1933

(The) development of a non-college preparatory course in chemistry as used in public schools

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Thesis

THE DEVELOPMENT OF A NON-COLLEGE PREPARATORY COURSE IN CHEMISTRY AS USED IN PUBLIC HIGH SCHOOLS

by

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INTRODUCTION

A survey of the teaching of chemistry in public high schools indicates that courses in practical chemistry are being introduced in many schools to meet the needs of the non-college students. Until recent years, courses in chemistry were planned to meet college entrance requirements and non-college students were forced to take courses which had neither interest nor practical value for them.

At the present time certain high schools are offering practical courses in chemistry which a pupil may apply to his home life, to his vocation, to his understanding of creative forces, to health, and to his relation to society. These courses include household chemistry for girls, industrial chemistry for boys and practical chemistry for both boys and girls.

In seeking material for the study of the development of non-college chemistry courses the writer has not been able to find books dealing wholly with the subject, although many writers have produced articles treating comprehensively certain phases of the subject. School Science and Mathe-

matics and the Journal of Chemical Education and others have furnished valuable material. An investigation of the situation in regard to practical chemistry by Clarence Stevens, under the direction of Professor Fred Weersing, School of Education, University of Southern California has given data which have been of great help.

The writer has sent questionaires to over a hundred science teachers to find out the number of pupils studying practical chemistry, the nature of these courses being taught as well as other information which have direct relation to the matter under investigation.

I

HISTORICAL BACKGROUND OF THE DEVELOPMENT OF CHEMISTRY

(The facts given here are taken from "The High School" p.346-366 Monroe and Weber.)

1821 - Chemistry First Recognized.

Science was not a part of the curriculum of the colonial Latin Grammar School, but a course having the title "natural philosophy" was offered in many of the private grammar schools. As early as 1726 books began to appear by this title or by similar titles.

By 1821, when the Boston English Classical School was established, chemistry was generally recognized as a science and "natural philosophy" was required in the last year. By 1824 two years of science were required. In 1857 the Massachusetts Legislature passed laws requiring high schools to give courses in "natural philosophy", chemistry and botany. For towns of four thousand or more inhabitants, astronomy and geology were required to be taught.

In 1867 a survey was made which showed that chemistry was taught considerably in city schools.

In a survey in the north central states, 1860-1890, it was found that chemistry was taught in seventy-five percent of the schools.

By the end of the nineteenth century science began to appear as a college entrance requirement and was accepted as such by Harvard University in 1876. Even as late as 1888 the John Green School of Science at Princeton did not require science for admission to its scientific course of study. It was not until 1895 that science was required for entrance.

1893 - Report of the Committee of Ten.

In 1893 the Committee of Ten reported "that there should be no difference in the treatment of physics, chemistry and astronomy for those going to college or to scientific schools and those going to neither".[1] The Committee also reported "resolved that it is the sense of the Joint Conference that at least one-fourth of the time of the high school course should be devoted to nature studies, and that this amount of preparation should

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1. Report of the Committee of Ten in Secretarial School Studies, New York: American Book Company, 1894. p.118.

be required for entrance to college".[1] In the program suggested for the classical curriculum the Committee allotted three periods per week per year for chemistry.

1899 - Report of the Committee on College Entrance Requirements.

In 1899 the Committee on College Entrance Requirements recommended that chemistry be taught in the fourth year and that it be allowed at least four periods a week throughout the school year.[2]

1920 - Report of the Committee on the Sciences of the Committee on the Reorganization of the Secondary Schools.

In 1920 the Committee on the Sciences of the Committee on the Reorganization of Secondary Education recommended that for the combination junior and senior high schools and for comprehensive high schools of over five hundred, courses in chemistry including general chemistry and specialized chemis-

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1. Ibid. p.141.

2. Report of the Committee of College Entrance Requirements, Washington National Education Association, 1899. p.23.

try for various curricula such as household chemistry, industrial chemistry, etc. The Committee also recommended that medium size high schools (less than five hundred pupils) offer a chemistry course in the third year with special emphasis on home, farm, and industries. For small high schools (not more than two hundred pupils) they recommended elective chemistry and physics.[1]

The United States Bureau of Education Statistics show the enrollment of chemistry for a number of years.

1895	1905	1915	1922[2]	1928[3]
9.15%	6.76%	7.38%	7.40%	7.1%

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1. Report of the Committee on the Reorganization of Science in the Secondary Schools. United States Bureau of Education Bulletin, No. 26, 1920, Washington Government Printing Office, 1920.

2. Philips, Frank M., "Statistics of the Public High Schools 1921-22"., United States Bureau of Education Bulletin, No. 7, Washington Government Printing Office, 1924. pp.46-47

3. Philips, Frank M., "Statistics of the Public High Schools 1927-28"., United States Bureau of Education Bulletin, No.35, Washington Government Printing Office, 1929. p.172.

II

INFLUENCE OF THE COLLEGE

The colleges have exerted a great influence on high school chemistry. In order to meet college requirements, high schools have planned their entire course for the needs of college students.

Report of The Special Commission on Education, Massachusetts Senate.

In 1919 a special commission was appointed to investigate and report upon the support, supervision, and control of all educational institutions directly and indirectly by the State. It reported:

1. "The college preparatory course is not adapted to the educational need of any but a small majority of high school students; in fact, this course needs extensive revision even for the majority."

2. "A student entering high school, generally at about fourteen years of age, under the present system of college entrance requirements, must choose between a college preparatory course, however poorly adapted to his educational needs, and other courses which appear to meet his needs but practically close to him the possibility of going to college."

3. "College entrance requirements do not encourage, or even permit, students to devote sufficient attention to subjects specifically designed to prepare them for the duties of citizens."

4. "College entrance requirements give almost no opportunity to prepare for the effective discharge of home making."

The committee "recommends greater flexibility in college entrance requirements, also that the preparatory course in high schools be adapted to the educational needs of the students rather than merely to fit students for college requirements".[1]

Subject Matter of the Course.

In comparing the subject matter of first year college chemistry with the subject matter of high school chemistry, a survey has shown considerable overlapping. In a report of the study of twenty-six high schools located in cities of 10,000 and over in six North Central States compared with forty-one colleges scattered over eleven states Koos found:

1. "Almost all courses represented both in high school and college extend over a full year. The number of recitations and laboratory periods per week tend to be identical in the two institutions; but in the aggregate the colleges devote somewhat more time to the courses because of longer periods."[2]

2. "As far therefore as is to be concluded from the analysis of texts it may be said that, although college texts are more extended than high school texts, the relative recognition of the several subdivisions does not differ widely, excepting that the former stress compounds (especially their preparation and properties) the rarer elements, and principles more than do the latter, while the latter make more of used (both of elements and compounds) organic materials, and pedagogical features such as questions and summaries. Furthermore the similarities far exceed the differences.

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1. Report of the Special Commission on Education, Massachusetts Senate, January, 1919. pp.75-76.

2. L.Koos "Overlapping in High School and College." Journal of Educational Research XI, May, 1925. pp. 323-324.

3. "Even when allowance is made for the larger number of sub experiments introduced into the college manuals, it must be admitted that the laboratory portion of college and high school courses in chemistry resemble each other vastly more than they differ -- that they cannot be far from identical in major aspects.

4. "It is clear from the comparisons made that, although there are some differences between high school and first college courses in chemistry, the courses are in reality much alike."[1]

"One thing has been accomplished which is both positive and lasting; an attitude of perranent and violent antipathy has been established. ..... From the psychological point of view, therefore, it is very unscientific to ignore the student's previous training."[2]

A test was prepared by Fred Mabee from the syllabus for first year college chemistry outlined by the Division of Education of the American Chemical Society. There were ninety-five items in the test which was given to three selected high schools and three colleges. The results showed an overlapping of the scores of high school and college students. One high school surpassed one college and practically tied another. "Thirty-one percent of all the high school students were above the median of all

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1. Ibid. pp.327-330

2. P.M.Glasoe "The Deadly Parallelism Between High School and College Courses in Chemistry". Journal of Chemical Education, VI, March, 1929. p.508.

of all the college students."[1]

"At present a considerable part of the first year college course is in reality a high school course and those pupils who have had high school chemistry repeat in large measure the work they have had the previous year."[2]

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1. F.Mabee, "A Test of Achievement in College. Chemistry and Results Obtained by its use with Both High School and College Classes." Journal of Chemical Education. 2 November, 1925. p.1002.

2. M.Stubbs, "The Place and Problems of Chemistry in the High School Curriculum." School Science and Mathematics, 27 October, 1927. p.747.

III

SITUATION AS IT EXISTS

Report of Stevens, University of Southern California

An excellent report of the situation in regard to practical chemistry is made by Clarence Stevens. The investigation, was under the direction of Professor Fred J. Weersing, School of Education, University of Southern California.

From 235 questionaires to representative high schools and a few colleges of the United States, Stevens summarized his report as follows:

"Number and Percentage of High Schools Offering Three Types of Courses."[1]

College Preparatory	42	47.2%
Quazi-pandemic	43	48.3%
Pandemic	4	4.5%

(Pandemic is a term which has been applied to what is commonly known as laical or practical chemistry.)

This shows that the trend is toward the middle ground.

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1. C.Stevens, "New Courses in High School Chemistry." School Science and Mathematics, 32 March, 1932. p.245.

Report of Investigation Made by Warren and Goding.

Preliminary

In conjunction with Mr. Ambrose Warren, (Head of the Science Department, Dorchester High School For Boys, Dorchester, Massachusetts), the writer sent a questionaire to 103 high schools. Of the 103 questionaires sent, seventy were sent to schools in Massachusetts and thirty-three to high schools outside of Massachusetts. Returns were received from forty local schools and sixteen out-of-state high schools. The questionaire was sent to the city schools of Massachusetts and the larger towns as Arlington, Beverly, Framingham, Norwood, etc. The out-of-state schools such as the high schools in Detroit, Cleveland, Chicago, New York City, Providence, Hartford, Portland, ~~etc~~. ~~These schools~~ were of little value for statistical study since the number returned was small and the questionaires were not sent back completely filled out in many cases.

The Questionaire

Since Mr. Warren was interested in both chemistry and physics, the writer used only part of the questionaire. The questionaire follows:

QUESTIONAIRE

School_____ Answered by_____

Address_____ Position _____

	Boys	Girls	Total
Enrollment			

Wherever possible indicate your answer by a check (v) mark in the proper column.	Yes	No
5. Do you have sections in chemistry intended primarily for pupils preparing to enter college or normal school?_____		
6. What is the enrollment in these sections_____		
7. Do you have sections in chemistry intended primarily for pupils in the general, commercial, or industrial courses?		
8. What is the enrollment in these sections_____		
9. What text book do you use in each of the above sections? _____ _____ _____ _____ _____		
10. Have you objective evidence that differentiation in courses such as is indicated in Nos. 3, 5, 7, and 9 above has increased the total enrollments in science in your school?_____		

QUESTIONAIRE

(Continued)

	Yes	No
11. Have you objective evidence that differentiation in courses such as is indicated in Nos. 3,5,7, and 9 above has decreased the percentage of failure in science in your school?_____		
12. If you have courses as indicated in Nos. 7 and 9 above, do they differ from the college preparatory courses in		
a. Being less mathematical?_____		
b. Being less technical?_____		
c. Being more practical?_____		
d. Being more descriptive?_____		
e. Making use of the project method?__		
f. Having a smaller percentage of laboratory work?_____		
g. Having a greater percentage of laboratory work?_____		
h. Introducing more industrial applications?_____		
i. Having greater coordination with other subjects in the program of studies, such as shop work, textiles, etc.?_____		
j. Making greater use of visual educational methods?_____		

Summary of Numerical Data in the Questionaire

1. Total enrollment of schools for which figures are available. 74,973

2. Number of pupils studying chemistry. 6030

3. Percentage of pupils studying chemistry. 8.04

4. Percentage of chemistry pupils enrolled in college preparatory classes. 50.83

5. Percentage of chemistry pupils enrolled in non-college courses. 49.17

Conditions in Certain High Schools Regarding the Number Studying Chemistry.

These examples are given to show that only a small number of the pupils are taking chemistry. In the schools mentioned, most of these students are taking the college preparatory course.

1. In a school of 1531 there are only 84 pupils studying chemistry and these are all taking the college preparatory course.

2. In a school of 1498, there are only 53 pu-

pils studying chemistry. Of these 28 are enrolled in a college preparatory class and 25 in a non-college class.

3. In a comprehensive high school of 3050 there is no chemistry of any kind taught.

4. In a school of 918 there are 100 pupils studying chemistry and these are all taking the college preparatory course.

5. In a high school of 2081 there is no chemistry taught.

6. In a school of 2400 there are 225 pupils studying chemistry and these are all taking the college preparatory course.

The following examples show that a much larger percentage of the total enrollment of pupils is taking chemistry. In these schools it also shows that of those taking chemistry, a large number is taking practical chemistry.

1. In a school of 570 there are 90 pupils studying chemistry. Of these,30 are enrolled in the college preparatory course and 60 in the non-college courses.

2. In a school of 2215 there are 357 pupils studying chemistry. Of these, 176 are in the college preparatory course and 181 in the general chemistry courses.

3. In a school of 704 there are 174 pupils enrolled in the chemistry classes. Of these, 50 are in the college preparatory course and 125 in the non-college courses.

4. In a school of 385 there are 111 pupils studying chemistry. There are 48 in the college preparatory course and 63 in the non-college course.

5. In a school of 1593 pupils there are 235 studying chemistry,of which 35 are in the college preparatory course and 200 in the practical course.

6. In a school of 741 there are 101 pupils studying chemistry. Of these, 41 are studying college preparatory chemistry and 60 non-college chemistry.

Summary of Non-Numerical Data

1. Objective evidence that differentiation

in college and non-college courses has increased the total enrollment in science in your school.

Yes - 45% No - 55%

2. Objective evidence that this differentiation has decreased the percentage of failure in science in your school.

Yes - 45% No - 55%

3. Do the practical courses differ from the college preparatory in:

	Yes Percent	No
a. Being less mathematical.....	95	5
b. Being less technical.....	92.5	7.5
c. Being more practical.....	85	15
d. Being more descriptive.....	76	24
e. Making use of the project method.	36	64
f. Having a smaller percentage of laboratory work.....	46	54
g. Having a greater percentage of laboratory work.....	29	71
h. Introducing more industrial applications.....	79	21
i. Having greater coordination with the other subjects in the program of studies such as shop work, textiles, etc.....	60	40
j. Making Greater use of visual education.....	40	60

From this subjective data it is evident that the non-college chemistry should be less mathematical, more practical, less technical and that more industrial applications and descriptive material should be included.

Text Books Used in Chemistry Classes

From this investigation it is found that fifteen different text books are being used in the schools from which replies were received. Black and Conants' "Practical Chemistry" is the book most widely (39 percent) used in the college group. This book is also used to considerable extent (22 percent) by non-college classes. Several books by Brownlee and others were second in choice. In the replies to the questionaire there was a noticeable absence of non-college books. There were two practical books in the list but these were used by few schools.

For information concerning books on practical chemistry in use in schools the writer visited ten of the leading school publishers. With one exception all of the chemistry books of these publishers followed the college entrance board outline. A few of these publishers had books of a practical nature,

but these were written about 1912-1915 and had not been revised since then. Many of the representatives of the publishing companies stated that there is a need for a good practical chemistry which does not follow the college outline.

These conditions were also found by Stevens[1] when he reported that no strictly pandemic text books for high school use could be found. The teachers of such courses, Stevens found, used the standard texts omitting certain parts and substituting other material in their place.

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1. C.Stevens, "A New Course in High School Chemistry", School Science and Mathematics; 32 March, 1932. pp. 244-249.

IV

CAUSES FOR THE DEVELOPMENT OF NON-COLLEGE PREPARATORY COURSES

The courses in practical chemistry have developed because of the failure of the college preparatory courses to meet the needs of the average high school student. The realization of failure has been brought about by the smaller percentage of pupils going to college from the high school, lack of interest in the chemistry course, the growth of large industries and the arousal of chemical consciousness since the World War.

Increased Enrollment of the High School

In these days of economic depression there is a smaller number of pupils attending college because of lack of funds. In 1930 in 430 colleges and universities there were 584,650 students attending, and in 1932 there were 558,290 students. These figures show a decrease of 4.5% in the enrollment.[1] On the

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1. R.Walter, "Statistics of Registration in American Universities and Colleges in 1932", School and Society, 36.December 10,1932. p.737.

other hand, a much larger number of pupils is attending the high schools. In 1932 there was an increase of 5.5% of students in the junior and senior schools over the enrollment in 1931.[1] In the Boston high schools there was an increase of 25.4% from 1928 to 1933.[2] With the increased enrollment it has been found necessary to provide courses of a practical nature for these pupils.

Interest in Chemistry

The lack of interest in high school chemistry has already been proved by the statistics taken from the United States Bureau of Education which show the decrease in percentage of students studying chemistry. Educators realize that courses in chemistry should be less mathematical, less technical, etc., for those not going to college. In some school systems courses given failed to attract pupils because of the mass of unrelated material, the uninteresting problems, poor text-books, and the mass of material to be mastered.

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1. "School Enrollment in 1932", American School Board Journal, 85. November, 1932. pp.45-46.

2. School Document Number 7, Boston Public Schools, 1932. p.7.

Another important factor in the development has been the awakening of chemical interest since the World War. The progress of science in industry has been brought before the public by means of newspapers, magazines, books, lectures, and radio.

V

CONTENTS OF PRACTICAL COURSES IN CHEMISTRY

Household Chemistry for Girls

A Committee of the American Chemical Society reported in 1923 that there is a need of chemistry courses for those not going to college. This committee also reported that one of the objectives of chemistry is "to show the service of chemistry to the home, to health, to medicine, to agriculture, to industries, etc. In a word to show the service of chemistry to the nation."[1]

With this as an objective some schools are offering courses in chemistry for girls. The students find this course of much more value than the regular college preparatory courses. A course of this kind is offered in the South Side High School, Newark, New Jersey. An excellent description of this course is given by Mr. Charles Dull in School Science and Mathematics (pp.841-5), for December, 1920. A list

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1. B.S.Hopkins, "A National Standard Minimum Course in Chemistry", School Science and Mathematics, 24. March, 1924. p.235.

of some of the experiments undertaken will give a good idea of the material studied in this course for girls:

13. Preparation and study of hard water. Softening of hard water.

14. Tests for simple impurities in drinking water.

17. Test for proteins in several foods.

19. Milk; Babcock Test; lactometer test; preparation of pasturized milk; effect of rennen (Junket tablets)

20. Preparation of baking powder. Test for commercial powders.

22. Test for adulterants. Selections are made from the following:

(a) Starch and gelatin in ice-cream

(b) Tumeric in mustard

(c) Coal-tar colors in candy; jellies or butter

(d) Chicory or cereals in coffee

(e) Cotton seed oil in olive oil

(f) Oleomargarin or process butter for butter

(g) Copper salts in canned vegetables

(h) Adulterants in vanilla or lemon extract

(i) Adulterants in maple syrup

(j) Glucose in candy

(k) Manufactured vinegar for cider vinegar

23. Test for rancidity of butter or olive oil.

26. Test for caffein from coffee; thein from tea; test for Kaffee Hag.

29. Determine purity of baking soda and cream of tarter.

32. Examination of fibers; action of chemicals on linen, wool, silk, and cotton.

33. Analysis of mixed fibers.

35. Removal of stains; ink, grease, grass, coffee, tea, fruit, vaseline, mildew, iodin.

(There are forty topics in Dull's list)

Industrial Chemistry for Boys

In some of the larger cities excellent industrial chemistry courses are given for boys. Vocational schools are offering related chemistry to pupils in all trades where the knowledge of chemistry may be of practical value. The amount of chemistry taught varies with the trade and is presented according to the administrative policy of the director. Chemistry as a trade offers the opportunity to get valuable industrial experience and enough knowledge of chemistry for advancement in the chemical world if further education is secured. The course of study for Industrial Chemistry, Community High School, Granite City, Illinois, follows:[1]

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1. M.Spencer, "Chemistry in Vocational High Schools of the Middle West". Journal of Chemical Education 8, April, 1931. pp.713-714.

Freshman

First Semester	Second Semester
English I	English II
Arithmetic I	Arithmetic II
Physiology I	Physiology II
Drawing I	Drawing II
Industrial Chemistry I	Industrial Chemistry II

Sophomore

English III	English IV
Algebra I	Algebra II
Physics I	Physics II
Sociology	Civics
Industrial Chemistry III	Industrial Chemistry IV

Junior

English V	English VI
Plane Geometry I	Plane Geometry II
American History I	American History II
Physics III	Physics IV
Industrial Chemistry V	Industrial Chemistry VI

Senior

English VII	English VIII
Electric Shop I	Electric Shop II
Algebra III	Trigonometry I
Drawing III	Drawing IV
Industrial Chemistry VII	Industrial Chemistry VIII

A complete description of chemistry in vocational schools of the middle west is given by Mabel Spencer in the Journal of Chemical Education for April, 1931.[1] In this course of study the plant

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1. Ibid. Pp. 714-715.

method is used and the pupil is taught to use an electric oven, balance, hydrometer, and the slide rule. Industrial samples are used whenever possible. The courses taught include general chemistry, quantitative analysis, the elementary parts of qualitative analysis, industrial and some organic chemistry.

On integral part of the course consists of visiting typical industries of the city such as: The American Steel Company, The St. Louis Coke and Gas Company, The General Steel Casting Company, The Swift Packing Company, and the Owen Illinois Glass Company. Here the students see chemistry at work. The boys are encouraged to read the available chemical magazines: Chemical and Metallurgical Engineering, Industrial and Engineering Chemistry, and the Journal of Chemical Education.

Charts of all kinds are used on the walls of the chemistry rooms and the periodic table and the various handbooks are used from time to time. Each week the students are required to write a theme on a chemical subject of his own choosing so that he will be able to express chemical information in a a clear and interesting manner.

The most decided difference between the voca-

tional and the academic course is in the method of instruction. In the vocational course the student progresses at his own rate (job sheet method). Students are not recommended for positions unless the shop instructor is satisfied that the boys are fitted to fill the positions, regardless of the time spent in preparation. The average boy spends twenty 50-minute periods a week for four semesters in these shops.

In all chemically industrial communities the range of chemistry is wide, therefore specialized courses are avoided. It is impossible to predict the exact chemical situation that the boy will meet, so a broad chemical knowledge is given. It is pointed out to the boy in every possible way that to succeed in chemistry one must go far beyond high school or even college and that work and ability are essential for success in this line.

Vocational chemistry is correlated with English in his chemical reading, writing and oral expression. In mathematics there is a direct correlation in solving chemical problems and plotting chemical data. Every opportunity is used to show the pupil that these subjects as well as other subjects will aid him in becoming a successful chemist.

Practical Chemistry for Both Boys and Girls.

It is evident that in the small high school it is not possible to have vocational chemistry for boys, household chemistry for girls, etc. If there is a sufficient number of pupils to have two divisions of chemistry there is nothing to prevent dividing this number into a college preparatory group and a non-college group. Such a course would include the practical applications of chemistry stressing such topics as:

1. Chemical changes in everyday life.
2. The ten elements necessary for life.
3. The relation of chemistry to human health.
4. Uses of chemistry in the home.
5. Applications of chemistry to our daily life.
6. How chemistry is applied in industries.
7. How chemistry contributes to the welfare of society.
8. The relation of chemistry to the progress of civilization.[1]

The results of investigation show that there are

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1. Chosen from the list in National Society for the Study of Education. Thirty-first year Book.pp. 264-265 (also The North Central Association Quarterly, March, 1931.)

few good texts for a course in practical chemistry. Until such time as there are numerous good texts it will be necessary to use several sources of information. As a practical suggestion, there are five excellent books offered at a special rate by the American Chemical Society (committee on prize essays). The books are:

1. "Creative Chemistry" - Edwin Slosson.
2. "Life of Pasteur" - R. Vallery Radot.
3. "Riddle of the Rhine" - Victor Lefebure.
4. "Discovery, or the Spirit and Service of Science." - Sir George Gregory.
5. "The Future Independence and Progress of American Medicine in the Age of Chemistry." - A committee of American Scientists.

If the five books were bought for each pupil, the total cost would be but little more than the usual cost of a standard text book. If individual laboratory facilities are available, correlated experiments should be undertaken. If these facilities are not available, correlated demonstrations should be an integral part of a practical course in chemistry.

VI

ADVANTAGES OF COURSES IN PRACTICAL CHEMISTRY

Practical chemistry offers great service to individuals and to society. It provides knowledge and training for the individual which will help him to attain his highest development and will enable him to fulfill his obligations to himself and through this development make him a useful member of society. With its unlimited resources, chemistry promotes health, improves home life, serves as a vocational guide, helps to prepare for and to improve citizenship, aids the development of character and provides means for the worthy use of leisure. Practical chemistry offers a training which fulfills the aims of secondary education as given in its Cardinal Principles.[1]

Chemistry and Health

Since health is of great importance during the high school age, chemistry provides information and

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1. The ideas as used here as suggested by Hatti Haub, "How to Teach Secondary Chemistry and Allied Science". pp.52-72.

training which will lead to the appreciation and understanding of the chemical reactions that take place in the body. The condition of this laboratory is largely controlled by him, in the kind of food he eats, how he eats, when he eats it, how it is digested and how the waste material is disposed of.

An individual who has been taught the scientific principles of good health can be of great service in improving health conditions in the community. He may use the knowledge which he has gained in high school to enable him to promote such projects as: making safe the water supply, proper disposal of sewage, and safeguarding the community with a pure and wholesome milk supply.

Chemistry and Worthy Home Membership.

Courses in practical chemistry provide boys or girls with knowledge which makes them better home members. The pupil who is taught at school the value of right eating is a better individual to live with in the home because he will cooperate with those who are working for his best interests in this particular phase of living. There will be no rebellion against eating fruit, vegetables, milk, salads, etc., as well

as meat and potatoes, and he will realize that sweets alone are not a proper diet.

There are innumerable opportunities in which a girl can be helpful in the home through her knowledge of practical chemistry. She will be taught the correct use of a gas flame, proper cooking of food, the best type of cooking utensils, the correct use of household water filters, value of alcohol as a solvent but its harm as a beverage.

Chemistry and Vocation.

The vocational value of the information received in a good chemistry course is invaluable. The student learns of many industries and the types of work open to a chemist at these plants. A practical chemistry course provides magazine articles, books, trips to industrial plants, motion pictures, etc., so that the student gains information which may help him to decide what he desires to do for his life work.

Chemistry and Citizenship

A good citizen works in harmony with his fellow neighbors. In chemistry, many experiments are performed by students working together. They learn to to cooperate with each other in the handling of reagents, of apparatus and the assembling of material.

Through his knowledge of chemistry the student will understand the value of local, state and national projects for the conservation of health, prevention of disease, and preservation of natural resources, and will be better fitted to carry on this work as an adult citizen. He will also be shown the necessity of maintaining local, state and government laboratories to carry out these programs.

In a world upset by so many serious problems, he will hear arguments for peace on one hand and for greater preparation for war on the other. A good citizen must decide whether newly discovered chemicals shall be used for warfare and destruction or for the betterment of mankind.

Chemistry and Ethical Character.

Chemistry offers many opportunities for the student to develop ethical character. Honesty is one of the essential qualities for success. He must learn to record the results of his experiments accurately, to reason rather than to accept doubtful authority, to question patent medicines, to be suspicious of "high pressure" newspaper and magazine advertisements, and to have too high an ideal to sell his chemical knowledge for unlawful purposes.

The honest industrial chemist strives to avoid waste and to utilize by-products so as to put a good article on the market at the lowest possible price. On the other hand, the shyster chemist puts harmful or valueless products on the market at an extremely high price for the unthinking and untrained public to buy.

Many industrial concerns are conducted today on sound ethical principles. As an example, a large match company, when the phosphorus match was made unlawful, offered the use of its phosphorus free formula to any company, in order to prevent danger to workmen.

The work of many eminent scientists could be mentioned who unselfishly gave their discoveries for the use of mankind. This was the motive of Doctors Best and Bunting who gave to the world their discovery of insulin for controlling diabetes. To many, the work of Louis Pasteur, Charles Martin Hall, William Perkin, Antoine Lavoisier, Sir Humphrey Davy, Robert Bunsen, and the Curies is well known because of its great service to humanity. Today such names as Antony Leeuwenhoek, Lazzare Spallanzi, Robert Koch, Elie Metchnekoff, Emil Roux, Theobald Smith, David Bruce, Ronald Ross, Walter Reed, and Paul

Ehrlich are receiving full recognition for their pioneer work in saving human life.

Chemistry and the Worthy Use of Leisure.

On account of shorter working hours, people today have a great deal of leisure time. A course in practical chemistry offers several ways in which we can use this free time in a whorthwhile manner.

Many pupils of chemistry find a home laboratory a source of much pleasure. Often in making a home museum many fine things are accomplished. A new and broader interest is developed in agricultural projects and the chemistry of plant and animal life. Photography and the home developing laboratory offer hours of worthwhile pleasure. Chemistry stimulates wider reading, induces visits to industrial plants, industrial exhibits, and museums. All of these afford both pleasure and profit for leisure hours.

VII

THE FUTURE OF CHEMISTRY IN THE HIGH SCHOOLS

There is a need of definite reorganization in the teaching of chemistry in the high school, if there is to be progress, and advancement in chemistry. To prevent the overlapping of high school and college chemistry, to solve the problem of overcrowded school buildings, and to make chemistry more attractive to high school pupils, there is need of the establishment of the junior college. Another plan for reorganization would be the study of chemistry for more than a year in order to allow for a course in practical chemistry. It has been suggested also, that there should be a combination of all sciences into a four-year course of science, in order to give the pupils the most worthwhile preparation for life.

Establishment of Junior College

The reorganization of chemistry in the high school can be partially accomplished by the forma-

tion of junior colleges. According to Stubbs[1] the linking of the senior high school and the junior college would help to overcome some of the difficulties which now exist. For example, the overlapping of high school and college chemistry would probably be eliminated, if the same teachers would teach both groups of students. The problem of over-crowded high school buildings might be solved by the formation of a junior college. More pupils might be interested in chemistry if they could study a more practical chemistry in high school and take up the more technical chemistry in junior college. This plan would make it possible to give high school students a more practical course in chemistry.

Chemistry for More than One Year.

Another suggestion is made by Clarence Stevens[2] who writes that chemistry should be extended to either a year and a half, or better still, to a two-year subject. It is proposed by Stevens that a course in

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1. M.Stubbs, "The Place and Problems of Chemistry in the United States." School Science and Mathematics 27. pp.741-748.

2. C.Stevens, "A New Course in High School Chemistry". School Science and Mathematics XXXII. pp. 244-249.

laical or pandemic chemistry be offered in the tenth year, followed by an elective semester of the more difficult parts of chemistry for college preparation. In addition to this, he suggests that a semester of qualitative analysis be taught in the eleventh grade.

Combination of All Sciences into a Four-Year Course of General Science.

The most practical suggestion of any offered is that of Hattie Haub. Her plan seems to predict the real future of chemistry. She says that not only will there be meetings of the chemistry, physics, and biology teachers in separate national, state or local groups, but that there will be a meeting of science teachers who will take from all science that which is most valuable. Such a course would progress through the high school as English does, and might be known as Science I, Science II, Science III, etc. This course would be most worthwhile and would prepare the pupils to live in the world of today.

"Before executives will aid in incorporating such a course in their curriculum, they must be shown by the science teachers that it will be a vi-

tal force in the development of our modern youth."[1]

Science of Tomorrow.

"Secondary school science has a glorious opportunity, and better, has the means and power to use the opportunity to her honor and exhaltation, and to the greater service of humanity. Never before has there been such a need for that which science can give. With thoughtful conservation it can be claimed that the science of tomorrow will serve the masses until they have been raised to new intellectual attainments and worthier and more complete living. Science will maintain higher public health, improve the ideals of home life, guide and educate vocationally, increase democracy and brotherhood among men, inculcate true ideals of service and social relations, it will open the door to many useful and pleasurable avocations and lastly, will assist in the development of ethical character. Thus science will develop the interests, habits and abilities, teach useful methods of solving life problems, stimulate and inform the students' minds, and give cultural and aesthetic values. The science of tomorrow will be the most educative and valuable force in the schools."[2]

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1. Hattie Haub, "How to Teach Secondary and Allied Science." pp.265-266.

2. Harold Dexter Sylvester, "Current Tendencies In Secondary School Science." pp.80-81. Unpublished Masters thesis of Boston University, School of Education, 1930.

VIII

SUMMARY

In this study of the development of the teaching of chemistry, it has been found that practical courses were necessary for the non-college student. The student whose formal education ended with his graduation from high school, found little interest or value in the courses planned especially for college preparatory students. His need was for courses which were not too technical for him to understand and which he could make use of in his daily life.

The history of the teaching of chemistry from 1726 to the present time, shows a gradual development. At first chemistry was included in a course called, "natural philosophy", and in 1857 it was required by legislation to be taught in the high schools of Massachusetts. The teaching of chemistry became more extensive and by the end of the nineteenth century, chemistry was accepted as a unit for admission to college.

From the time chemistry became a college entrance unit, courses in chemistry have been domin-

ated by the college. Non-college students were obliged to take the same courses as college preparatory students. In 1920 there was a definite tendency toward a change in the chemistry course. It was recommended that the courses in chemistry include industrial chemistry, household chemistry, and general chemistry. It was also recommended that in small high schools there should be a chemistry course in the third year, which would emphasize home, farm and industries. While no definite measures were adopted, the recommendations offered show the need of practical chemistry.

It has already been pointed out that the courses in chemistry have been planned to meet college entrance requirements. High school chemistry meets the needs of only a small number of high school students. Text books are often written from the college point of view for the use of college preparatory students and not for those who will end their formal education with the high school. Is it any wonder then, that the large number of non-college students can neither grasp nor enjoy their work in chemistry? It is evident that there is need of revision of both chemistry text books and chemistry courses for high school students, since the subject

matter used in high school is largely repeated in college chemistry.

As a result of the investigation of the situation which now exists regarding the teaching of chemistry in high schools, it has been found that the trend is to modify the courses to include more practical material. The fact is shown in the report of Clarence Stevens, who sent out 235 questionaires to representative high schools and a few colleges.

From a questionaire sent out by the writer in conjunction with Mr. Ambrose Warren, Head of the Science Department, Dorchester High School for Boys, the writer found that from a study of 74,973 pupils enrolled in comprehensive high schools 8.04 percent are studying chemistry. Of these 50.83 percent are enrolled in college preparatory classes and 49.17 percent are enrolled in non-college courses. From the data which is subjective in nature, it is evident that teachers agree that practical courses should be less mathematical, more practical, less technical, and that more industrial applications and descriptive material should be used.

From the investigation by Stevens and by the writer it was found that there are few books written for practical courses in chemistry and that most

of the teachers of these subjects use college preparatory texts, omitting certain parts and substituting other material. Very few of the publishers visited by the writer were found to have text books of a practical nature, but most of them agreed that there is need of a good practical chemistry book.

In seeking the causes for the development of practical courses in chemistry it has been found that the economic conditions, lack of interest in the courses as planned for college preparatory students, the awakening of chemical interest since the World War, and the demand in industries for trained chemists are important factors in the change which is taking place.

The economic conditions have increased the enrollment in the high school. It is reasonable then, that these pupils must be prepared to meet life with the education that they have received in high school and that for the majority, chemistry courses must be of a practical nature. Text books are needed which will be less mathematical, with problems of a more practical nature. The growth of large industries and the progress of science in the industry has awakened an interest in practical chemistry. The

World War has made the people conscious of the relation and service of chemistry to mankind.

In this study of the development of chemistry for non-college students it has been found that practical chemistry courses include household chemistry for girls, industrial chemistry for boys, and practical chemistry for both boys and girls. In school Science and Mathematics, Mr. Charles Dull gives a description of a course offered for girls in the South Side High School, Newark, New Jersey. This course includes forty experiments of value to homemakers such as: test for proteins in foods, preparation of pasturized milk, and impurities in water.

In the Community High School, Granite City, Illinois, a four-year course of industrial chemistry is given. As far as possible the other subjects taught, English, Arithmetic, Physics, Algebra, Drawing, etc., are correlated with the work in industrial chemistry. A part of the work is to visit the industries of the city. The boys are trained to fill positions in the laboratories of these and other industries.

The year book of the National Society for the Study of Education suggests a practical chemistry

course for both boys and girls for smaller high schools. Some of the topics included in this course would be: chemical changes in everyday life, relation of chemistry to health, the service of chemistry to society.

The American Chemical Society offers five excellent books at special rates which could be used as texts in practical chemistry, until there are more good books written especially for use in schools having this course. The list includes: Slossons' "Creative Chemistry", Radots' "Life of Pasteur", Lefebures' "Riddle of the Rhine."

In an age when people are becoming more enlightened in the application of chemistry to their daily life, courses in practical chemistry give valuable help. Practical chemistry promotes health since it provides information about food and the chemical reactions which take place in the body. It also enables an individual to be of service to the community in promoting health projects. Home life will be improved through knowledge gained at school in this subject, and will make the home a more comfortable and happy place in which to live.

To the student seeking vocational guidance, practical chemistry provides information that will

help him to choose his life work. Citizenship will be benefited because a student will learn about projects for the conservation of health, prevention of disease, and the preservation of natural resources. He will learn the value of coöperation because his experiments will have been performed with his fellow students.

Ethical character will be developed by the conscientious student who is taught to be accurate in his work, to avoid waste, to handle with care materials which have been furnished by the school. As he studies the work of eminent scientists, he will realize the sacrifices that they have made, the risks that they have taken, and the wonderful service that they have given for the benefit of mankind. Today an individual is judged by the use which he makes of his leisure,and practical chemistry provides material that will make leisure both profitable and pleasurable.

In this survey of the teaching of chemistry in the high school, the development of chemistry has been traced from 1726 to the present day. There are problems to be solved and there is much that can be done to improve the present conditions and to promote chemistry in the future. It has been suggested

by Stubbs that the establishment of the Junior College will help to overcome some of the present difficulties and will make it possible to have more practical work in chemistry. Stevens believes that chemistry should cover a period of two years. His plan would also provide for a course in practical chemistry. Haub predicts that a combination of all sciences into a four-year course of science will give to a pupil all that is profitable in science and would be a benefit to his whole future life. In his thesis entitled, "Current Tendencies in Secondary School Science.", Sylvester says that science has the opportunity, the means and the power to serve the masses so that they will be raised to new attainments and to worthier and more complete living. He says, "The Science of tomorrow will be the most educative and valuable force in the schools."[1]

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1. Harold Dexter Sylvester, "Current Tendencies in Secondary School Science." pp.80-81. Unpublished Masters thesis of Boston University, School of Education, 1930.

IX

BIBLIOGRAPHY

1. Bancroft, Wilder D., "Pandemic Chemistry", Journal of Chemical Education, 3 (April, 1926). pp.396-400

Proposed cultural course for college freshmen. A list of topics to be used in the course.

2. Bowman, R.E., "A Secondary Course in Industrial Chemistry", Journal of Chemical Education, 4 (March, 1927). pp.346-354.

A course in industrial chemistry as offered in Wilmington Trade School, Wilmington, Del.

3. Bradberry, Robert H., "Recent Tendencies in High School Chemistry", School Science and Mathematics, 15 (December, 1915). pp.782-793.

Necessity of beginning chemistry earlier in the curriculum and having a two-year course. More need of scientific method and study of subject matter.

4. Collier, Robert, Jr., "A New Type of Chemistry", Journal of Chemical Education, 8 (November, 1931). pp.2214-2226.

Necessity of modernizing chemistry. Advantages and difficulties in such a course.

5. Coulson, Francis C., "Educational Aims in Teaching Elementary Chemistry", Journal of Chemical Education, 6 (June, 1929). pp. 1121-1125

Statement of the aims of high school chemistry.

6. Dull, Charles E., "Outline of a Course in Practical Chemistry for Girls", School Science and Mathematics, 20 (December, 1920). pp.841-845.

Excellent outline of course in household chemistry.

7. Hopkins, B.S., "A National Standard Minimum Course in Chemistry", School Science and Mathematics, 24 (March, 1924). pp. 223-237.

A minimum course in chemistry.

8. Jackson, Walter, "What Sort of Chemistry Should be Taught in the High Schools?", Journal of Chemical Education, 4 (January, 1927). pp.58-65.

Excellent article on the necessity of a practical course in chemistry for high school pupils.

9. Jaques, Agnes F., "Differentiated Chemistry for Girls", Journal of Chemical Education, 3 (May, 1926). pp.585-586.

A plea for a differentiated course in chemistry for girls, emphasizing household applications.

10. Kaufman, Gretchen, "A Chemistry Curriculum for Every Mans' Son and Daughter", Journal of Chemical Education, 4 (August,1927) pp.976-978.

Shows demand for a revised curriculum in chemistry to keep abreast of the times.

11. Koos, Leonard V., "Overlapping in High School and College", Journal of Educational Research, 11 (May, 1925). pp.322-330

Overlapping of high school and college chemistry.

12. Ladd, Robert M., "Classwork in Industrial Chemistry", School Science and Mathematics, 19 (October, 1919). pp.633-642.

Experiments to be performed in industrial chemistry.

13. Le Vesconte,A., "Adapting Elementary Chemistry to Girls Interests", Journal of Chemical Education, 9 (September, 1932). pp. 1620-1624.

Many interesting applications of chemistry related to everyday things in home life.

14. Mabee, Fred. C., "A Test of Achievement in College Chemistry and Results Obtained by Its Use with Both High School and College Classes", Journal of Chemical Education, 2 (November, 1925). p.1002.

Overlapping of high school and college chemistry.

15. Nason, Edith H., "The Teaching of Maintaining Interest in Chemistry in Teaching Students of Home Economics", Journal of Chemical Education, 2 (May, 1925). pp.386-389.

Shows that by giving practical applications of chemistry, interest is much greater in the teaching of home economics.

16. Osborn, Raymond W., "Some Suggestions for Modifying the Content of High School Chemistry to Better Serve the Purposes of a Liberal Education", Journal of Chemical Education, 2 (September, 1925). pp.737-742

Plan of reorganization of high school chemistry.

17. Osborn, R.W., "Report of the Committee on Re-Organization of High School Chemistry", School Science and Mathematics, 20 (March, 1920). pp. 240-242.

Aim of chemistry teaching.

18. Pierce, Edwin, "A High School Course in Trade Chemistry", School Science and Mathematics, 20 (January, 1920). pp.27-33.

Outline of a trade chemistry course at East Technical High School, Cleveland, Ohio.

19. Pierce, Edwin, "Teaching Science to Girls", School Science and Mathematics, 27 (November, 1927). pp.811-813.

A course in chemistry for girls.

20. Powers, S.Ralph, "Some Problems of Curriculum and Methods of Instruction in High School Chemistry", Journal of Chemical Education, 2. (November, 1925). pp.998-1007.

Overlapping of college and high school chemistry. Necessity of a reorganization.

21. Sampey, John R., "An Outline of Pandemic Chemistry", Journal of Chemical Education, 5 (October, 1928). pp.-1243-1249.

Description of class and laboratory work in a cultural chemistry course.

22. Segerbloom, W., "What the College Board Chemistry Examination is Doing for the Teaching of Chemistry", School and Society, 18 (September, 1923). pp.370-373.

Effect of the College Board Entrance. Examinations on high school chemistry.

23. Spencer, Mabel, "Chemistry in Vocational High Schools of the Middle West", Journal of Chemical Education, 8 (April,1931). pp.712-716.

Course of study for industrial chemists in the Community High School, Granite City, Illinois.

24. Stevens, Clarence, "New Courses in High School Chemistry", School Science and Mathematics, 32 (March, 1932). pp.244-249.

Investigation of the Pandemic movement in the United States.

25. Stone, Charles H., "The High School Chemistry Course Versus the College Requirements", Journal of Chemical Education, 1 (March, 1924). pp.55-58.

A plea for the loosening of the College Entrance Board Requirements. Desirability of practical chemistry.

26. Stubbs, Morris, "The Place and Problems of Chemistry in the High School Curriculum", School Science and Mathematics, 27 (October,1927). pp.741-748.

Shows necessity of revision of curriculum so that high school chemistry will serve those who are not going to college and will prevent repetition of material for those going to college.

27. Walter, Raymond, "Statistics of Registration in American Universities and Colleges in 1932", School and Society, 36 (December, 10, 1932). p.737.

Decrease of college and university registration in 1932.

28. "Report of the Committee on Relationship Between High School and College Chemistry", Journal of Chemical Education, 2 (August, 1925). pp.269-275.

Shows similarity of material taught in high schools and in colleges.

29. Glasoe, P.M., "The Deadly Parallelism Between

High School and College Courses in Chemistry", Journal of Chemical Education, 6 (March, 1929). pp.505-509.

Shows failure of colleges to stimulate interest in chemistry and the similarity between high school and college chemistry.

30. Haub, Hattie, D.F., "How to Teach Secondary Chemistry and Allied Science", pp.52-64, pp. 73-87, pp.265-266. San Francisco, California. Harr Wagner Publishing Company, 1929.

Teaching of chemistry as based on the cardinal principles of education. A course of study and the future of chemistry.

31. Koos, Leonard, "The Junior College Movement", pp.257-286. Boston, Massachusetts. Ginn and Company, 1925.

Overlapping of high school and college chemistry.

32. Monroe, Waler, and Weber, Oscar, "The High School". pp.344-369. New York, New York. Doubleday, Doran & Company, Incorporated. 1928.

Historical development of chemistry.

33. Twiss, George R., " A Text-Book of Science Teaching", pp.353-379, 388-396. New York: Macmillan Company, 1917.

Principles and methods of teaching chemistry. Practical suggestions in the teaching of chemistry.

34. Woodhull, John F., "The Teaching of Science", pp.40-45, 173-184. New York: The Macmillan Company, 1918.

Teaching principles with applications. Learning from experience.

35. "Report of the Special Commission on Education", pp.75-78. January 29, 1919. Massachusetts' Senate.

Effect of college entrance requirements on high school curriculum.

36. "National Society for Study of Education. Thirty-First Yearbook". Part I. " Program for Teaching Science", Bloomington: Public School Publishing Company, February, 1932.

Powers, S. Ralph, "What are Some of the Contributions of Science to a Liberal Education", pp. 27-40. Contributions of science to education.

Curtis, Francis A., "Investigations Relating to the Content of the Science Course", pp.116-118. Need of revising high school chemistry course.

Watkins, Ralph K., "Science in the Secondary Schools", pp.259-267.

a. Content of high school course.
b. Overlapping of high school and college chemistry.
c. Report of the American Chemical Society on standard minimum requirements.
d. Report of the North Central Association suggesting fourteen units.

37. Sylvester, Harold Dexter, "Current Tendencies in Secondary School Science", Unpublished Masters' Thesis, Boston University, School of Education.

Valuable material on practical science, trade science and the science of tomorrow.

38. "School Enrollment in 1932", American School Board Journal, 85 (November, 1932). pp.45-46.

Increase of secondary school enrollment in 1932 over 1931.

39. "School Document, Number Seven", Boston Public Schools (1932), p. 7.

Increase of secondary school enrollment in Boston from 1928 to 1933.