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Scope of the Report: Various articles have been written dealing with various aspects of the recent trends in chemistry teaching in the secondary school. Committee reports on teacher preparation or the lack of it, new ideas on presentation of the chemistry course, and attempts to provide up-to-date training aids have been written up in science journals, books, and pamphlets. This report has dealt with each of these areas. An attempt is made to provide the interested chemistry teacher one complete report on the recent trends in curriculum development, special courses for advanced or gifted students, recent developments in television and film teaching, teacher improvement programs, and groups or organizations cooperating with the teacher to improve chemistry teaching in the high schools.

The report indicates that an awakening has occurred on the various levels from the individual teacher and citizen to the National Government which has numerous groups working at present in all science areas. Because of this awakening, the future of chemistry teaching in high school is looking brighter.

ADVISOR'S APPROVAL 

RECENTLY DEVELOPED IDEAS AND PROGRAMS FOR THE IMPROVEMENT OF CHEMISTRY TEACHING IN HIGH SCHOOL

by

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for the degree of
Master of Science
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RECENTLY DEVELOPED IDEAS AND PROGRAMS FOR THE

IMPROVEMENT OF CHEMISTRY TEACHING

IN HIGH SCHOOL

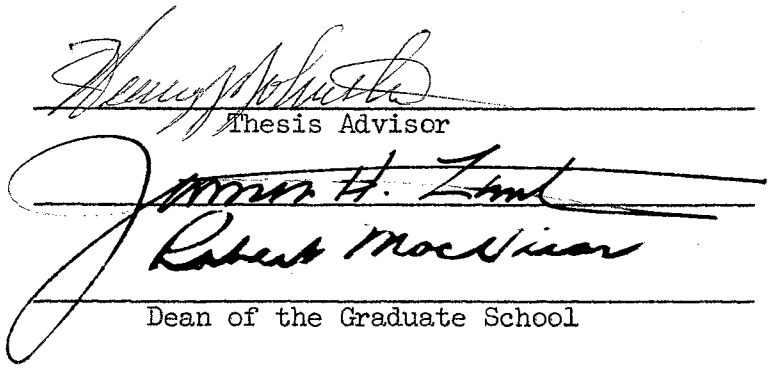

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TABLE OF CONTENTS

Chapter Page

CHAPTER 1

INTRODUCTION

The purpose of this report is to provide an up-to-date survey of the new developments in the area of secondary school chemistry. This includes the basic structure of the course and the materials and methods used in its presentation. The report does not attempt to discuss all of the organizations, ideas, or methods in the particular area discussed, but it does attempt to give a sampling in each area discussed to indicate the basic trends.

The information in this report came from published articles in chemical journals, supplemented with information gained by personal correspondence with teachers, organizations, and institutions where work is being done. Additional information on the topics discussed can be found periodically in the Journal of Chemical Education, the Chemical and Engineering News, and The Science Teacher. These periodicals can be of great value to teachers who wish to keep up with new developments in chemical education. Also, a new book published in 1960 by the National Science Teachers Association entitled Recent Developments in High School Science Teaching is especially good for those interested in programs on the local level.

The information contained in this report can be of tremendous interest and help to teachers of chemistry who usually feel quite isolated and unaware of what is being taught in other areas, whether or

not their program is adequate for those who plan to go to college, and what methods others are using to keep up-to-date with new ideas in chemistry since high school textbooks are almost out of date by the time they reach the market.

Areas Discussed in This Report

There are some definite trends shown in the area of content or structure of the chemistry course. One of the most general trends is that of paring away of descriptive materials with the inclusion of more theoretical material and an increased use of mathematics. To give examples of this, three structurally different courses are outlined and discussed in chapter two. One course discussed is the one suggested by the Oklahoma Curriculum Improvement Commission, another is the "Chemical Bond Approach Course" which attempts to use a central theme or unifying concept throughout, and a third distinct course discussed is based on integration of chemistry and physics into a single course extending over a two year period.

Chapter three of this report discusses some of the methods of presentation that have "evolved", so to speak, in the past few years and at present are being used in many schools throughout the country. As the amount of chemical knowledge increases by leaps and bounds, the teacher finds it increasingly difficult to present this knowledge to the student by ordinary lecture, demonstration, or laboratory methods alone. In fact, the teacher is finding it difficult to keep up himself. To cope with this situation, new types of laboratory experiments have been developed; teaching by television and film have been adopted.

The problem of the teacher of chemistry in secondary schools

mentioned in connection with new methods of presentation, that of keeping up with new chemical knowledge, is the object of discussion in chapter four of this report. This chapter describes briefly a few organizations who are attempting to assist the chemistry teacher. For example, the National Science Foundation with its Institute program is discussed. Also discussed is the trend toward increased standards for teacher certification. This approach to the problem is an attempt to have teachers better prepared before they begin teaching and thereby elininate the need for furthur study to obtain basic knowledge. This allows the teacher to spend whatever time is available to study newly developed chemical knowledge.

Our public schools have in the past and will in the future tend to teach toward the average student. This is, of course, necessary where qualitative and quantitative differences of great degree exist among students in the same class. There have been some attempts to allow for the above average or gifted student in high school chemistry though surely a good deal more effort is needed in this area. Some of the attempts, both on the national and local level, are discussed in chapter five.

Education in general, and in the sciences specifically, has enjoyed a tremendous increase in interest by the national government and industry. It appears that industry has finally realized that it owes something to our educational system--its very existence. And similarly, the national government has realized that the continued existence of our present form of government depends on the education of the people, both for defence from external aggressors and for the understanding and appreciation of a democracy by the people to retard or eliminate decay from within.

CHAPTER II

THE BASIC STRUCTURE OF THE GENERAL CHEMISTRY COURSE

This chapter is designed to define or present the programs of chemistry as they are today by taking a sampling of the programs set up by various groups in the country. The suggestions and syllabuses are for a general introductory course in high school chemistry. Other special courses for advanced or bright students will be discussed later in this report.

Three programs are presented in this chapter under separate headings, each representing a different approach to the general chemistry course.

The Oklahoma Curriculum Improvement Commission Report

The first program selected for discussion is one suggested and outlined by the State Science Committee of the Oklahoma Curriculum Improvement Commission under the direction of Paul R. Taylor.

The O.C.I.C. in a bulletin issued August, 1960, noted some of the general trends in secondary school chemistry and made some suggestions to teachers and administrators of Oklahoma schools in an attempt to bring their instruction into line with these trends. The list of general trends as stated by the committee in their report as deemed desirable by the National Education Association, National Science Teachers Association, and other organizations were:

1. Emphasis on the theoretical subject matter stressing concept development.
2. Fewer descriptive materials are being used.
3. Physical chemistry is the preferred area for continuous stress.
4. Quantitative measurements are being stressed extensively.
5. "Open-end experiments[1] are preferred.
6. The study of nucleonics is on the increase.

The traditional descriptive chemistry is not entirely discarded, but less emphasis is recommended in this area. As was stated in the report:[2]

> The traditional course in descriptive chemistry certainly can not be discarded as inappropriate and many chemists and teachers still believe that emphasis should first be placed on descriptive chemistry prior to the introduction of theoretical chemistry. There is much to be said for this approach; however, the present trend is clearly toward the theoretical with emphasis on chemical structure and early introduction of the mathematical interpretation of chemical phenomena.

The committee does, however, recommend that the descriptive nature of chemistry be used mainly as a tool in helping the learner to understand and appreciate broad and fundemental concepts, not as an end itself.

A preliminary outline of the course in introductory chemistry was

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[1]Open-end experiments refer to the type of experiment that creates a problem solving situation in which the student can use his knowledge of chemistry and his know-how with apparatus to obtain answers to new questions. A group of such experiments have been prepared (31 experiments) by top science teachers in the nation. In performing these experiments, it is felt that the student is called upon to work like a scientist. These experiments were collected and made available by the Manufacturing Chemists Association. By fall of 1959 over half of the schools in the nation had ordered this series of experiments. At present the complete set of experiments is available from Henry Holt and Company.

[2]Improvement of Science Instruction in Oklahoma, The Oklahoma State Department of Education, (Oklahoma City, August, 1960), p. 45.

given by the commission for use in planning the course. It was felt that any satisfactory course in chemistry must include these topics:

A. Scientific Method

B. Nature of Matter and Energy

1. Physical measurement
2. Particle theory (states of matter)
3. Elements, compounds, and mixtures
4. Metals and non-metals
5. Atoms
    a. Atomic structure and valence
    b. Subatomic particles
    c. Atomic weights
    d. Periodic law
6. Molecules
    a. Kinetic molecular theory
    b. Gas laws
    c. Bonding and valence
    d. Mole concept
7. Equations, symbols, formulae, qualitative and quantitative expression.
8. Nomenclature

C. Changes in Matter

1. Physical-Kinetic energy vs intermolecular attraction
2. Chemical-Electron activity and types of chemical reactions
3. Nuclear-Atomic number, radioactivity, isotopes

D. Ions and Ionization

E. Chemical Equilibrium

1. Le Chatliers' principle
2. Law of mass action
3. Reaction rates
4. Equilibrium changes
5. Catalysts

F. Acids, Bases, Salts, Oxides, and Hydroxides

G. Water, Solutions, and Crystallization

H. Chemical Calculations (integrated with various principles throughout the course)

I. Nuclear Chemistry

J. Organic Chemistry (emphasis on hydrocarbons particularly of the petroleum industry)

K. Important Non-metals (families)

L. Important Metals (families)

M. Introduction to Qualitative Analysis

N. Laboratory

1. Introduction, statement of scientific method
2. Introductory laboratory techniques
3. Distinguishing and identifying substances
4. Yield calculations
5. Purification
6. Saftey in the laboratory

The above outline indicates a rather strong turn toward use of more mathematics in the chemistry course, and accordingly, the Commission suggests that that student's mathematical background be strong; however, it was emphasized that use of mathematics should not be an end in

itself, but rather, it should be used as the language to express the "why" of a concept.[3]

The Chemical Bond Approach Chemistry Course

For years groups or individuals have published lists of topics to be covered in a chemistry course with the sequence left to the teacher. This suggests that there is no logical sequence or consistency, yet modern chemistry has developed considerable internal consistency.[4] It is believed by many teachers that due to this internal consistency, the chemistry course should follow a definite sequence and should have a clearly recognizable central theme. A central theme that has been the object of much discussion recently and is considered to be the most logical central theme is "chemical bonds".[5]

A beginning course in general chemistry using the chemical bonds approach is on trial in several high schools and colleges across the country. This approach to chemistry had its origin at a conference held in June, 1957, at Reed College, Portland, Oregon.[6]

Using this approach, chemical reactions are discussed in terms of the initial and final states of the reacting substances. These states

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[3]Ibid, p. 48.

[4]Grant Smith, "Difficult Concepts in Beginning Chemistry", The Science Teacher, XXVll (March, 1960), 15.

[5]Lawrence Strong and M.K. Wilson, "Chemical Bonds:A Central Theme for High School Chemistry", Journal of Chemical Education, XXXV (February, 1958), 56.

[6]"The Reed College Conference on Chemistry Teaching", Journal of Chemical Education, XXXV (February, 1958), 54.

are a result of the forces holding the particles together. Even the color and texture of substances are products of bond linkages and are altered if the bonds are altered.[7] Indeed, the making and breaking of chemical bonds or the ties between the atoms is chemistry.

It is suggested that three general bond types be considered for purposes of simplification. They are ionic or electrovalent bonds, covalent bonds in which the bonding forces result from mutual attraction of two nuclei for a pair of electrons, and metallic bonds in which the bond arises from the mutual attraction of many nuclei for many electrons. These would, of course, represent the extreme types of bonds, and most real bonds would have linkages which might not correspond perfectly to any one bond type.

Initial work on the chemical bonds course began when seventeen chemistry teachers with National Science Foundation support spent six weeks at Reed College during the summer of 1959 writing a new introductory chemistry course with chemical bonds as the central theme. Furthur grants from the National Science Foundation were received for continued production of textual materials and for trial of the program in nine high schools.[9] The project is now centered at Earlham College and is under the direction of Lawrence E. Strong. By the end of the 1959-60 academic year, eighteen chapters of text had been produced. Also, a laboratory manual of twenty experiments had been produced and tested

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[7]Arthur Livermore and Lawrence Strong, "A Writing Conference for the Chemical Bond Approach High School Project", Journal of Chemical Education, XXXVll (April, 1960), 28.

[8]Lawrence Strong and M.K. Wilson, p. 56.

[9]"Report on the CBA Project", Chemistry, XXXlll (February, 1960), 2.

in the laboratory. Reports on the students' using these materials in pilot schools are favorable.[10]

The CBA text material was studied, and the laboratory experiments were carried out by teachers of both high school and college levels during the summer of 1960 in four Institutes sponsored by the National Science Foundation. One-hundred and thirty teachers participated, and many of them tried the chemical bond approach during the 1960-61 school year. Six summer institutes are set up for the summer of 1961, and starting in the fall of 1961, there will be a large number of high schools in this country using the chemical bond approach course.

The following is a general outline proposed for a high school chemistry course based on chemical bonds as the central theme.[11]

A. Introduction

1. Metric system

B. Elements and Atoms

1. Laws of chemical combination
2. Atomic weights and symbols
3. Atomic structure
4. Electrons
5. Electronic forces: coulomb, exchange
6. Atomic numbers
7. Periodic table

C. Chemical Bonds-Discontinuity of Chemical Change

1. Bond types; covalent, ionic, and metallic

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[10]"CBAC Progress Report", Chemistry, XXXIV (September, 1960), 1.

[11]Lawrence Strong and M.K. Wilson, pp. 55-56.

2. Physical properties of substances
3. Gases; gas laws, kinetic molecular theory
4. Liquids
5. Solids; crystals
6. Physical transformations and temperature
    a. Gas to liquid, liquid to solid
    b. Relation of mass to properties
    c. Relation of transformation to bond type
    d. Classification of matter and physical transformations
    e. Purification proceedures
    f. Discontinuities between elements and compounds

D. Chemical Change and Covalent Chemical Bond

1. Reactive systems go to unreactive systems
2. Inert gases
3. Reactivity and structure
4. Study of methane, hydrogen, chlorine, and hydrogen chloride
5. Substitution reactions; formulae, equations, and calculations
6. Study of chloromethanes, oxygen, water, and carbon dioxide
7. Combustion
8. Chemical energy
9. Chemical geometry

E. Chemical Change Involving Metallic and Ionic Bonds

1. Atomic structure of metals
2. Oxidation and reduction
3. Study of chemical and physical properties of sodium chloride, magnesium chloride, potassium chloride, and magnesium oxide
4. Main chemistry of electrolysis

F. Periodic Table

G. Polar Covalent Bonds; hydrogen chloride

H. Properties of Water and its Reactions

I. Acids and Bases

1. Stoichiometry

2. Titration

J. Equilibrium

1. Nitrogen and ammonia system

K. Polyatomic Ions

1. Oxidation of ammonia to yield nitrate

2. Sulfuric acid

L. Bonds Between Like Atoms

1. Carbon chains

2. Multiple bonds

3. Functional groups

In part C, properties should be shown to be a reflection of the bond type; also, in part D, the subject of chemical change is discussed with emphasis on the role played by the various bond types.

The chemical bond course should not be thought of as entirely theory or even the major portion of the course as theory. While the proposed course is developed around a major conceptual scheme, this is used as a way of illuminating a variety of chemical phenomena.[12] With the concept of "chemical bonds" linked with a rich variety of descriptive chemistry, the teacher should be able to show the student the scientific operation

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[12]Lawrence Strong and Arthur Livermore, p. 28.

in as true a perspective as possible.[13] The descriptive chemistry in the course includes carbon chemistry, metals and alloys, acids and bases, and others.

There are some unresolved issues that will require individual consideration by the teacher of the course. Some of these issues are:

1. How should the idea of energy be presented?
2. Should equilibrium constants be introduced as such, or should equilibrium be discussed exclusively on a free energy basis?
3. How should the electron picture be presented first--as particles or as charged clouds?

It is obvious that whether or not the "Chemical Bonds Approach" is accepted by all teachers or even a majority of them, its influence is certain to be felt throughout this country and abroad.

An Integrated Course in Chemistry and Physics-

A Unified Approach

> Hence we must believe that all the sciences are so interconnected that it is much easier to study them all together than to isolate one from all the others. Therefore, if anyone wishes to search out the truth of things in earnest, he should not select any one special science; for all the sciences are conjoined with each other and dependent.
>
> René Descartes

The D. Van Nostrand Company of Princeton, New Jersey, recently published Book One of two volumes written by John C. Hogg, C.L. Bickel, and E.P. Little, entitled PHYSICS AND CHEMISTRY-A UNIFIED APPROACH.[14]

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[13]Lawrence Strong and M.K. Wilson, p. 56.

[14]Material on the unified course obtained by personal correspondence with Stanton Whitney, Vice Pres., School Dept., D. Van Nostrand Co.

The authors of this book believe that the major need for integrating the physics and chemistry course is to take advantage of the underlying unity of the two sciences. As long as they are taught separately, there will be of necessity a good deal of overlapping with a consequent waste of time for the student.

There is no doubt that chemistry leans heavily on physics, and many feel for this reason that physics should precede chemistry; however, physics leans heavily on mathematics. This leaves a problem to be resolved. Should the physics be taken prior to chemistry even though the student does not have the mathematical background for the course, or should the chemistry course come first and an attempt be made to fill in the amount of physics needed? This problem does not arise in the integrated course which lasts over a two year period. Concepts can be developed and expanded as maturity develops and as background is added.[15]

It is realized that there are some topics that are strictly chemistry and others that are strictly physics. It is impossible to completely fuse the two, but in most cases topics can be linked together. A brief discussion of some of the units of the book by Bickel, Little, and Hogg will indicate some of the various degrees of integration possible. Book One is the first year course; Book Two is the second year course.

Book One is weighted on the physics side as a whole to present the concepts needed for an understanding of chemical concepts to follow. Unit One, Book One deals with concepts of energy and electricity. Unit Two,

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[15]Harry F. Lewis and M. Gilbert Burford, "The Wesleyan Conference of 1958", Journal of Chemical Education, XXXVl (February, 1959), 90.

UNIT THREE

1. Pressure in liquids
2. Pressure in gases
3. The kinetic theory and the gas laws
4. Volume calculations in chemical reactions

UNIT FOUR

1. Temperature and expansion
2. Heat, its measurement
3. Heat from electricity
4. Evaporation and vapor pressure
5. The liquification of gases
6. Carbon
7. Carbon dioxide and carbon monoxide
8. Heat energy in chemical reactions

UNIT FIVE

1. Parallel forces
2. Forces acting at a point
3. Velocity and acceleration
4. Newton's laws of motion
5. Momentum and gravitation

UNIT SIX

1. Faraday's laws of electrolysis
2. Rate and extent of chemical reactions
3. Ionization theories
4. Acids and bases
5. Water as an electrolyte
6. Neutralization

7. Electrolysis

8. Voltaic cells

9. Oxidation-reduction

UNIT SEVEN

1. Reflection of light

2. Refraction and speed of light

3. Lenses and optical instruments

4. Color, dispersion, and nature of light

5. The electromagnetic spectrum

6. Waves and their properties

7. Electric and magnetic fields

UNIT EIGHT

1. Mendeleeff's periodic classification

2. Atomic structure

3. The modern periodic classification

UNIT NINE

1. The haolgen family

2. The sulfur family

3. The oxides and the oxy-acids of sulfur

4. The nitrogen family

5. Some compounds of nitrogen

6. Some metals

7. Some chemical industries

8. Colloids

UNIT TEN

1. Energy in atoms

2. Natural radioactivity

3. Transmutation and artificial radioactivity

4. Fission and fusion

UNIT ELEVEN

1. Compounds of carbon and hydrogen

2. Other families of carbon compounds

3. Isomerism

4. Some reactions of organic compounds

Summary

This chapter has presented three quite different approaches to the development of an introductory course in chemistry. It is certainly not assumed that these three represent the only approaches, for there are probably as many different approaches as there are chemistry teachers. However, many, if not most of them, will correspond closely with one of these.

CHAPTER 111

ADVANCED HIGH SCHOOL CHEMISTRY COURSES-

HELP FOR THE MENTALLY GIFTED

One trend in some of the high schools today is that of making provision for the mentally gifted child in the field of science.[1] New chemistry courses for those high school students of greater than average ability far outnumber other new chemistry courses.[2] From a survey of 23 high schools in the eastern United States conducted by a committee of four secondary school chemistry teachers at Pennsylvania State University, 9 had an advanced chemistry course and 5 others planned to initiate one within a year or two.[3]

A comparison of several of the advanced courses uncovers some trends.[4] First, more time (more hours per week or more semesters) is alloted to the course; second, there is a pruning away of descriptive materials; third, there is an increased use of higher mathematics; and fourth, quantitative measurements are stressed and "open-end" experiments[5] are used in the laboratories.

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[1]J.F. Yon and William McIlwaine, "Advanced High School Chemistry", The Science Teacher, (April, 1959), p. 176.

[2]Donald G. Decker, New Developments in High School Science Teaching, (Washington, 1960), p. 64.

[3]Yon and McIlwaine, p. 167.

[4]Donald G. Decker, p. 64.

[5]Scientific Experiments In Chemistry, (Washington, D.C., 1958).

Of course, there are some problems that will arise when an advanced course in chemistry is undertaken by the school. One of the major problems is to find a qualified teacher for the course. Many high school chemistry teachers of today have inadequate preparation even for the elementary course. This is a topic to be developed later in this report. Another problem is that of fitting the course into the school schedule. Some schools have used after-school hours; others have used Saturdays.[6,7]

Most teachers of the advanced courses believed that creative thought and laboratory skills should be emphasized. Some of the topics most often included in the advanced courses beginning with the most frequently included topics are:[8]

1. Ionization and electrochemistry
2. Radioactivity and nuclear chemistry
3. Introductory organic chemistry
4. Oxidation-reduction equations
5. Solution theory
6. Chemical equations
7. Wave mechanics and atomic structure
8. Description of elements
9. Nature of the chemical bond
10. Periodic chart
11. Qualitative analysis
12. Acids, bases, and salts with emphasis on theory

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[6]Donald G. Decker, p. 5.

[7]Personal correspondence with the chemistry teacher of Union High School, Union County, New Jersey.

[8]J.F. Yon and William McIlwaine, p. 177.

13. Mathematics of chemistry
14. Nature and states of matter
15. Colloidal state
16. Gas properties and problems
17. Thermochemistry and radiation
18. Quantitative analysis
19. Kinetic theory
20. Solid state and liquids

The advanced or accelerated courses for the gifted students in chemistry can be divided for the purpose of description into three types: (a.) The advanced placement program courses which are presented as first year courses in some schools and as second year courses in others, (b.) other first year accelerated courses, and (c.) other second year courses.

Advanced Placement Courses

The advanced placement program (APP) grew out of two experiments supported by the fund for the Advancement of Education in the early 1950's. In 1955 the College Entrance Examination Board took over the APP project which now operates through the Boards Committee on Advanced Placement.[9]

The primary objective of the program is to encourage schools and colleges to provide able and ambitious students with work equal to their abilities. At present, there are 560 colleges and universities active in the APP which during the 1959-60 academic year gave credit to 1182

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[9]"Advanced Placement:A Break For The Talented", Chemical and Engineering News, XXXVlll (September 12, 1960), pp. 56-58.

students who had participated in the Advanced Placement Program in 850 secondary schools.[10] There is considerable increase each year in the number taking the Advanced Placement Examination in chemistry.[11] For example, there were 189 in 1956, 269 in 1957, and 478 in 1958 who took the examination. Of these, about 45 percent recieved college credit. The credit given varies from college to college. Some colleges allow the student to take an accelerated college course while others automatically give credit for freshman chemistry. Reports from colleges indicate that APP students do well academically.[12]

The APP sponsors ten subject conferences each year in June to develop communication between colleges and high schools and to improve the courses and examinations. Members of the APP Examiners are present, and high school and college teachers may attend. The chemistry conference for 1960 was held at the University of Illinois and was guided by Dr. John C. Bailor Jr.

Some areas in the country are far ahead of others in this program. In New York State, for example, a bulletin has been published by the Curriculum Bureau of the Secondary Education Division of the New York State Education Department encouraging schools in New York to set up programs pointed toward advanced placement in college.[13]

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[10]Ibid., p. 57.

[11]John R. Valley, "A Report on CEEB Advanced Placement Mathematics and Science Examination Candidates", The Science Teacher, XXVl (October, 1959), 399.

[12]"Advanced Placement: A Break for the Talented", p. 58.

[13]Advanced Placement Program in Chemistry, New York State Education Department Bulletin, (Albany, 1957), p. 7.

Prerequisites for the advanced chemistry course at Thomas Jefferson High School, Richmond, Virginia include one year of chemistry, one year of physics, and three years of mathematics. Two days each week classes begin at eight o'clock instead of nine o'clock to provide two hour laboratory periods. A research chemist designs some of the experiments and periodically presents some of the lectures.

The above examples are typical of many schools offering Advanced Placement Chemistry. Common to most of the courses are longer laboratory periods, quantitative and partially structured experiments, and use of college texts. Students are usually selected on the basis of I.Q. (Midwood High School of Brooklyn, New York requires an I.Q. of 130 or better), scholastic record, and teacher recommendation. Most students in the advanced placement courses take the Advanced Standing Program chemistry examinations. Suggestions for testing, texts, and laboratory manuals are obtainable from the Advanced Placement Chemistry Committee or from neighboring colleges.

The following outline of topics was proposed by the New York State Education Department as basic for the advanced placement course:

UNIT ONE-THE WORK OF THE CHEMIST

a. Historical development

b. Fundemental laws

UNIT TWO-SOLUTIONS AND NEAR SOLUTIONS

a. Percentage, molar, molal, and normal solutions

b. Boiling and freezing point; determination of molecular weights, colligative properties

c. Types of solutions

d. Colloids

e. Dalton's law of partial pressures

f. Debye-Huckel theory

g. Rauolt's law

h. Brownian motion, electrophoresis, emulsions, gels

UNIT THREE-BEHAVIOR OF GASES

a. The gas laws; Boyle's, Charles', and Gay-Lussac's

b. Avogadro's principle

c. Molar volumes

d. Graham's law of diffusion

e. Kinetic molecular theory of gases

f. Equation of state

g. Deviation from ideal behavior of gases

h. Van der Waal's equation

i. Critical temperature

UNIT FOUR-ATOMIC STRUCTURE OF MATTER

a. Dalton's atomic theory

b. Periodic law

c. Theories of atomic structure

d. Electronic configuration

e. Ionic bonding, electrovalence, coodinate covalence, polar bonds

f. Law of Du Long and Pettit

g. Avogadro's number

h. Electronic energy levels

i. Quantum mechanics

j. Dipoles, polar and non-polar molecules

k. Electronegativity

UNIT FIVE-THE LANGUAGE AND MATHEMATICS OF CHEMISTRY

a. Stoichiometry

b. Molecular formulae and weights

c. Moles, atomic weights

d. Determination of atomic weight; equivalent weight

e. Calculation of formulae; percentage composition

f. Calculations involving normality, molarity, and molality

g. Oxidation states

h. Redox equations

i. Heat of reaction

j. Du Long and Pettit, Cannizario, and Avogadro's laws

UNIT SIX-IONIZATION, ACIDS, BASES, AND SALTS.

a. Ionization of water

b. Hydronium ion

c. Acid-base theories

d. Neutralization

e. Polyprotic acids

f. Equilibrium constants; electrolytes; percentage dissociation

g. Buffer solutions

h. pH and pOH

i. Common ion effect

j. Hydrolysis

k. Titration

l. Solubility product

m. Ionization constants

n. Dissociation in water; ionization potential

o. Electrochemistry

UNIT SEVEN-NUCLEAR ENERGY

a. Nuclear structure

b. Fission; fusion

c. Radioactivity; uranium, actinium, and thorium series

d. Artificial radioactivity; transmutation and new elements

e. Packing effect; mass and energy relationships

f. Transuranium elements

UNIT EIGHT-ORGANIC CHEMISTRY

a. The hydrocarbons; saturated and unsaturated series

b. Various organic groups-alcohols, aldehydes, ethers, ketones, esters, and others.

c. Polymers

d. Nature of organic reactions

UNIT NINE-METALS AND METALLURGY

a. Ionization potentials-relate to "activity" concept

b. Complex ions formed by metals

c. Analytical groups formed by metals; identification

d. Regular and transition metals

e. Rare earth metals

f. Alloys

g. Compounds of metals

h. Metallurgical processes

UNIT TEN-PRINCIPLES OF REACTION

a. Equilibrium and stability

b. Kinetics (reaction velocity)

c. Factors affecting the velocity of a reaction

d. Catalysis

Second Year Advanced Courses Not Primarily Designed For Advanced Placement

Most second year chemistry courses are designed to cover topics not covered in the first yesr course, at least, not covered satisfactorily or fully. In some cases the course covers generally the same material but on a much more theoretical and advanced level. Most of these second year courses also stress analytical laboratory work much more than the first year courses.

The following are examples of second year programs to indicate the depth and breadth of the material covered.

The chemistry curriculum at Yuba City Union High School, Yuba City, California is divided into two one-year courses, Chemistry 1 and Chemistry 11. Students who plan to take furthur work in college science are urged to take Chemistry 11 if they made A in Chemistry 1. The Chemistry 11 group meets formally three hours each week after school (buses are held). College texts are used and only grades of A or B are given. If the student cannot achieve this level, he is asked to drop the course. Students are required to begin research projects immediately after beginning the course and may continue in one area of speciality for the entire year or select more than one area for the year.

Tulsa, Oklahoma High Schools offer a second year chemistry course that is made up of two independent semesters, one of organic chemistry and one of advanced inorganic chemistry.

A one-semester course beyond the first year course is offered at Wauwatosa, Wisconson High School which is designed to study in depth a limited number of units: application of the second quantum number to

chemical bonding, practice in qualitative analysis, and advanced problems in chemistry.

Stuyvesant High School in New York City offers a one-year chemistry elective in qualitative analysis. General chemistry is a prerequisite.

Hillsborough County Public School at Tampa, Florida presents a second year chemistry course called "Theoretical-Analytical Chemistry". This course is conducted on a highly theoretical level, discussing such topics as the quantum theory, anti-matter, the phase rule, thermochemistry, and complex redox equations.

First Year Advanced Courses Not Primarily Designed For Advanced Placement

Most one year courses not designed specifically for advanced placement in college are for the accelerated groups that can go faster and deeper into the general chemistry course than the average student is able to do. In many cases, the basis for selection is on previous work in mathematics and interest in chemistry.

A sampling of first year advanced or accelerated courses is given below.

An advanced chemistry course called Science 10-D is taught at St. Paul, Minnesota schools and covers the following broad topics: Theoretical chemistry, organic chemistry, inorganic chemistry, and nuclear chemistry. The unit on theoretical chemistry is twelve weeks in length, the inorganic unit is twelve weeks, the organic unit is six weeks in length, and the unit on nuclear chemistry lasts two weeks.

"Chemistry AX," a course taught at the Pleasant Hill, California High School, is a mathematics-centered accelerated chemistry course.

The students selected for this course must show both interest and ability to handle the physical and mathematical aspects of chemistry. Students lacking either of these are placed in another chemistry course.

Union High School of Union, New Jersey offers two chemistry courses in addition to its regular general chemistry. One is composed of a group of accelerated mathematics students who have been block scheduled since the ninth grade and have also taken physics together. Each student is required to do research on a topic of his choice, subject to the instructors approval, and then submit a formal report. The second course is an accelerated course that runs concurrently with the regular course but topics are covered in much greater depth. These classes are conducted on Saturdays to a select few.

As was mentioned previously, certain sections of the country are much ahead of others in offerings of advanced courses in chemistry. It should be remembered by those contemplating beginning an advanced course that many administrative problems must be solved in advance and the actual need for the course should be established. In the northeastern United States, almost 100 percent of the schools offer general chemistry whereas the figure is only about 45 percent for the southwest.[15]

It was suggested by the Oklahoma Curriculum Study Commission that advanced courses should not be contemplated until basic courses were available and perhaps also advanced courses in mathematics.[16] This

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[15] Offerings and Enrollments in Science and Mathematics in Public Schools, United States Department of Health, Education, and Welfare Bulletin No. 120, (Washington, 1956), p. 16.

[16] Improvement of Science Instruction in Oklahoma, The Oklahoma State Department of Education, (Oklahoma City, August, 1960), p. 49.

appears to be sound advice when one examines studies such as the survey by Kent State University, Kent, Ohio, which shows that the grades made by freshmen in college chemistry are very similar to their score on cooperative mathematics tests.[16] As indicated by the advanced chemistry courses examined, the trend is toward use of more and higher mathematics in chemistry.

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[16] Mathematics and Science Before College, Kent State University Bulletin, (Kent, February, 1958).

CHAPTER lV

SOME RECENTLY DEVELOPED METHODS OF PRESENTATION

As we live and teach in an age of science, it seems fitting that science should develop an instrument which can do a more effective job of science instruction. Of all subjects treated by television, science seems most rewarding and has proved to be the best adapted.[1] Of course, there are other methods of science instruction that are just as potent as television; for example, filmed courses of instruction or special short films designed to discuss a particular topic.

Another idea that is by no means new, but is in use now in many high schools and could expand tremendously in the next few years, is the semi-micro program. These have apparent advantages that will focus attention on them as time passes.

A program that is almost certain to take deeper roots in the next few years is the "Seminar" program. This makes use of the scientists located in a particular area in a rather unique way. It allows them to present technical information to a select group of high school students during evening hours or week-ends at the request of the students themselves. This is an outgrowth of the science clubs.

Each of these methods will be discussed in this chapter.

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[1]John H. Grate, Television in the Classroom", Science Education, XXXXlV, (March, 1960), p. 84.

Television Instruction

It might be of interest to examine briefly the historical development of the use of television as a medium of instruction. First, a long step back to the year of 1938 finds 250 students of New York University viewing television recievers and having questions relayed to the instructor to be answered.[2] This was the first time television was used as a medium of instruction.

In 1952, the Federal Communication Commission reserved 242 television channels for education. This was an act similar in scope and forethought to the Morrill Act of 1859 establishing land grant colleges.[3]

The first full time educational channel was KUHT of the University of Houston which began May 25, 1953.[4] Now teaching science by television is currently coming into use all over the country. Legislatures of many states have passed legislation dealing with educational television. In general, these were to make funds available for their operation.

Closed circuit television instruction is used by colleges and schools throughout the country. Even the armed forces are using this medium for instruction. There are now over 200 closed circuits in operation.[5]

Some look at television as a solution to the teacher shortage, others as an opportunity to upgrade teacher skills. However, it is the opinion of most educators that television is merely another teaching

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[2]Leon Fletcher, Televisions New Engagement, (San Francisco, 1958), p. 5.

[3]Four Years of Progess in Educational Television, Joint Council on Educational Television Bulletin, (Washington, 1956), p. 1.

[4]Leon Fletcher, p. 5.

[5]Ibid.

aid. It can not replace a good teacher, but it can enrich and elevate our science program. The teacher must become a member, a willing member, if it is to be effective.[6]

Various experiments and studies are in progress at the present to explore the uses and problems of educational television. One such experiment is being engaged in presently by the Cincinnatti Public Schools to determine the best role for television in the classroom.[7] Another such program is being carried on by the National Science Foundation.[8]

It might be informative to examine closer one of the individual state programs, that of Oklahoma.

The first educational television broadcasting venture in Oklahoma was in the summer of 1956 by the Oklahoma City Public Schools from their studio and transmitted by state owned equiptment over channel 13. Out of this experience came financial aid from the Frontiers of Science Foundation of Oklahoma. In October of 1956, twelve schools and 57 pupils participated. In the summer of 1957 the Ford Foundation Fund for the Advancement of Education made funds available for continued operation until July, 1961. There are now three educational channels in operation in Oklahoma. These are KETA-TV, channel 13 in Oklahoma City; KOED-TV, Channel 11 in Tulsa; and a closed circuit KOKH-TV, channel 25 in Oklahoma City.

At present there are 128 students from 20 different high schools enrolled for credit in high school chemistry by television. This does

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[6]Improvement of Science Instruction in Oklahoma, The Oklahoma State Department of Education, (Oklahoma City, August, 1960), p. 87.

[7]John H. Grate, p. 85.

[8]Education in the Sciences, National Science Foundation Bulletin, (Washington, March, 1959).

not appear to be a very large number, but one must consider the fact that these students from 20 schools would not otherwise have an opportunity to take high school chemistry since most of the schools are quite small and do not have either facilities or an instructor for the course.[9]

Now, a brief look at a program on the national level, that of Continental Classroom of Learning Resources Institute.

Continental Classroom emerged as a partial solution to a national problem. When the Russians, by placing a satallite into orbit, shocked the United States out of its complacency, an examination of the science teaching revealed some disquieting facts. Most of the teachers were not prepared to teach the kind of physics and chemistry that would even give their students an understanding of what was taking place, not to mention the fact that these students are the ones who are to expand our national defences and technical know-how and must have a very thorough basic knowledge of science to do this.

The problem was handed to John J. Kelly to set up a course in modern physics for the fall of 1958. Dr. Harvey White, Professor of Physics, University of California was chosen as the man to be the first national television instructor because he was known as a scholar and a master teacher. Of this first course, researchers found that approximately 300,000 people viewed Dr. Whites' lectures, 28000 purchased lesson synopses in the first semester, 5000 teachers and others enrolled for credit in the 250 participating colleges. The second offering, a course in

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[9]Information concerning Oklahoma Educational Television was obtained through personal correspondence with Mr. E.F. Bryan, Director of Television Instruction in Oklahoma.

"Modern Chemistry" was offered and was viewed daily by 440,000 people from 6:30 to 7:00 am daily, September 28, 1959 through May 27, 1960. The Instructor for this course was Dr. John F. Baxter, Professor of Chemistry, University of Florida. One of the things that was perplexing to the Continental Classroom sponsors was that less than ten percent of the viewers enrolled for credit.

At present, courses in mathematics are being offered, and such courses as Economics, Biology, the Humanities, and a course in Non-western Culture are being considered.

A distinct advantage of a program of this type is that most colleges do not offer courses for two or three individuals, but over the nation, a few individuals from each college make up a rather large class. For example, there are 5000 college level students taking the course in mathematics for credit from 300 colleges. Many of these are teaching while taking the course.

The total cost of each program is about $6950 or about 2 1/2 cents a day per viewer. This leads many to believe that network television can make education less expensive. Of course, there are some problems such as the loss of intimacy between teacher and student which is believed to lower the efficiency of the teaching situation.

Another problem is that of financing. Private industry has played a large part thus far, but sooner or later other agencies both government and private must join in. Another major obstacle to be overcome before a really effective national program is accomplished is the availability of network time. Commercial systems can be expected to go only so far.

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[10]Information on Continental Classroom supplied by J. J. Kelly, National Coordinator.

Use of Films in Teaching

Another method of instruction that has come into its own in the past few years is the use of film in teaching, especially the use of an entire filmed course as the one produced by Dr. John F. Baxter, Professor of Chemistry, Florida University. It is at present being distributed by Encyclopaedia Britannica Films. This course is a series of 160 films of 30 minutes length. It was first used during the 1958-59 school year.

The course was originally designed for schools where a teacher with inadequate training was handling chemistry. However, Dr. Baxter now believes it has found its best use in the hands of an experienced teacher and for teacher training programs.[11]

The American Chemical Society Advisory Committee on the Filming of a Course in High School Chemistry worked closely with Dr. Baxter on the project. The Committee was created especially to help plan the filmed chemistry course.[12] The filmed course was financed mainly by the Ford Foundation for the Advancement of Education and cost one-half million dollars. It can be purchased by schools for $12,500 in black add white or for $25,000 in color.

The production of this film had a fourfold purpose:[13]

1. To permit high school chemistry to be taught by inadequately trained chemistry instructors.

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[11]Information obtained by personal correspondence with Dr. Baxter.

[12]"Chemistry Film Shooting Starts", Chemical and Engineering News, XXXV, (November 18, 1958), p. 120.

[13]"High School Chemistry on Film", Chemical and Engineering News, XXXV, (November 18, 1957), p. 88.

2. Aid science teachers who carry heavy teaching loads in other fields.
3. Permit teachers in training to watch a top instructor and view expertly directed laboratory demonstrations.
4. Enable adults now in industry to get a basic training in chemistry which they missed in high school.

Some of the advantages of filmed instruction can be noted. First, time puts a limit on the human eye, but the camera can stretch time out or compress it to show chemical phenomena that can not otherwise be shown. Second, as stated by Dr. Baxter, many of the demonstrations shown on film required 20 to 30 man hours of preparation to produce an experiment that occupies three or four minutes of film time. No teacher could afford this kind of preparation time. Dr. Baxter also stated, "I believe wholeheartedly in teaching from the experiment, but in my own classroom, I have never been able to perform even a fraction of the number of experiments or demonstrations we were able to put on film". Third, ions and molecules have never been seen, but by animation techniques they can be seen graphically, at least what the chemist thinks they look like.

Use of this filmed series for teacher education will be discussed in another chapter of this report.

Another type of filmed instruction that is presently being used is the short (15 to 30 minutes) films presenting experiments whose principles can not effectively or safely be taught in high schools. Many of these can be obtained from college film libraries at a nominal cost, and others are available from industry. For example, the Manufacturing Chemists' Association has produced four films already for use by public schools. They are at present working on two others. The names of these films are: 1. Combustion 2. Chlorine-A Representative Halogen 3.

Oxidation-Reduction 4. Chemistry of Water 5. Sodium 6. Nitric Acid.[14]

Films produced by the MCA are viewed by experts so that they can be edited and be free of error. This is typical of other industrial films produced. For this reason and others, these short films are a valuable source of up-to-date and well presented information in the field of chemistry.

Semi-micro Chemistry

It has already been stated that semi-micro chemistry is not a new idea since it has been used for several years in some high schools and colleges. It has not been very widely used, however, and might be considered as only developing now. At some time in the near future, it could be used extensively, especially in qualitative analysis and even organic chemistry courses.

There are apparent advantages, such as smaller quantities of reagents used, less storage space required, greater saftey, and greater precision in techniques.[15] There are some advantages that are not as apparent, but nevertheless real, such as better class organization and control (since the student can work seated at desks and work individually), less time is required of the teacher in preparing apparatus for the laboratory and in putting it away after class.

In a report on the use of semi-micro laboratory techniques by W. L. Hubbard of Tampa, Florida, Florida Public Schools, the student in the semi

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[14] Report to the Board of Directors on the MCA Aid to Education Program, Education Advisory Committee Report, (Washington, 1960), p. 10.

[15] John T. Stock, "Expansion of High School Chemistry", The Science Teacher, XXVl (April, 1959), p. 168.

micro course appeared to take more pride in his work and in the care of his equiptment than students in the same school using macro-techniques. The micro-chemistry class averaged twenty percent higher gradewise than the macro-chemistry group.[16]

Seminars

For the past ten years, science seminars have been replacing science clubs. The seminar is a means of breaking down the boundary lines among the sciences and is a means of providing students with contacts with scientists whth whom they can discuss questions about careers in science.[17]

A plan that has recieved wide adoption across the country is the Berg plan for science seminars. In general, scientists from community industries serve as dollar-a-year science teachers that bring students and scientists together usually one evening a week. The Joe Berg Foundation with offices in Chicago provides plans for bringing together students and scientists.

Some examples from specific high schools and their programs will provide a better idea of the seminar program.

A seminar at Nicolet High School, Milwaukee, Wisconson is encouraging able and interested students to pursue projects of their own choice. Once each month at "Science Forum" an industrial scientist will lecture on his particular field.

A chemistry seminar at New Trier Township, Illinois High School is designed to help prepare students for advanced placement examinations. Chemistry and advanced mathematics are required for participation in

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[17]Donald G. Decker, New Developments in High School Science Teaching, (Washington, 1960), p. 72.

this course which meets once each week. Work is done whenever the student finds time, even during vacation.

Seminars provide credit toward graduation in some schools; in others they do not. To be of value, the seminar must be designed to serve a given situation and need of a community or school.

Summary

It might be noted that in all four methods of presentation discussed in this chapter, each was designed as an aid to the teacher who in this age of rapidly advancing knowledge can not, and usually is not expected to, keep abreast of all developments in all areas. This in itself is quite a break from the past when teachers were supposed to know all in their teaching field.

It can be noted that there is an active interest in the industrial field, especially in the chemical industry in the schools. This is shown in their willingness to provide funds for such projects as the Continental Classroom program, the production of useful short films to be used by the teacher, and various committees whose job is to find ways to provide more up-to-date teaching aids and to give encouragement to teachers who are doing a good job by giving recognition to them. It has been realized that the high school chemistry teacher can not be a specialist in all areas of chemistry.

CHAPTER V

IDEAS AND PROGRAMS DESIGNED TO IMPROVE THE TEACHER

We are living in an era without precedent in the history of chemistry education, one in which as a matter of course, some mechanism for helping the well trained teacher keep up with developments in the field of chemistry must be provided.[1]

Many organizations have recognized the importance of helping the chemistry teacher and have instituted various types of programs to help them. Some of the programs have been sponsored by industry, others by government agencies, and still others by local school systems.

One of the first organizations to help the high school teachers was the Manufacturing Chemists' Association which is now in the fourth year of its program of developing "Aids To Education Materials". A description of these materials can be found in a recent pamphlet "An Industry Aids Our Schools," a 1960 report of the program of the chemical industry.

Another organization to help was the Crown-Zellerbach Foundation which provided funds for bringing together a group of high school and college chemistry teachers to study the problem of chemistry instruction in high schools. As a result, the National Science Foundation is supporting both the preparation of a new textbook for high school students and the training of teachers to use this book.

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[1]Arthur F. Scott, "Retreading the Chemistry Teacher", Journal of Chemical Education, XXXVll, (September, 1960), p. 442.

The organization that has done the most of the retreading is the National Science Foundation. The Foundation began Summer Institutes as long ago as 1953 and now sponsors a large number of Institutes and conferences designed to help the chemistry teacher.[2] The National Science Foundation and other programs will be discussed individually in this report.

National Science Foundation Programs

The National Science Foundation was established in 1950 by Public Law 507, Eighty-first Congress. It is an independent agency of the Federal Government and is concerned primarily with the support of basic research, training, and education in the sciences. It is also concerned with interchange and desimination of scientific information.[3] We will consider only a few of the many programs, namely those dealing primarily and directly with the improvement of the high school teacher of science.

There are seven different fellowship programs offered by the National Science Foundation, one of the seven designed especially for the secondary school teachers. This program began during the summer of 1959 and was designed to supplement the Summer Institute programs discussed later in this report. Applications presented by the applicant must contain appropriate plans of study and evidence that they can be carried out at the proposed institution. Tenures can be as short as one summer session or as long as three sessions. Stipends and allowances

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[2]Ibid.

[3]N.S.F. Programs for Education in Science, U. S. Government Bulletin, (Washington, March, 1959), p. 29.

are paid to the individual; tuition and fees are also paid by the Foundation.

Another very important teacher improvement program of the N. S. F. is the Institute Program. Three types of Institute programs are in operation at present for secondary school teachers. They are the Summer Institutes, the Academic Year Institutes, and In-service Institutes.

The Summer Institutes have been presented annually since the Summer of 1954 for high school teachers beginning with one that year and increasing to 395 in 1961. One hundred and thirty of the 1961 institutes include chemistry.[4] The number of participants average fifty and the average duration of the institutes is seven weeks. Graduate credit is usually available for those completing the work. Teachers apply directly to the institute they wish to attend.

In 1956 the Academic Year Institutes Program started with two institutes, one at Oklahoma A and M College (now Oklahoma State University) and one at the University of Wisconson.[5] The number had increased to forty-three for the 1961-62 academic year, with twenty-seven of these offering study in chemistry. The program is generally designed to allow participants to earn a graduate degree such as the Masters of Science in Science Education. In-service Institutes are specifically designed to meet the needs of high school teachers for supplemental instruction through courses offered on Saturdays of after school hours. There were 85 such

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[4]"Details on Summer Institutes for Chemistry Teachers", Chemical and Engineering News, XXXIX, (January 16, 1961), p. 48.

[5]Alan T. Waterman, "N.S.F.- A Ten Year Resume", Science, CXXXI, (May 6, 1960), p. 1348.

programs in effect during the 1958-59 academic year. No stipends are given to participants of In-service Institutes; however, funds are available for costs of tuition, fees, and limited travel. This program began in 1957.

Additional information on these programs and others can be obtained by writing to The Institutes Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

State Program in New Jersey

A program to improve the science instruction in New Jersey was begun as a result of a survey showing that many science teachers did not possess a Master of Science degree. This program sponsored by the State Education Department and the Dreyfus Foundation provided funds directly to teachers to attend classes in chemistry.[6]

Local Program in San Francisco, California

In San Francisco, California, the public schools held evening sessions to bring teachers up-to-date on such topics as trans-uranium elements, ionization theories, covalent bonds, combustion, thermodynamics, and other topics. The Board of Education of the city provided funds to pay for qualified lecturers.

Other Programs and Ideas

There are other programs such as the ones mentioned above, esp-

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[6]Fred T. Pregger, "A Poogram for the Improvement of Science Teaching in N.J. Public Schools", Science Education, XXXlV, (October, 1960), pp. 262-267.

ecially many different local programs being planned or are now in the process of being carried out. One such program, if it may be called that, was suggested by the Oklahoma Curriculum Improvement Commission. The Committee suggested that the extra curricular load for science teachers be cut to allow for more intensive class preparation.[7] It also suggested that teachers be granted paid sabbatical leaves if they intend to devote them to furthur study. It furthur suggested that summer study be subsidized.

A similar suggestion was made by Arthur Scott in an article "Retreading the Chemistry Teacher", in which he stated that teachers of chemistry must either be given a lighter load in order to be able to study on his own during the school year, or be granted regular leaves of absence during the school year. The Summer Institutes and evening classes, he felt, did not appear to be a permanent solution.[8]

Along with the formal programs of teacher improvement, there also appears some informal programs designed to improve the teacher both in the area of knowledge and method of presentation. One such program is the "Continental Classroom" program that allows the teacher to remain at home and be exposed to some of the recent discoveries in the field of chemistry and at the same time observe a master teacher's techniques.

Another informal program in use is the use of the Baxter Film Series for local in-service programs, especially when the film series is

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[7] Improvement of Science Instruction in Oklahoma, The Oklahoma State Department of Education, (Oklahoma City, August, 1960), p. 7.

[8] Arthur F. Scott, p.442.

to be used by the school.

The use of the Baxter Film Series for such an in-service program was the object of an experiment sponsored by the Camille and Henry Drefus Foundation of New York.[9] Eighteen high school chemistry teachers were selected for the experiment and met Tuesday evenings from 7 to 9:30. Films were shown to the group and discussion of the film and its use followed each film. Some of the findings of the group were:

1. A course of chemistry films can be used by inexperienced teachers to gain the type of experience which can otherwise be gained only after many years of actual classroom teaching.

2. Films enable the experienced teachers to become acquainted with the latest advances in science.

3. Films enable experienced teachers to become acquainted with the newest scientific instrumentation and facilities.

4. Films can be viewed repeatedly to assure the mastery of organization, presentation, methodology, and techniques.

With the small sampling of teacher improvement programs shown here, it can be seen that programs can and do range from the individual to the national level.

Teacher Certification

Parallel with the attempt to up-date and expand the knowledge of the teacher is a trend throughout the country to raise certification require-

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[9]Samuel Schenburg, An Experiment in the Use of Films for Instruction of High School Chemistry Teachers, Board of Education of the City of New York, (New York, July, 1960).

ments. At the present time, thirty-three states are making a study of their certification requirements generally tending to up-grade them.[10,11]

Actually, teachers are better prepared in the area of chemistry than in other areas of science, but the U.S. Office of Education seriously questions the value of their training since much of it was taken before 1950. In the schools of Maryland, Virginia, and New Jersey, science teachers reported an average of 17.4 semester hours of chemistry.[12]

Since the teacher training programs are greatly influenced by the certification requirements, these requirements should be examined and revised periodically to maintain the level of teacher preparation desirable.[13]

The New york State Education Department in effect doubled the certification requirements for teachers of science following a two year study by a 42 member advisory group appointed by the Commissioner of Education. Effective September, 1963, the following requirements as shown in the table must be met to be certified to teach chemistry.[14] The old requirements are shown for comparison. There is no comparison made for the professional education requirements since no increase was made in this area.

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[10]"New York Raises High School Teachers Standards", Chemical and Engineering News, LXV1, (September, 1960), p. 40.

[11]"Schools Reorient Courses Around the Three R's", Chemical and Engineering News, XXX1X, (January 2, 1961), p. 40.

[12]"High School Science Teachers: A Bit Rusty", Chemical and Engineering News, XXXV111, (May 2, 1960), p. 38.

[13]Oklahoma Curriculum Commission Report, p. 89.

[14]New York Raises High School Teachers Standards, p. 66.

	OLD REQUIREMENTS		NEW REQUIREMENTS	
CERTIFICATE	PROVISIONAL	PERMANENT	PROVISIONAL	PERMANENT
CHEMISTRY	12	12	16	22
PHYSICS	3	6	8	11
BIOLOGY	3	6	6	6
EARTH SCIENCE	3	3	6	9
MATHEMATICS	0	3	6	9
TOTAL HOURS	21	30	42	57

Along this same line of thought, the Oklahoma Curriculum Commission made a suggestion that is interesting. It recommended that holders of specialized science certificates such as the areas of chemistry, physics, and biology should be required to have a Masters Degree before recieving standard teaching certificates.[15]

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[15]Oklahoma Curriculum Improvement Commission Report, p. 89.

CHAPTER VI

GROUPS AND ORGANIZATIONS THAT ARE HELPING TO IMPROVE HIGH SCHOOL CHEMISTRY TEACHING

There are many organizations throughout the country whose job or ambition is to improve the facilities for science teaching in high school, or to provide the student with such materials or personal contacts that would not otherwise be available. A very few representatives of this group will be discussed in this chapter. Most of those discussed are concerned with several science areas, but their support in the area of chemistry teaching will be of primary concern in this report.

One of the best known and largest organization or agency is the National Science Foundation which has already been discussed in connection with teacher training. The functions of the National Science Foundation are so many and varied that this report can not discuss the entire program but certain programs connected with or supported by the National Science Foundation will be discussed.

The Traveling High School Science Library Program

The Traveling Science Library Program[1] now in its seventh year is administered by the American Association for the Advancement of Science

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[1]Hilary J. Deason, The Traveling High School Science Library, (Washington, 1959), pp. 1-5.

at the request of the National Science Foundation which provides an annual grant for its support.[2]

The Traveling Science Library Program began in 1955-1956 academic year with a collection of 150 books which were loaned to 66 senior high schools. The collection was enlarged to 200 the following year and was circulated to 200 schools. By the 1959-1960 academic year, about 1700 senior high and preparatory schools participated.

The program came into being due to a shortage of science books, particularly up-to-date science books in most high school libraries. It can be used to supplement existing libraries and is particularly useful for science programs where reports on special areas are required. The books, however, were chosen primarily for the academically talented student in high school who has interest and initiative to go beyond routine textbook assignments.

The traveling library of 200 books is divided into eight units of 25 books each and is placed in a traveling case that is also useable as a display case. The general plan of operation is to send each program school 50 books to be used for two months. An exchange is made with other schools until all 200 books are used by the program school.

Only twelve books in the collection are labeled specifically as chemistry but many others are very closely related areas such as physics, medicine, history of science, biochemistry, metallurgy, and atomic science.

The American Association for the Advancement of Science has also

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[2]Note: The American Association for the Advancement of Science, (AAAS), organized in 1848 is the oldest general national scientific organization on this continent. It has given rise to many specialized scientific societies in the United States.

compiled a list of 800 titles of science books recommended by scientists, librarians, and educators that can be used as a guide for those desiring to build an adequate science book collection and make use of the assistance provided by the United States Education Act of 1958.

The Traveling Science Demonstration Lecture Program

The Traveling Science Demonstration Lecture Program is sponsored by the National Science Foundation in cooperation with the United States Atomic Energy Commission and is conducted by the University Relations Division, Oak Ridge Institute of Nuclear Studies (ORINS), Oak Ridge, Tennessee.

The program was begun in 1956 to help solve the problem of finding a new and effective means of improving the quality of high school science teaching in the United States. As a solution to the problem, seven outstanding teachers were selected, given an intensive summers training period at Oak Ridge and visited schools throughout the nation giving lectures to science classes, confering with teachers and administrators, and generally improving the quality of science education in any way they could. The program enlarged to ten teachers in 1957-58 and to nineteen in 1958-59 school years.

In 1958-59 academic year the program changed somewhat. Seven teachers traveled at large throughout the country while the other twelve were sponsored by individual states and remained in their borders. These nineteen teachers visited more than 500 schools. The program expanded with additional training centers at Oklahoma State University, Michigan State University, and the University of Oregon accommodating 20 teachers each in 1959. The Oak Ridge Institute of Nuclear Studies also trained

29 teachers that year, part for travelors at large and part to be sponsored by individual states.

The program is expanding in several directions and increasing in scope and size. One of the new features of the program is the inclusion of locally sponsored teachers that will be trained and returned to the sponsoring system. The teacher will be supported financially for the 13 weeks training period by N.S.F. and provided with a $1000 demonstration kit. He will then be sponsored by the local system.

The lecture demonstration program is one week in length at each school. Some of the demonstration lecture topics that would be of particular interest to the chemistry teacher are: (a) Atomic Structure (b) Nuclear Phenomena (c) Structural Chemistry and Chemical Change (d) Molecules and Motion (e) Chemical Kinetics: Rates of Reaction (f) Electricity and Chemistry.

Furthur information concerning the Traveling Science Teacher Program can be obtained by writing to: W. W. Grigorieff, Chairman, University Relations Division, ORINS, Oak Ridge Tennessee.

The M. C. A. Aid to Education Program

In 1956 the Manufacturing Chemists' Association approved a five year aid to education program to be executed in behalf of the entire chemical industry and supported voluntarily by member firms. The goals of the program as set forth by the Education Advisory Committee were:

1. To make the study of technical subjects as interesting as possible.

2. To make the most effective contribution to raising the standards of chemistry teaching in American schools and colleges, principally

through developing new types of materials.

3. To enhance the dignity and standing with the public of science teachers at all levels.[3]

Some of the projects that have already been accomplished are: (a). the production of a booklet on chemistry for the elementary student, (b). teacher awards for outstanding college chemistry teachers, (c). a series of senior high school chemistry films that present difficult, dangerous, or expensive experiments-others are being produced at the present time, (d). senior high school experiments program-31 "open-end" experiments are now available from Henry Holt and Company with 8 more at present being prepared, (e). cooperation with other organizations such as the American Chemical Society and the National Science Foundation in supplying materials to summer institute programs, (f). participation in the N.S.F. sponsored chemical Education Materials Study Committee headed by Dr. Glenn T. Seaborgaat Berkley, California.

It is probable that the Aid to Education Program of the M.C.A. will continue and become a permanent committee. The Education Advisory Committee of M.C.A. feels it can best serve by producing new and better materials for teaching and then turn them over to commercial publishers and distributors. This they have done with the "open-end" experiments and the film series. This allows more of the budget to be used for research and development.

Frontiers of Science Foundation of Oklahoma Inc.

The Frontiers of Science Foundation of Oklahoma Inc., established

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[3]David Morgan, A Sound Investment Pays Off, Education Advisory Committee Report, (Washington, June, 1960), p. 1.

on October 1, 1955, is a non-profit corporation made up of Oklahoma leaders in business, education, and government. It has as its purpose the promotion of a broader educational background throughout Oklahoma in the field of science and technology. This has been accomplished in a variety of ways. A few examples of the programs sponsored by the corporation are: (a). Exhibits such as the "Atoms for Peace" exhibit in 1956, (b). Research grants to individuals and institutions in Oklahoma, (c). Sponsorship of educational television in Oklahoma, and (d). Symposiums such as "I.G.Y. Report to the American Youth", and "Origins of Life" which were heard by thousands of Oklahoma youth.

The Frontiers of Science Foundation has brought to Oklahoma many outstanding scientists and educators to speak to thousands of Oklahoma students and teachers.

The Chemical Education Material Study

The Chemical Education Material Study Group[4] is a project that grew out of a study committee set up in 1959 by the American Chemical Society under the chairmanship of Professor A. B. Garrett of Ohio State University. The American Chemical Society examined the purposes and content of high school chemistry with the view of producing a drastically improved course. Following the receipt of the recommendations from the American Chemical Society Committee, the University of California at Berkley submitted a proposal to the National Science Foundation to make a broader study of the problem. The National Science Foundation

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[4]Glenn T. Seaborg, "The Chemical Education Materials Study", CHEMS Newsletter, 1, (November, 1960), p. 1.

supported the proposal and set up a second study center at Harvey Mudd College at Claremont, California, under the direction of J.A. Campbell.

Dr. Glenn T. Seaborg of the University of California (now chairman of the Atomic Energy Commission) was selected as chairman of the Steering Committee which had its first meeting on January 9, 1960. The general objectives of the study were outlined in this first meeting. They included the development of new teaching materials for high school chemistry course including a textbook, laboratory experiments and a laboratory manual, films, and supplementary reading material.

Some specific objectives of the study were: (1). to diminish the current separation between scientists and teachers in the understanding of science, (2). to stimulate and prepare those high school students whose purpose it is to continue the study of chemistry in college as a profession, (3). to encourage teachers to undertake future study of chemistry geared to keep pace with the advancing frontiers and thereby improve their teaching methods, (4). to furthur an understanding of the importance of science in current and future activities by students who end their study of chemistry in high school.

The first materials from this group were used in a few high schools during the academic year 1960-61. The present plan calls for the general availability of the basic high school chemistry text and related laboratory manual, films, and monographs as soon as possible after the completion of the second trial of the materials during the academic year 1961-62. A series of thirty to forty films[5] are being produced to

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[5]"Schools Reorient Around the Three R's", Chemical and Engineering News, XXXIX (January 2, 1961), p. 38.

supplement the course, the producer of the films is David Ridgeway, the producer of the Baxter film series.[6]

After each trial of the materials in the schools across the country, revisions and deletions or additions will be made. The final version should be available to all schools in the fall of 1963.

The group emphasizes that chemistry is an experimental science and the materials produced place great emphasis on this aspect. The course is begun with a series of experiments. The emphasis on the experiments is carried throughout the course and is considered to be one of the important features of the CHEMS Study course.[7]

For the training of teachers in the use of the materials developed by the group, two Summer Instututes sponsored by the National Science Foundation will be held in 1961. Additional Institutes will be held in 1962 and 1963. It is estimated that about 500 to 1000 teachers will have had an opportunity to study the materials in an Institute before their general release in the fall of 1963.[8]

It should be emphasized that the CHEMS Group is not in competition with the Chemical Bond Approach Project discussed in another chapter of this report, but is considered supplemental to this project. Liaison has been set up between the groups from the beginning.

The CHEMS approach to high school chemistry is not considered to be

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[6]David W. Ridgeway, "Films for Chemistry Study", CHEMS Newsletter, 1, (November, 1960), p. 1.

[7]G. C. Pimental, "Chemistry-An Experimental Science", CHEMS Newsletter, 1, (November, 1960), p. 1.

[8]J. A. Campbell, "Future Plans", CHEMS Newsletter,1 (November, 1960), p. 3.

radical by the group, but it is quite different from what goes on in secondary school chemistry now.[9]

One of the areas of difference in the CHEMS course and the CBA course is in their approach to teaching the concept of energy. The CBA group is working vigorously on entropy and free energy, while the concept of energy and its role in chemical reactions is treated extensively in the CHEMS course, but there is very little specifically on either entropy or free energy.[10]

Summary

In this chapter, an attempt has been made to point out and describe some of the types of projects that have been undertaken on various levels of government, industry, and scientific organizations to assist the high school teacher in presenting a more realistic and up-to-date chemistry program. These programs and many others came into existence during thep past few years. Some of them are part of a coordinated effort. For example, the Traveling High School Science Library, the Traveling Science Demonstration Lecture Program, and the CHEMS Group are all sponsored at least in part by the National Science Foundation; some of the programs represent individual efforts by companys and interested groups. There is a noticeable trend, however, toward coordination and cooperation among all the groups to eliminate duplication of effort and waste of time; this is highly desirable.

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[9]J. A. Campbell, "The Chemistry Educational Materials Study Group", Journal of Chemical Education, XXXVll, (January, 1961), p. 3.

[10]Ibid.

CHAPTER V11

SUMMARY

There have been many changes in both method and content in high school chemistry in the past decade. Many of these changes have been brought about more rapidly by the arrival of the first satallite launched by the U.S.S.R., shocking the American people into the realization that our scientific programs were not advancing at the rapid pace that was felt desirable. Subsequent investigations indicated that the reason for this was at least in part due to the fact that our schools were not producing scientists of high caliber due to certain basic weaknesses. Most of these weaknesses centered around the teacher who had inadequate preparation, and subject matter taught that was thirty years out of date.

Study groups were formed by various organizations and the National Government. Some groups suggested "crash" programs to thrust Americam education foreward. Others expressed fear that such programs without careful and adequate planning would be disastrous.[1] Some programs were in existence prior to the Russian satallite success such as the N.S.F., but most of them were not very active or effective. This report has attempted to describe some of the groups and methods used in their attempts to overcome the weaknesses found.

One such area of defficiency was the basic structure of the course

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[1]Sidney Rosen, "High School Science-Looking Backward", Journal of Chemical Education, XXXV, (April, 1958), p. 48.

itself. Many of the texts and teachers were twenty to thirty years behind the times in chemical knowledge. The texts were primarily designed for descriptive chemistry, almost entirely disregarding the theoretical aspect that is necessary in understanding chemical phenomena. A typical text of the pre-World War 11 school contained 56.8 percent descriptive material, 25.2 percent useful application, 4.9 percent equations and problems, and only 13.1 percent theory.[2] The basic structure of the course is now in a period of evolution, and the change is most noticeable by the increased use of mathematics and theoretical approach to the subject.

This report described only three outlines proposing a change in the basic structure but many others have been published by various groups in the Journal of Chemical Education, and the Science Teacher published by N.S.T.A. It is believed that these three outlines give a representative view of the serious proposals.

Programs such as the Advanced Placement Program have been developed to assist the talented to move at a somewhat more rapid pace, and many schools are beginning programs of accelerated chemistry courses or advanced chemistry courses.

There have been efforts to "retread" the chemistry teacher by organizations such as the N.S.F. with its Institute programs. There is a general trend toward upgrading of the curriculum requirements for secondary school teachers, and some areas of the country have already stiffened the certification requirements. The National Education Association Commission of Teacher Education and Professional Standards (TEPS) are at pre-

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[2]Jacob Carnog and J.C. Colbert, "What We Teach Our Freshmen in Chemistry", Journal of Chemical Education, 1, (January, 1924), p. 8.

sent studying proposals and recommendations of the American Association for the Advancement of Science Cooperative Committee on Teacher Certi-- fication that deal with course requirements for certification. The course in modern chemistry taught by Dr. Baxter on "Continental Classroom" was another effort toward giving the teachers as well as the advanced students an opportunity to increase their basic fund of knowledge, and also to bring them up-to-date. Dr. Baxter's filmed chemistry course has been used extensively for teacher training.

To cope with the ever increasing shortage of qualified teachers, television and filmed instruction has emerged. It is not believed by many that either can take the place of a good chemistry teacher, but they can certainly be used as a supplement to the teacher and in some cases where no teacher is available, are better than nothing.

Materials are being developed for use by the teacher to assist in the preeentation of difficult concepts and dangerous experiments. These are being developed by groups such as the Manufacturing Chemists' Association Committee on Education and the Chemistry Education Materials Study Group sponsored by the National Science Foundation. Also being developed are new laboratory manuals and experiments, films, and teacher guides.

Schools that have an inadequate library can now take advantage of the Traveling Science Library. Also, the Traveling Science Teacher Program is available to give instruction on a one week basis on various areas that are beyond the ability of some high school teachers.

The outlook for chemistry teaching in the future is quite healthy and bright, for even though some of the projects must be expected to be found unsuitable in the future, the awakening that has taken place across the country and the realization that improvement is needed itself

tremendously valuable, for no improvement can occur in a stagnant educational atmosphere.

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