach. In direct contrast of CHEM Bond, Ashmore considers CHEM Study a course having more direct connection between experiment, interpretation, and theory. In summarizing his article, Dr. Ashmore writes the following:

It is difficult to do full justice to these two great experiments in providing courses of instruction that take account of the fundamentals of the subject and the different needs of teacher and pupil. They have evolved courses that appear to have many good qualities in common and many individual features, with a few aspects that might be improved. It is entirely in the spirit of the design of these experiments that, although their results may be regarded as the most useful available at the time, further modifications and fresh approaches will be needed as the subject and the objectives of the courses slowly evolve.¹²

¹²Ibid., p. 35.

WHAT IS THE NATURE OF CHEMISTRY PROGRAMS CURRENTLY
BEING USED IN SOUTH DAKOTA SECONDARY SCHOOLS?

The following criteria will be used to ascertain the nature of chemistry programs in South Dakota:

1. Teacher Preparation
2. Recency of Instructional Materials
3. Use of Class Time
4. Financial Support of Chemistry Programs
5. Opportunities for Individual Study
6. Teacher Evaluation of Students
7. Factors limiting the effectiveness of laboratory instruction

Teacher Preparation

Two factors will be considered in an attempt to evaluate teacher readiness for teaching chemistry in South Dakota. These are (1) academic degree and undergraduate major, and (2) courses taken in college chemistry. Table II illustrates the type and number of degrees held by the teachers.

TABLE II
DEGREES HELD BY TEACHERS OF SECONDARY SCHOOL
CHEMISTRY IN SOUTH DAKOTA IN 1965-1966

Degree	Number of Teachers holding the degree	Percentage of the Group
B.S.	21	42
B.A.	7	14
M.Ed.	8	16
M.A.	2	4
M.S.	10	20
M.D.	1	2
B.Mus.	1	2
Totals	50	100

Table III shows the undergraduate majors of the teachers, and Table IV indicates the chemistry courses these teachers have taken. According to the data obtained from the questionnaire, of the $66\frac{2}{3}$ percent of teachers who returned their questionnaires, 42 percent held the B.S. degree, 14 percent the B.A. degree, 16 percent the M.Ed. degree, four percent the M.A. degree, 20 percent the M.S. degree, two percent the M.D. degree, and two percent the B.Mus. degree.

The chemistry teachers had various majors, and some had more than one major. Major subjects, and the percentage of teachers holding each major, are tabulated in

Table III below.

TABLE III

UNDERGRADUATE MAJORS HELD BY TEACHERS OF SECONDARY
SCHOOL CHEMISTRY IN SOUTH DAKOTA IN 1965-1966

Undergraduate Major	Number of Teachers holding the major	Percentage of the Group
Physical Science or Combined Science	18	36
Mathematics	13	26
Biology	7	14
Chemistry	6	12
History	4	8
Zoology	2	4
Social Science	2	4
Animal Husbandry	1	2
Horticulture	1	2
Latin	1	2
Music Education	1	2
Agricultural Education	1	2
Secondary Education	1	2
No entry	1	2

Of the responding teachers, 36 percent had majored in either combined science or physical science, 26 percent in mathematics, 14 percent in biology, 12 percent in chemistry, four percent in history, four percent in zoology, two percent in social science, two percent in animal husbandry,

two percent in horticulture, two percent in Latin, two percent in music education, two percent in agricultural education, and two percent in secondary education. Two percent of the teachers did not specify an undergraduate major.

TABLE IV
COURSE WORK HELD IN CHEMISTRY BY TEACHERS
OF SECONDARY SCHOOL CHEMISTRY IN SOUTH
DAKOTA DURING 1965-1966

Chemistry Course	Number of Teachers having taken the course	Percentage of the Group
First Semester General Chemistry	50	100
Second Semester General Chemistry	49	98
Qualitative Chemical Analysis	39	78
Quantitative Chemical Analysis	36	72
Organic Chemistry	40	80
Physical Chemistry	12	24

Recency of Instructional Materials

Nearly 70 percent of the textbooks used by the responding teachers had been printed within the last five years. Table V tabulates the names, authors, and editions

of the textbooks used in the schools where these people teach.

TABLE V

TEXTBOOKS USED BY TEACHERS OF SECONDARY SCHOOL CHEMISTRY
IN SOUTH DAKOTA

Title	Author(s)	Edition	Percentage of Teachers using the book
<u>Modern Chemistry</u>	Dull, Metcalfe, Williams	second	32
<u>Modern Chemistry</u>	Dull, Metcalfe, Williams	first	8
<u>Modern Chemistry</u>	Dull, Metcalfe, Williams	third	2
<u>Chemistry--An Experimental Science</u>	Writing Committee	first	14
<u>Chemistry--Man's Servant</u>	Fliedner and Teichman	second	4
<u>Chemistry in Action</u>	Rawlins and Struble	third	2
<u>Chemistry in Action</u>	Rawlins and Struble	fourth	4
<u>Chemistry--A Modern Course</u>	Smoot, Price, and Barrett	first	2
<u>Chemistry</u>	Garrett, Richardson, Kieffer	first	2
<u>Elements of Chemistry</u>	Brownlee, Fuller, Whitsit	second	2
<u>"Vitalized Chemistry"</u>	Dorin	fifth	2
<u>Chemistry and You</u>	Baker, Bradbury, McGill, Eichinger	first	10
<u>Chemistry and You</u>	Baker, Bradbury, McGill, Eichinger	second	14

Use of Class Time

Seventy-two percent of the teachers who returned their questionnaires described their chemistry programs as being discussion centered, eight percent described their chemistry programs to be equally laboratory and discussion centered, and 20 percent considered their courses to be primarily laboratory centered. The average number of hours spent in the laboratory, calculated from the questionnaire data, was 1.64 hours per week.

Financial Support of Chemistry Programs

Forty-four percent of the teachers returning questionnaires did not specifically state an annual budget; many of these teachers entered "no set amount" for their answers. Of the 56 percent of the chemistry teachers giving a numerical response, the average amount allotted per student was 12.32 dollars.

Opportunities for Individual Study

Eighteen percent of the respondents specified research facilities; 82 percent reported having no research facilities.

Teacher Evaluation of Students

Four percent of the teachers made no response in regard to student evaluation; two percent of the teachers reported trying a "self-grading" system. Ninety-four percent of the instructors did specify a given percentage. According to these percentages, the average percentage of a student's grade dependent upon laboratory performance was 20.7. Other criteria upon which a student was evaluated were recitation and examinations, which varied greatly from school to school.

Factors Limiting The Effectiveness of Laboratory Instruction

One hundred percent of the teachers who returned the questionnaire made comments concerning factors which they felt limited the effectiveness of chemistry laboratory instruction. Three factors appeared more frequently than others. These three factors, and the percentage of their frequency, are as follows: (1) time, 58 percent; (2) insufficient equipment and limited facilities, 36 percent; and (3) space, 28 percent. Eighteen percent of the teachers suggested that double laboratory periods are necessary for most laboratory exercises.

WHAT FACTORS ARE INVOLVED IN CHANGING FROM TRADITIONAL
CHEMISTRY PROGRAMS TO THE "NEW PROGRAMS," SPECIFICALLY
CHEMICAL EDUCATION MATERIAL STUDY, AND THE CHEMICAL
BOND APPROACH PROJECT

In South Dakota, Mr. Guy O. Karnes¹³ of Brookings High School, and Mr. Alfred A. Halsted¹⁴ of Yankton High School, are considered among the most successful and experienced secondary school chemistry teachers. Mr. Halsted was the first science educator in South Dakota to adopt the Chemical Education Material Study materials into a high school chemistry program. Mr. Karnes is presently in the process at Brookings High School.

On June 8, 1966, the investigator and Mr. Karnes were able to discuss at length with Mr. Halsted, factors necessary in changing from a traditional chemistry program to either CHEM Study or CHEM Bond. This section is a summary of the information gathered from both Mr. Karnes and Mr. Halsted.

Mr. Halsted stated that there are four primary factors which must be considered in developing the new programs, in the adoption of either CHEM Study or CHEM Bond. These four factors are as follows:

¹³G. O. Karnes, Interview with Bernal Kiser, June 8, 1966.

¹⁴Alfred A. Halsted, Interview with Bernal Kiser, June 8, 1966.

1. Adapting the physical plant
2. Stocking chemical reagents required
3. Glassware and hardware required
4. Development of a healthy student philosophy

Adapting the Physical Plant

Mr. Halsted stated that the physical plant required for teaching the new chemistry courses differs very little from the requirements of the traditional courses. Because such small amounts of laboratory reagents are used during any given experiment, very little danger is involved in the laboratory work. Mr. Halsted continued that it is very helpful for the teacher to arrange the laboratory tables in such a manner as to be able to face each student.

Mr. Halsted further remarked that there is one provision which can not be sacrificed at any cost. This is having a laboratory which can be used at any time during class. This is necessary, Halsted continued, because of the many fifteen minute experiments which are vital at certain specific places during a given discussion.

Although Mr. Halsted prefers a separate classroom and laboratory, he did state that a combined classroom-laboratory facility would be very appropriate for use in teaching either CHEM Study or CHEM Bond.

Stocking and Preparation of Reagents

Both Mr. Karnes and Mr. Halsted commented that the quantity of chemicals required for a traditional course exceeds that of either CHEM Study or CHEM Bond. Mr. Halsted remarked that the only single chemical, which is both expensive and required in considerable amounts is silver nitrate. Thirty dollars worth of silver nitrate was used for the CHEM Study program during 1965-1966 at Yankton High School. This represents only a portion of the \$400.00 budget which the questionnaire for this study has shown to be somewhat typical of schools of this size. In summarizing, Mr. Halsted stated that the over-all amount of chemicals used is quite similar to that of a reasonably good descriptive course.

Glassware and Hardware

Apparently many teachers have hesitated to change from descriptive approaches to the new approaches because of their reservations concerning the cost of glassware and hardware. Mr. Halsted feels that such reservations are not necessary, for he has found that the amount of equipment required is about the same as in a traditional program, with the exception of ten milliliter test tubes and graduated cylinders. Mr. Halsted feels that each student should be provided with a single graduated cylinder, and that students can, if necessary, work very well in pairs.

Development of a Healthy Student Philosophy

It is the shared opinion of Mr. Karnes and Mr. Halsted that the ultimate success of the new chemistry approaches will depend directly upon the attitude of the student toward the course. Mr. Halsted emphasizes that the teacher must assure his students that things will fall into place. Mr. Halsted continued that students have been used to rote memorizing, and have received superior grades oftentimes from memorizing. The new approaches, which attempt to divorce the student from his habits of memorizing, often leave the student intellectually confused. This is the reason, Mr. Halsted continued, that the teacher must spend a considerable amount of time to acquaint the student with the aims, methods, and objectives of the new programs.

HOW CAN CHEMICAL EDUCATION BE IMPROVED IN SOUTH DAKOTA SCHOOLS?

The opinions cited below are those of chemistry teachers employed in South Dakota secondary schools. The comments of seven teachers comprise a selected sample. The investigator assumed these teachers to be a reasonable sample due to the following: (1) the respect these people hold by their fellow science educators, and (2) the completeness with which each teacher selected had filled out his questionnaire.

Roy W. Rissky, M.S.,¹⁵ chairman of the department of science, Mitchell High School, Mitchell, South Dakota, expressed concern with courses studied prior to the junior and senior years of high school. Rissky stated that too many coaches and "fill-ins" serve as instructors in these courses, resulting in poorly prepared students who later enter college chemistry. Mr. Rissky stated that one possible means of improving chemical education might be for the State Department of Education to devise means by which to enforce a minimum amount of science equipment in order for schools to win accreditation.

James M. Martin, M.S.,¹⁶ instructor of chemistry, Belle Fourche High School, Belle Fourche, South Dakota, listed two major points in his questionnaire response. These were as follows:

1. Require at least an undergraduate major in chemistry for prospective chemistry teachers.
2. Chemistry training should be offered only at those institutions in South Dakota having proper equipment and an adequate teaching staff.

Mr. Martin further expressed, that in his opinion, South Dakota State University, South Dakota School of Mines and Technology, and the University of South Dakota should

¹⁵Roy W. Rissky, Letter to Bernal Kiser, May 11, 1966.

¹⁶James M. Martin, Letter to Bernal Kiser, May 11, 1966.

be the only institutions to award a major in chemistry.

Ralph Cook, B.A.,¹⁷ instructor of chemistry at Brandon Valley High School, Brandon, South Dakota, suggested that the in-service and other institutes offered by institutions of higher learning be taught in a manner practical for teachers of secondary school science. Mr. Cook suggested that one possible means of achieving this might be having the teacher--responsible for teaching the institute--teach one year in an average high school. (Excluding Huron, Watertown, and Sioux Falls High Schools)

Mr. Cook later expressed his feeling that South Dakota is in considerable danger of losing its competently trained instructors. The following illustrates his point:

The new teachers coming out from college will not last, because, if they have anything on the ball, they will not be satisfied with the low salaries paid, and secondly, they can't take the proper disciplinary action to discipline the high school student.

In closing, Mr. Cook made a comment frequently made in the investigator's returns. This comment was as follows:

Last, but not least, chemical education could be improved in South Dakota by seeing to it that when a new school is built, the chemistry teacher gets the say, not some architect who has never taught in a chemistry laboratory.¹⁸

¹⁷Ralph Cook, Letter to Bernal Kiser, May 9, 1966.

¹⁸Ibid.

Harold Schmidt, B.S.,¹⁹ instructor of chemistry at Groton High School, Groton, South Dakota, suggests two means by which he feels chemical education could be improved. These are better facilities and better qualified teachers. In addition, Mr. Schmidt made the following remark:

School administrations must be convinced that they are selling their students short in education and that a course cannot be made effective if it must take second place to any other activity. Scheduling around bus schedules, music, and sports is the greatest single sin in South Dakota education.

David Bergan, B.S.,²⁰ instructor of sciences at White High School, White, South Dakota, lists three features which he feels would advance science education in South Dakota, and specifically the smaller schools. These are as follows:

1. A lack of laboratory facilities. For example, one laboratory table for an entire chemistry class.
2. Too-heavy teacher loads. For example, one teacher having to prepare for biology, history, mathematics plus chemistry.
3. Inadequately trained teachers.

¹⁹Harold Schmidt, Letter to Bernal Kiser, May 11, 1966.

²⁰David Bergan, Letter to Bernal Kiser, May 15, 1966.

Donald E. Kennedy, M.S.,²¹ instructor of chemistry, Rapid City High School, Rapid City, South Dakota, strongly supports requiring those persons teaching chemistry to have at least an undergraduate major in the subject. In addition, Mr. Kennedy commented that South Dakota education might be improved by promoting better coordination between instructors of high school and college chemistry.

E. L. Snyder, M.S.,²² chemistry instructor at Faulkton High School, Faulkton, South Dakota, expressed his opinion in regard to educational improvement as follows:

I would like to see a few meetings at S.D.E.A., or other times, with secondary and college personnel. I would like to know:

1. What are the important topics we should be covering in chemistry class and laboratory?
2. What do most incoming freshman lack in the way of preparation. What are the strong and weak points?
3. A chance to present ideas. I feel I have a few, and I could also use some new ones. A few of these are exchanged in an informal way, but nothing of a formal nature. A question-answer period might be of value.

Guy O. Karnes, M.S.,²³ head of the department of science, Brookings High School, Brookings, South Dakota, commented in regard to improving chemical education in South Dakota as follows:

²¹Donald Kennedy, Letter to Bernal Kiser, May 11, 1966.

²²E. L. Snyder, Letter to Bernal Kiser, May 19, 1966.

²³Guy O. Karnes, Letter to Bernal Kiser, May 23, 1966.

The simple solution would be to put in CHEM Study and require all who teach to take CHEM Study training. Now, I know this cannot be done, but there are several things we can do, as:

1. Raise standards for chemistry instructors.
2. Raise standards for facilities and equipment.
3. Have sufficient supervision from the state department of education to see that schools measure-up to proper standards.

Finally, several other means by which chemical education might be improved, without specific reference to individuals, were given. Among the most frequently tallied from the questionnaires were the following:

1. Lighter teaching loads, allowing chemistry teachers adequate time to prepare for laboratory instruction.
2. Retention of institute enrollees in South Dakota.
3. Two hour laboratory periods.
4. Better science instruction in the junior high schools.

CHAPTER IV
SUMMARY CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

Purpose of The Investigation

This investigation had for its purpose an analysis and evaluation of methods used in chemistry instruction, based upon a survey of teachers in South Dakota and professionals in the field of chemistry. The study was also an inquiry into the possibilities of the Chemical Education Material Study and the Chemical Bond Approach Project.

Procedures Used

The study was based on data which were obtained from the following sources:

1. A review of the literature pertaining to the problem.
2. Questionnaire returns from South Dakota chemistry teachers.
3. Visits to four South Dakota secondary schools.
4. Letters received from prominent chemists throughout the United States.

Problems of The Study

This study was divided into a number of separate problems. These problems, and the results relative to them, will be briefly discussed.

1. Opinions of the experts in the field of chemical education concerning traditional instruction.

This investigation revealed that it is the opinion of the country's leading chemistry teachers that a lack of correlation between science as understood by scientists and science as taught in the secondary schools exists. The highly recognized science educators of the nation seem to feel that too much memorization of data without comprehension of basic principles is detrimental to satisfactory science instruction.

2. Opinions of the experts in the field of chemical education in regard to CHEM Study and CHEM Bond.

The experts appear to agree that both CHEM Study and CHEM Bond approaches are superior to the traditional or descriptive methods of teaching secondary school chemistry.

3. The nature of chemistry programs in South Dakota secondary schools during 1965-1966.

Chemistry programs in South Dakota appear to be predominantly class-room discussion centered. As the investigation revealed, the average amount of time spent in the laboratory per week was 1.64 hours. Teachers

responding to the questionnaire all held degrees; 40 percent held the master's degree, two percent held the Doctor of Medicine degree, and 58 percent the bachelor's degree. Nearly 70 percent of the textbooks used by the respondents had been printed within the last five years. The training of the teachers varied greatly. All teachers had taken first semester college chemistry, yet only 24 percent had taken physical chemistry. Only 12 percent of the total group of teachers held an undergraduate major in chemistry. Thirteen different majors were tabulated for the group. The average percentage of a pupil's grade dependent upon laboratory performance was calculated as 20.7. Only 18 percent of the respondents specified research facilities at their institutions.

4. Factors involved in changing from traditional programs to the new chemistry programs.

Four factors seem to need consideration in instigating either CHEM Study or CHEM Bond into a secondary school chemistry program. These are (1) adapting the physical plant, (2) stocking chemical reagents, (3) procuring proper glassware and hardware, and (4) developing a healthy student philosophy.

5. Improvement of chemical education in South Dakota secondary schools.

This study indicates that chemical educators feel that science education could be improved in South Dakota by raising standards for chemistry teachers, allowing two hour laboratory periods, raising standards for facilities and equipment, and having sufficient supervision from the State Department of Education.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the data presented in this investigation, the following conclusions and recommendations appear warranted:

1. Many teachers of chemistry in South Dakota secondary schools are teaching outside of their major areas.
2. Both Chemical Education Material Study and Chemical Bond Approach Project are superior to traditional methods of teaching high school chemistry.
3. The State Department of Education should establish standards concerning facilities and equipment required for an approved secondary school science curriculum.
4. The Chemical Bond Approach Project does not appear leveled at the average high school student, but at the superior student.
5. Two hour laboratory periods are desirable for modern day chemistry programs.

RECOMMENDATIONS

The investigator has tried to give an account of chemical education as presently existing in South Dakota. This investigation was perhaps somewhat premature, in that the new approaches have not yet become widespread in South Dakota. Because of the newness of CHEM Study and CHEM Bond to South Dakota, time must elapse before anyone can accurately assess their potential usefulness to education. It is this investigator's opinion that study should be made regarding the effectiveness of these new approaches in South Dakota five years or more from the present. Another point of interest which might be investigated is the reactions of the college and university chemistry teachers to the new programs. Such questions as, "How do students, having been exposed to CBA and CHEM Study programs, respond to traditional college chemistry courses?" might be well worth investigation.

SELECTED REFERENCES

1. Anonymous, "The Committee's Purpose," CBA Newsletter, 2:1, April, 1963.
2. Ashmore, P. G., untitled review, Chemistry, 38:1, 1965.
3. Bergan, David, Letter to Bernal Kiser, May 15, 1966.
4. Campbell, J. Arthur, "Chemistry--An Experimental Science," School Review, 70:52-53, Spring, 1962.
5. Cook, Ralph, Letter to Bernal Kiser, May 9, 1966.
6. Fast, Kenneth V., "The Role of Laboratory Experiences in the CHEM Study Program," School Science and Mathematics, 63:155, February, 1963.
7. Geffner, Saul L., Letter to Bernal Kiser, March 8, 1966.
8. Halsted, Alfred A., Interview with Bernal Kiser, June 8, 1966.
9. Karnes, Guy O., Interview with Bernal Kiser, June 8, 1966.
10. Kennedy, Donald, Letter to Bernal Kiser, May 11, 1966.
11. Malm, Lloyd E., Editor, Laboratory Manual for Chemistry--An Experimental Science. San Francisco: W. H. Freeman and Company, 1960, p. v.
12. Martin, James M., Letter to Bernal Kiser, May 11, 1966.
13. Merrill, Richard J., "Chemistry--An Experimental Science," The Science Teacher, 30:31, April, 1963.
14. Montean, John J., and Others, "An Evaluation of CBA Chemistry for High School Students," Science Education, 47:36, February, 1963.

15. Neidig, H. A., and Others, Investigating Chemical Systems. St. Louis: Webster Division, McGraw-Hill Book Company, 1963, p.2.
16. Parry, Robert W., "The New High School Programs in Chemistry," First Conference On Undergraduate Chemistry Curriculum In the North Central States Region, North Dakota State University, 1:23, April, 1966.
17. _____, Letter to Bernal Kiser, April 26, 1966.
18. Pimentel, George C., Editor, Chemistry--An Experimental Science. San Francisco: W. H. Freeman and Company, 1960, p. vii.
19. Risky, Roy W., Letter to Bernal Kiser, May 11, 1966.
20. Roberts, Eugene, Letter to Bernal Kiser, March 10, 1966.
21. Schmidt, Harold, Letter to Bernal Kiser, May 11, 1966.
22. Silber, Robert L., "Resources for improving instruction in chemistry," School Life, 45:16, October, 1962.
23. _____, Letter to Bernal Kiser, March 18, 1966.
24. Snyder, E. L., Letter to Bernal Kiser, May 19, 1966.
25. Taylor, Wendell H., Letter to Bernal Kiser, February 23, 1966.
26. Vitters, Richard, Letter to Bernal Kiser, May 18, 1966.
27. Westmeyer, Paul, "The Chemical Bond Approach to Introductory Chemistry," School Science and Mathematics, 61:321, May, 1961.
28. _____, "Do It Yourself--But Wear Goggles," The Science Teacher, 32:22, September, 1965.

APPENDIX

March 4, 1966

Dear Sir:

I have enclosed a questionnaire, which I sincerely hope you will fill out. I have made the questionnaire such that it can be completed quickly. The questionnaire has two parts. The first part consists of placing a check beside the appropriate entry. The second part has four questions, which I would very much appreciate your answering.

I realize that this is a most difficult time of the year for teachers, and for this reason I have attempted to make the questionnaire as objective as possible. Thank you so much for your cooperation, and best wishes for the coming academic year.

Sincerely yours,

Bernal A. Kiser

1. Please indicate, by a check, which degree you presently hold.

___ B.A. ___ B.S. ___ M.Ed. ___ M.S. ___ M.A.

2. Indicate your undergraduate major. _____

3. Check those courses, listed below, which you have taken.

_____ First Semester General Inorganic Chemistry

_____ Second Semester General Inorganic Chemistry

_____ Qualitative Chemical Analysis

_____ Quantitative Chemical Analysis

_____ Organic Chemistry

_____ Physical Chemistry

List others you have taken: _____

4. Indicate the name, author, and edition, of the textbook presently used in your chemistry classes. If you also use a laboratory workbook, kindly indicate the same.

Textbook:	_____	Lab. Manual	_____
	(name)		(name)
	_____		_____
	(author)		(author)
	_____		_____
	(edition)		(edition)

5. On the average, how many hours, per week, do your students spend in the chemistry laboratory? _____ hour(s)

6. How long do your "scheduled" laboratory periods last? _____

7. What percentage (roughly) of a student's grade depends upon his laboratory performance? _____%

8. How much is your chemistry budget per year? \$ _____

9. How many students are enrolled in your present chemistry program? _____
10. If you were to teach either of the modern approaches below, which would you prefer? _____ Chemical Education
Material Study
_____ Chemical Bond
Approach
11. Explain your answer to question 10.
- _____
- _____
- _____
- _____
12. Which do you consider better describes your present program? _____ Essentially laboratory centered
_____ Essentially classroom discussion centered
13. How many students does your present laboratory comfortably accommodate? _____
14. Does your department possess any research facilities?
_____ Yes _____ No
15. Does your examination material cover laboratory material directly? _____ Yes _____ No
16. Do you feel your present laboratory instruction is too regimented, i.e., "cut and dried?" _____ Yes _____ No

17. Which is most characteristic of your students?

_____ Are "insecure" and "shaken-up" in laboratory

_____ Seem apathetic toward laboratory work

_____ Partake well in, and gain from, the laboratory
work

Directions: Please write a short paragraph on each of the following 4 questions.

1. Do you anticipate changing your chemistry program? If so, please explain.

2. How much explanation do you give your students concerning that which is to be covered in a given laboratory exercise?

3. What factors, if any, do you feel limit the effectiveness of your present laboratory program?

4. How do you feel chemical education in South Dakota could be improved?

Thank you for your time