

THE TRENDS IN HIGH-SCHOOL CHEMISTRY  
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## I. INTRODUCTION

### A. The Purpose of the Study

"I used to think theology

was rather rough on doubt,

But chemistry with ions beats

theology all out.

You'd better join the church before

your course is well begun,

Because you'll need to exercise

the art of faith, my son."

The little verse above, by an unknown author, has a very pertinent application to the teaching of high-school chemistry. In the past it has not been teaching, it has been merely the handing out of facts to the pupils, where even the art of faith could not help the pupil, or guarantee results.

Many new agencies have contributed to the development of a new interest in revising and reorganizing the technique of teaching high-school chemistry. This new interest has led to the recognition of need for new aims, new content, and new methods of teaching.

Realizing that there has been a change, a reorganization, and a new development, the writer believes it would be well to point out some of these trends as revealed by a study of the teaching of high-school chemistry. The writer seeks to answer questions which are ever in the minds of enterprising, enthusiastic, and interested teachers, and to questions which prohibit other teachers from ever becoming very proficient in their work. Among

these questions would come: What are good methods? What are good methods for laboratory work? What should the course of study contain? Why have a chemistry club? Are projects valuable? What is the value of visual education? Are textbooks valuable? What should be the aims? What are the chief difficulties of pupils? How can a chemistry department be built up? Which is the better method, demonstration or laboratory? What helps are available for the teacher? Many other equally difficult problems should receive consideration. Also, most important was the construction of a cross-indexed bibliography of the literature dealing with the teaching of high-school chemistry. This was the basic feature of the study, for it was through the use of classification that the rest of the material was produced. And by the use of such a cross-indexed bibliography desired references on all phases of chemistry instructions, as given in the literature from 1923-33, can more readily be located.

#### B. THE METHOD USED IN THE STUDY

How might these questions be solved? What method of attack should be used? The study recorded here was made on the basic assumption that the most prevalent and outstanding results of investigations of these problems, both of research character and discussion type, would be found in the literature dealing with the teaching of high-school chemistry. So a survey of the literature from January, 1923 to July, 1933, on this topic, was made, the author reading all available studies of individuals and groups of individuals.

The method used in this survey consisted of the compilation of as extensive a bibliography as possible on the topics dealing

with the teaching of high-school chemistry, through the use of The Education Index, The Reader's Guide, The Loyola Index, and The Record of Current Educational Publications by Department of Interior, U. S. Bureau of Education. Then all the articles included in this bibliography were read and digested; during the reading of these articles, the writer found many other references which he added to his bibliography. By this method it is evident that a large majority of the articles which were published during this period were included in the study.

When all these articles had been read, they were prepared in an annotated bibliography which appears in the appendix. Then using the digests as material included in the articles, the articles were classified on an arbitrary basis for the development of a cross-indexed bibliography. The classification developed through the reading of The Teaching of High-School Chemistry, by J. O. Frank<sup>1</sup>, and A Program for Teaching Science, by the National Society for the Study of Education.<sup>2</sup> This classification helps one to locate desired articles readily.

#### C. SOME SIMILIAR STUDIES.

The investigation of the literature dealing with the subject, the teaching of high-school chemistry, brought to light the results of other investigations of the trends in chemistry teaching. In order to profit by the results of similiar studies, a careful study was made of their content. These similiar studies are mentioned here, and excerpts from them appear throughout the entire study.

<sup>1</sup> J. O. Frank, No. 63 (These footnote numbers refer to numbers in annotated bibliography, Appendix)

<sup>2</sup> Thirty-First Yearbook of the National Society for the Study of Education, Part I. (A Program for Teaching Science). (Bloomington: Public School Publishing Company, 1932).



F. D. Curtis has two volumes, a First Digest of Investigations in the Teaching of Science in Elementary and Secondary Schools and a Second Digest of Investigations in the Teaching of Science in Elementary and Secondary Schools in 1926 and 1932. The material and aim of his study are shown in the introduction by the following explanation: "A report of diligent search into the pedagogical literature of the past twenty years in an endeavor to make available for convenient and ready comparison, two types of research studies and investigations in the field of elementary and secondary school science. The two types are those with emphasis upon learning and those with major emphasis on curriculum and occasionally others which include tests etc., when they are definitely related to the previously mentioned material." He has in this first book selected the material on a purely arbitrary basis, feeling that his opinion was of sufficient value to determine the best of the literature. However, when he began the construction of the second volume, he asked help in the selection of articles to appear, by sending to the members of the National Association for Research in Science Teaching, a list of the proposed articles, asking them to select articles on relative merits. By this means he was able to improve the type of articles on the basis of viewpoints portrayed. However, in both volumes he has reviewed well the articles chosen, in a scientific, concise manner listing the material under findings, methods used, and conclusions and recommendations. He states the aim of these books to be a source and reference book for teachers, and a text-book for the teaching of science teachers.

Probably the most valuable yet produced of the investigations

of the trends and practices of science teaching has come as a result of the study made by the committee selected by the National Society for the Study of Education and published in the Thirty-First Yearbook, Part I, "A Program for Teaching Science". The introduction gives the aims and methods of the study, saying: "In the preparation of his report, attention has primarily been directed to the problems associated with the planning of a program for the teaching of science. There are evident discrepancies between the best thought in education and the current practices in the teaching of science....Under the influence of these uncoordinated and often conflicting agencies, science has not attained the recognition in the schools that it deserves.....The committee has focused its attention upon the essential elements in the program of education; namely, the gradual maturing children on one hand and the materials of education on the other."

In Chapters VI to IX, inclusive, there is an analysis of the contributions from educational research that relate to the field of science teaching. In these chapters are presented, in order, the interpretations of research relating: (1) to problems of classroom teaching; (2) to problems of laboratory teaching; (3) to the content of science courses; and (4) to curricular developments in school centers."<sup>3</sup>

J. O. Frank has written The Teaching of High-School Chemistry<sup>4</sup> in which he has presented material which he feels will be of immediate aid to those teaching high-school chemistry and will also offer such discussion and interpretation as possible on the many

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<sup>3</sup>

"A Program for Teaching Science", op. cit.

<sup>4</sup>

J. O. Frank, No. 63

unsettled and debated questions dealing with various aspects of chemistry instruction. He has attempted to list every important reference on the main phases of chemistry instruction in bibliographies placed at the ends of the various chapters of his book.

## II. THE TRENDS IN AIMS

### A. The Need for Uniformity.

It is related that a student of Agassiz, at the beginning of a course, said, "I suppose that you will begin with a general classification".

"No," said Agassiz, "I shall begin with a bushel of clams."

This statement, by one of the greatest teachers of science that history has ever known, holds a great meaning for any teacher. It also well applies to any investigation which is made. Here interpretation of the many researches and discussions in the field of high-school chemistry teaching should begin with something that is common, that forms a fundamental basis for all, and that can be appreciated.

In this investigation the most evident thing which would form such a common ground is the very apparent lack of uniformity and standardization, pointed out by many of the authors in the early part of this study. Then, continuing throughout this study, there is ever the idea expressed that there should be more standardization, more uniformity, and more emphasis on the values to be derived from collective organizations of teachers who have similiar problems and difficulties. Many science teachers, recognizing this value, have undertaken researches calculated to reduce the debatable features of instruction, and to develop chemistry-teaching methods so that results will be more in keeping with those which should be the outgrowth of a science study.

In order for the reader to appreciate some of these important

discrepancies, the writer gives excerpts from various authors dealing with the topics of instructions.

A. E. Brown and W. G. Bowers<sup>1</sup>, in an article written in 1923, point out that the chief items of instruction should be (1) observation, (2) generalization and (3) application.

Cornog and Colbert<sup>2</sup> in 1924 made a study of the aims of high-school chemistry by (1) sending a questionnaire to 550 high schools, (2) analyzing five textbooks, (3) compiling teacher opinion on the basis of things stressed, and (4) analyzing 3,600 examination questions from eighty-three high schools in thirty-seven states. The chief conclusions of the study were that: the teaching was a man's job; there was small attention to pure theory; the backbone of the course was devoted to parrot-like repetition of the texts; 24.7 per cent of final examinations were on equations and problems (the college idea); and there is a wide divergence in aims, not due to large and small schools or industrial regions. All of these conclusions point to lack of uniformity.

G. M. Browne<sup>3</sup> in 1925 made some rather radical statements; Namely, that chemistry is the foundation of living and should be given early in the high-school course; that the present topics should be changed to those of common good, such as a study of carbon compounds; that there should be no graduates from a high school who has not completed one year of high-school chemistry; and, also, that the idea of college ideals should be forgotten, for the colleges do not set up any special considerations for such a course.

A. L. Ferguson<sup>4</sup> in 1924 indicated that the high school chemistry

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<sup>1</sup> A. E. Brown and W. G. Bowers, No. 24

<sup>2</sup> J. Cornog and Colbert, No. 43

<sup>3</sup> G. M. Browne, No. 25

<sup>4</sup> A. L. Ferguson, No. 57

should be primarily disciplinary; develop ability to do, observe accurately, make logical inferences, draw correct scientific conclusions; and that practical application is distinctly subsidiary.

J. O. Frank<sup>5</sup> in 1925 made a list of objectives based on a study of authoritative sources, saying that instruction, training, inspiration, discipline, power to interpret, exploration and guidance, and recreation should be the objectives of a teacher.

W. C. Hawthorne<sup>6</sup> in 1923 suggested that high-school chemistry does not exist for the colleges, nor for what they consider valuable now but for what will be valuable in from ten to twelve years, and that it should train for living in sympathetic relationship to modern life. "A high-school chemistry course that does not make the boys and girls work--yes, and make some of them fail--is not worth while".

H. H. Humphrey<sup>7</sup> in 1926 said that everything has a chemistry aspect; that chemistry stimulates curiosity, the desire to invent, caution and admiration for truth; that all should be the recipient of a good broad general course in chemistry for better understanding of daily work; and that it should furnish a foundation on which to increase knowledge and an optimistic philosophy.

T. D. Kelsey<sup>8</sup> in 1925 emphasized the social values of work by pointing out that the course should build character, develop truth and accuracy, open-mindedness, need of weighing evidence, honesty, regard for others, some self government, and willingness to serve; and an inspiration should be gained from the lives of other chemists.

These citations from some of the authors of articles dealing with technique and, especially, the aims of high-school chemistry

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5 J. O. Frank, No. 66  
 6 W. C. Hawthorne, No. 89  
 7 H. H. Humphrey, No. 101  
 8 T. D. Kelsey, No. 109

show wide divergance of thought. It would not be difficult to continue with the list, but such is not the problem of this study.

Now, with these as examples of the wide diversity of thought, it is evident that a very serious obstacle to the progress of chemistry teaching lies in this diversity of thought. An early attempt was made by the Commission for the Reorganization of Secondary Education on "The Cardinal Principles of Secondary Education," which was published 1918, by the United States Bureau of Education, Bulletin Number 25. Although this commission attempted to crystalize aims of the secondary schools, the result was a list of general terms which we know as the seven cardinal principles; health, command of fundalmental processes, worthy home membership, vocation, citizenship, worthy use of leisure and ethical character. Then, since these did not especially pertain to science sources, a second bulletin was developed which attempted to show how the science teacher could contribute to the general aims set forth in the other report. But these were too general in terms for the teacher to get very desirable results. However, there was a distinct contribution made in the fact that the investigation brought a shift in emphasis from value to be derived from mastery of the subject matter to values more closely associated with human relationships and associations.

"The need was for specific aims which could be directly translated by the average teacher into classroom and laboratory activities which would result in the accomplishment of these aims."<sup>9</sup>

"The traditional support for physics and chemistry has been stated in terms of (1) formal discipline, (2) knowledge, and (3) college preparation; and the offerings in these fields have been the least affected by the movement initiated by the educators for

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<sup>9</sup> J. O. Frank, No. 63, pp 30-31

reorganization."<sup>10</sup>

The wide diversity in aims of the courses of teaching chemistry would at once indicate that there are probably as many different conceptions of methods and content. Realizing this, the writer believes that it is not essential to develop in this study the many different methods or the ideas of various advocates of certain types of subject matter; the knowledge that they are different is the essential factor.

Now the problem lies in what has, what is being, and what should be done, to develop chemistry teaching, by pointing out the most worthwhile phases of the work, by developing functional values, by cooperative planning and solving similiar problems, by making for uniformity and standardization in so far as is advisable, and by really placing the study of chemistry and its methods on a scientific basis.

In order to place chemistry teaching on a scientific basis, it is essential that the scientific method be used in the determination of the solution of the many problems that constantly menace the teacher. It is very evident that the old method of debate, and of merely setting forth of one's own opinions has but little value. So the application of scientific method to the problem should assure correct interpretation of these problems.

The chief means of science is research; so, as a result of the studies of the literature dealing with the teaching of high-school chemistry, those articles which have been the result of a survey of school practices, the results of some individual's inquiry into some pertinent problem, or the results of an investigating committee into problems of similiar nature should give many helpful, important, desirable and scientific attitudes and trends in the phases of the work undertaken.

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<sup>10</sup> QA Program for Teaching Science", p 24.



## B. The Type of Material in the Articles

The need for research on the problems of high-school chemistry instruction has been pointed out by E. R. Glenn<sup>11</sup> as a result of his study of articles appearing in magazines for twenty-five years before 1923, who found that but few of the articles were of any value to the classroom teacher, and that the articles were not continuous.

This study is dealing with the articles appearing in magazines and books for the years 1923-1933, and, in a manner similar to the method used by Glenn, the materials were analyzed. Figure 1, and Tables I and II show the results.

Research is quite essential in the process of bringing the methods of science teaching up to a desirable standpoint, a fact which is being recognized more and more by the teachers of the subjects. Chemistry is very much a science; and, consequently, such methods would be of extreme value to the improvement of the teaching of chemistry in the revision of aims, methods and content. Investigations of these phases have produced some results such as the minimum courses and minimum equipment; comparative values of different methods have shown the results of scientific application.

With this in mind, an analysis was made of the material in the articles read which are listed in the bibliography. Research studies were taken as studies which were actual experimental studies made on the pupils of one or more classes, with the express purpose of determining the value of some particular method, aim,

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<sup>11</sup> E. R. Glenn, No. 76

pupil difficulty, and studies of content included studies of analysis and comparison of textbooks of laboratory manuals and of courses of study. Other types of studies were listed as discussion, for they listed ideas, opinions and reactions of teachers or groups of teachers to a particular situation or condition. Using these two criteria, the subject matter of the articles appearing in the bibliography, was analyzed and is shown in table below, showing that in 1923, forty-six per cent of the articles were research articles.

TABLE I.

A COMPARISON OF NUMBER OF RESEARCH AND DISCUSSION ARTICLES  
1923-1933

YEAR	TYPES OF ARTICLES		TOTAL
	Discussion	Research	
1923	7	6	13
1924	11	13	24
1925	13	17	30
1926	12	8	20
1927	11	8	19
1928	5	13	18
1929	5	15	20
1930	9	10	19
1931	7	15	22
1932	6	6	12
1933	3	3	6

In 1924, this increased to fifty-eight and three-tenths per cent; in 1925, 50.6 per cent; in 1926, forty per cent; in 1927, 42.1 per cent; in 1928, 72.2 per cent; in 1929, seventy-five per cent; in 1930, 52.6 per cent; in 1931, 72.7 per cent; in 1932, fifty per cent; and in the first half of 1933, fifty per cent. This investigation has shown the type of articles on basis of content.

Having shown what the content is based upon in these various articles, the author next considers the question of who does the writing of these articles, and whether they are the men who should be advocating certain practices and theories. With this question in mind, the following facts were found to be true, as shown in Table II.

There are 205 references listed, 196 of which are magazine articles, in the bibliography which were written by 137 different men. How many articles each author wrote is shown in Table III. But of the 137 authors; sixty-nine, or 50.36 per cent were classroom teachers in high school at the time these articles were written; nineteen, or 13.862 per cent were university teachers; nineteen or 13.862 per cent were members of small college faculties, state colleges, and three are here included who were from academies; fifteen, or 10.946 per cent were from teachers' colleges; fifteen, or 10.946 per cent were either unknown or not listed as engaged in any phase of education.

TABLE II  
POSITIONS HELD BY AUTHORS OF MATERIAL READ

Authors	Total	Per Cent of Total
High schools	69	50.360
Universities	19	13.862
Other occupations	19	13.862
Teachers' colleges	15	10.946
Occupations unknown	15	10.946
<b>TOTAL</b>	<b>137</b>	<b>99.976</b>

Closely linked with the question of who writes these articles comes the question of the length of these articles, results of which are shown by Table III, in which the 196 magazine articles are classified on basis of length. Showing that twenty-seven one-half page articles were 13.77 per cent of the total, 30, 2-3 page articles were 15.3 per cent of the total, the largest number of articles being in this class; twenty or 10.2 per cent were 3-4 of a page; twenty-five or 12.75 per cent were 4-5 of a page; 29, or 14.88 per cent were 4-5 of a page; fifteen or 8.65 per cent were 5-6 of a page; thirteen or 6.63 per cent were 6-7 of a page; nine, or 4.59 per cent, were 7-8 of a page; ten or 5.10 per cent, were 8-9 of a page; six, or 3.06 per cent, were 9-10 of a page; four, or 2.04 per cent, were 10-11 of a page; two or 1.02 per cent, were 11-12 of a page; and the rest were single articles of fourteen, fifteen, eighteen twenty, thirty or thirty-five pages each, being .51 per cent of the total. All this shows that the majority of the articles, 66.9 per cent, are from one to six pages in length.

TABLE III  
LENGTHS OF ARTICLES READ

Length in pages	Number of articles	Per cent of Total
1.	27	13.77
2.	30	15.30
3	20	10.20
4	25	12.75
5	29	14.88
6	15	7.65
7	13	6.63
8	9	4.59
9	10	5.10
10	6	3.06
11	4	2.04
12	2	1.02
13	1	.51
15	1	.51
18	1	.51
20	1	.51
30	1	.51
35	1	.51
	196	

Do the authors who are writing these articles contribute regularly? A view of this situation was made possible by finding that; 117 of the authors had written only one article on the subject; 17 had written 2; 4 had written 3; 3 had written 4; one each had written 5 and 6 articles, and two men had written 7 articles on this subject. The table below shows this situation.

TABLE IV.  
NUMBER OF ARTICLES WRITTEN BY AUTHORS IN STUDY

Number of Articles	Number of authors
1	117
2	17
3	4
4	3
5	1
6	1
7	2

Thus far it has been the attempt of the writer to show the wide differences in aims, methods and subject matter of the teaching of

high-school chemistry along with the necessity for revision and organization, and the need for research in order to better the teaching, and some features of the articles reviewed in this study as shown by Tables I, II, III and IV. Further discussion and implications indicated by these tables will be shown in latter part of this study.

#### C. The Aims as Revealed by the Studies.

A result of these analyses of the subject matter dealing with the amount of research and amount of discussion material tend to give the idea that there has been a shift in tendencies, from discussion to research work. This condition has been pointed out as essential to the best interests of the chemistry teacher. Since this is true, then, what are some of the trends in and results of these researches along the instructional line, dealing with aims, subject matter and methods? Such a question can be answered by showing the result of these researches, that is, a resume of ideas presented by the authors of the articles included in the bibliography of this study.

The committee of the National Society for the Study of Education<sup>12</sup> has pointed out that it "----recognized the aim of science teaching to be contributory to the aim of education; viz; life enrichment."

Whether this viewpoint is accepted or not makes a great difference in the policy the teacher will have in his classroom, first of all with the aims that he will set up and strive towards. So the first important feature, probably the fundamental basis of the whole program of secondary-school chemistry, is the acceptance of a certain code of aims.

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<sup>12</sup> "A Program for Teaching of Science", (Bloomington: Public School Publishing Company, 1932) p 57

J. O. Frank<sup>13</sup> devotes a chapter in his book to the aims and objectives, listing and discussing these general objectives and attempting to point out that these general aims will be of value only insofar as they are directly translated into specific and objective activities which can be used in the classroom and laboratory. His list includes: (1) instruction, including understanding as well as knowledge, and a list of samples of principles, generalizations, and fundamental facts which he considers the basic material of such a course. Also the type of laboratory work that is to be given, giving instruction in observation, generalization and first hand information is included. (2) Training, the operation and manipulation which will leave the pupil with certain skills, abilities, attitudes and habits which are found in such work, with a list of these skills and abilities, habits and attitudes. (3) Inspiration, the establishment of ideals and appreciations following the study of the achievement of men of science. Also the pupils should be left with some enthusiasm for the subject. (4) Discipline, definite ideals of procedure and method, making for the scientific attitude and method of reasoning to free them from magic, fear of the unknown and superstition. (6) Exploration and guidance. (7) Recreation, by giving the pupils some tastes and appreciations which will give pleasure. These are his interpretation of the modern views concerning objectives of the high-school chemistry teacher.

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<sup>13</sup> J. O. Frank, No. 63

The standard minimum course<sup>14</sup> for high-school chemistry has done much for the reorganization of the technique of instruction, listing the aims as: (1) the service of chemistry to the home, health, medicine, agriculture, etc., and the service to the country, (2) developing the teaching around minimum standard topics, (3) using order teacher feels is best for his class, (4) training student in keen observation and exact reasoning, (5) carefully correlating laboratory and recitation, (6) encouraging the keeping of accurate, concise notebooks, (7) building on the knitting with other science courses, (8) encouraging the use of references, (9) helping the students to find themselves determining whether they have aptitude for further study and if so encouraging them, and (10) stressing general principles.

As result of the study of the aims shown in the field, the courses of study, textbooks, and curricular investigations, K. M. Persing<sup>15</sup> presented a list of 235 specific objectives, and pointed out that there was a high degree of standardization found. These objectives are not, of course, as the number indicates, bases for fundamental phases of the course.

The objectives of high-school chemistry teaching according to the consensus of opinion of the Chicago Association of Chemistry Teachers were: (1) getting an appreciation of chemistry and science as early as possible, (2) teaching the use and understanding of the scientific method of problem solving, (3) correlating facts to build principles and laws, (4) applying principles and laws to daily problems, (5) co-operating in groups for human welfare, and (6) developing moral law and religious attitude in daily life.<sup>16</sup>

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<sup>14</sup> Committee Report, No. 107

<sup>15</sup> K. M. Persing, No. 142

<sup>16</sup> H. R. Smith, No. 171



At a discussion of the American Chemical Society<sup>17</sup> in 1925 several men gave their opinions on what the objectives of chemistry teaching were. W. C. Morgan pointed out that there was too much emphasis on method, too much emphasis on texts, too much information material, and that scientific method is not even mentioned in the minimum course. J. E. Bell stated objectives as the creation of high-minded, broad-minded and open-minded pupils, the instillation of scientific mind into pupils, and the realization, appreciation, and understanding of chemistry in simple phases. L. F. Foster lists objectives as better methods, less information, and methods of teaching which will give subject matter in a well organized manner.

In these statements of various men who are interested in the development of chemistry teaching have been revealed several similiar features regarding the objectives and aims of a good chemistry course. Probably it would be wise to give here a list which is comprehensive and covers all the aims which have come from many sources. Such a study was made in 1925 by S. R. Powers, who gathered the aims from many sources and stated that he felt that the list produced covered all objectives which have been defined in literature on the subject. The objectives should be, on the basis of Power's study:

"(1) To give pupils a broad genuine appreciation of what the development of chemistry means in the modern social, industrial, and national life.

"(2) To satisfy the natural interests in the things and forces of nature with which men are surrounded and with which they must deal; to give information which is interesting for its own sake.

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<sup>17</sup>Symposium, No. 189

- "(3) To provide opportunity for the student to become acquainted with the application of chemistry to industry for the purpose of educational and vocational guidance and possibly to furnish a beginning of vocational training.
- "(4) To develop such broad concepts and natural laws as the ultimate composition and indestructibility of matter, nature of chemical composition, interrelation of chemical elements, etc., to the end that science and reality may function in place of superstition and uncertainty in explaining natural phenomena.
- "(5) To contribute such specific ideals, habits, and concepts as those of accuracy, achievement, persistency, open-mindedness, honesty, cause and effect, which are essential to the study of science.
- "(6) To develop system, order, neatness, and possibly other attributes, to the end that they will function in the ordinary affairs of life.
- "(7) To afford in some measure an opportunity to show the importance of scientific research and to stimulate the the spirit of investigation and invention on the part of the student.
- "(8) To give the children full opportunity to indulge in the playful manipulation of chemical material, in order that they may explore the world of reality as widely and as deeply as possible.
- "(9) To provide opportunities for acquaintance with such applications of chemistry in public utilities, in order that the student may more adequately fulfill the duties of citizenship.

- "(10) To provide opportunity for acquaintance with such applications of chemistry as contribute to the maintenance of health of the individual and the community.
- "(11) To provide opportunity for acquaintance with the elementary laws of nature which aid in understanding those citizenship problems which arise in connection with such topics as waste products, elimination of smoke, pure foods, etc.
- "(12) To make pupils able to read more intelligently and with greater interest, articles on chemistry in magazines and scientific books of a popular character.
- "(13) To give such training as will result in increasing respect for the work of recognized experts."<sup>18</sup>

This inclusive list of objectives brings clearly to the front one of the most important of the trends which have been made in chemistry teaching, the fact that the pupils are becoming the center of activity, that teachers are attempting to meet the needs and interests of them, rather than use the subject matter as the center. But still, in this list are many broad and meaningless objectives; and, too, the length of the list places a bar, in that so many could not be well met in a single course.

In answer to this the committee in the Thirty-First Yearbook of the National Society for the Study of Education has attempted to formulate objectives in terms of the controlling concepts or ideas necessary to understand facts in chemistry, to train in scientific method, and to develop attitudes:

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<sup>18</sup> S. R. Powers, No. 145

- "(1) Pupils should develop better understandings of fundamental concepts which will enable them to better interpret natural phenomena, common and industrial applications of principles.
- "(2) Pupils should learn the use of the reflective thinking problem solving, and techniques of study which best apply to problems presenting themselves, especially those which are met in daily life.
- "(3) Pupils in senior-high-school classes should develop attitudes toward facts, principles and methods of investigation which will guide them in use of such facts, principles, and methods in problem solving."<sup>19</sup>

#### D. Summary and Conclusions.

In conclusion then, the results of the latter two studies just mentioned show the present objectives and aims in the teaching of high-school chemistry as they are generally accepted. The most important feature to note is the stress placed on the needs and interests of the individual pupil, and the creation of aims in terms of the great majority of those who take the courses, rather than in terms of those preparing for college.

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<sup>19</sup> "A Program for Teaching of Science". (Bloomington: Public School Publishing Company, 1932), pp 259-61

### III. THE TRENDS IN SUBJECT MATTER

There have been several agencies which have exerted a very powerful influence on the content of high-school chemistry courses, among them are chiefly the College Entrance Examination Board and the New York Regents. Through these agencies, and to a large extent, as a result of their demand, the present textbooks have been written. This influence is now deemed detrimental to the best interests of the pupils, for the aims have changed, by attempting to meet the needs and the interests of the great majority of pupils who will never take any more chemistry or will never go to institutions of higher learning.

What is the influence of the textbooks on the teaching of chemistry? This can be answered in the statement that for most teachers the textbook serves as a core for the course. Then for the most part standards set by these governing agencies and resulting material included in the texts has largely been the cause for poor teaching of high-school chemistry. It is to be realized however, that there are other factors to be considered.

#### A. Textbook Analyses.

With this in mind, some of the analyses of textbook material, some of the courses proposed by men in order to meet the objectives, and results of committee investigation on essentials and minimum content of high-school chemistry courses will be given.

By analyzing five textbooks and thirty-six hundred examination questions, Cornog and Colbert<sup>1</sup> were able to show some representative samples of subject matter included in textbooks and examination questions.

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<sup>1</sup> Cornog & Colbert, No. 43

The results of the textbooks analyses show that the subject matter was 55.8 per cent descriptive material, 25.2 per cent useful applications, 5.9 per cent equations and problems, and 13.1 per cent theory. This is shown in Figure 1.

The stress placed on various phases of subject matter was shown by the results of a questionnaire to teachers in that 32.3 per cent was descriptive, 25.5 per cent useful applications, 21.8 per cent equations and problems, and 20.7 per cent theory as shown in Figure 2.

The examination of the questions by the New York Regents revealed the subject matter as 32.3 per cent descriptive, 37 per cent useful applications, 23 per cent equations and problems, and 6.7 per cent theory, as shown in Figure 3.

The examination of the average, high-school examination questions indicates that 42.4 per cent is descriptive, 20.4 per cent useful applications, 24.7 per cent equations and problems, and theory 8.5 per cent as shown in Figure 4.

The content of the College Entrance Examination Board questions shows that the subject matter is 24.4 per cent useful applications, 32.1 per cent descriptive, 29.2 per cent equations and problems, and 12.3 per cent theory; this is shown in Figure 5.

The summary of the study indicates that theory is of but little importance; the backbone of the course is parrot-like repetition of text material; importance of equations and problems is the college idea; there is a wide divergence in aims; the general aims are not due to large and small schools or to industrial situations or geographical regions; and that chemistry is not a memory subject

*p. 26 out of order between p. 12 and 13.*

and should not be taught as such.

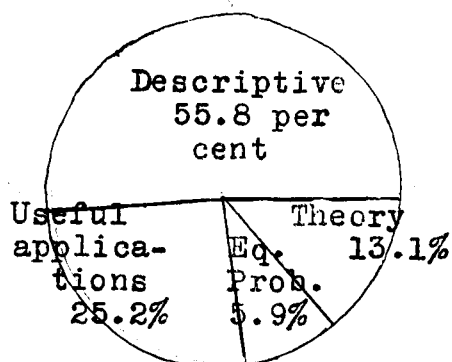


Figure 1. Average content of high-school texts.

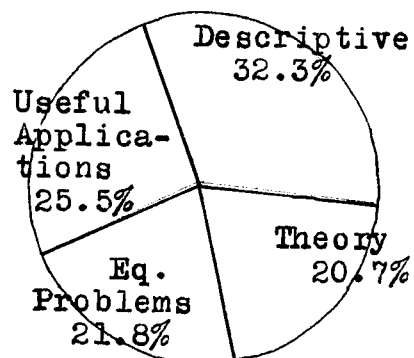


Figure 2. High-school teachers' stress in courses.

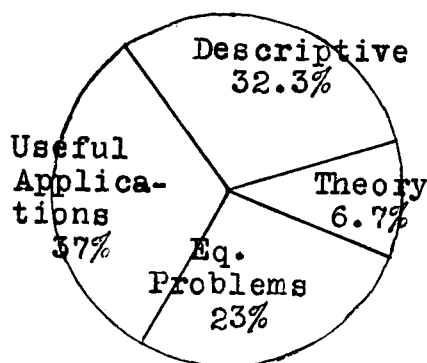


Figure 3. New York Regent questions.

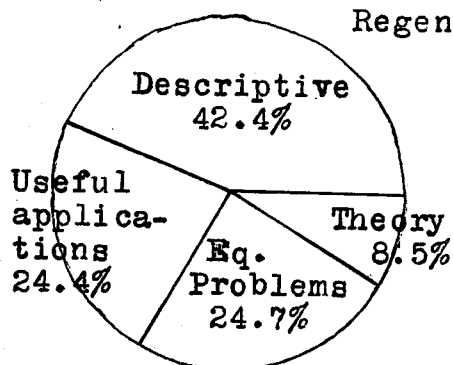


Figure 4. Average content of high-school examination questions.

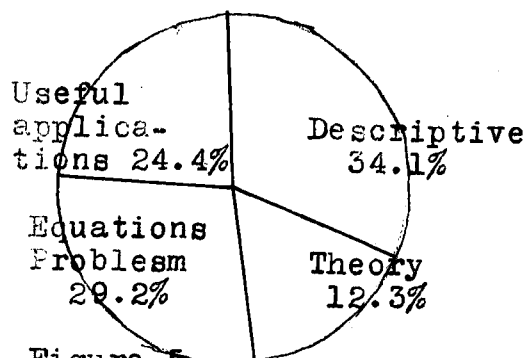


Figure 5. Content of College Entrance Board questions.

Various other men have made analyses of textbook material and the majority have pointed out the necessity of removing the large amount of descriptive matter from the texts and basing the work, to a large extent on concepts and problem situations which will give the pupils training in the method of scientific thinking.

#### B. Courses of Study.

A great influence in the reorganization of the chemistry course in relation to content has come through the results of the Committee on Chemical Education of the American Chemical Society.<sup>2</sup> The report presented by the, the "Standard Minimum Course", has not attempted, in terms of objectives which are at present felt to be the most essential, to present content based on important major ideas. A great value, though, has come from this minimum course, in that it has to some extent standardized material and given many helpful aids and hints to teachers.

E. E. Bayles<sup>3</sup> has attempted to outline a course based on principles of giving the student the only systematic view he will ever get of chemistry, which may lead him into the work as a vocation, but is primarily for those who will not go further. His course is based on (a) needs, which are defined as a speaking acquaintance with the common facts of chemistry, and the ability to apply principles to problems when they appear; (b) principles, the main underlying concepts not facts; and (c) order and method, using the unit plan with inductive and deductive methods of thinking.

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<sup>2</sup> Committee Report, No. 38

<sup>3</sup> E. E. Bayles, No. 7



### C. Content of Courses Today.

J. O. Frank<sup>4</sup> lists some plans which have been utilized to derive and select subject matter in an efficient manner, including; (1) an evaluation of generalizations on basis of contributions to civilization and general welfare, (2) a study of questions in the field which are asked by students, thus anticipating their interests, (3) an analysis of peoples' activities and the building of a program on the increasing efficiency of these activities, (4) the construction of a course based on activities related to production, transportation, and consumption of products, (5) an analysis of reading material found in the community, showing that material will be most conducive to increasing living efficiency in the locality, (6) the planning of a program as a result of study of the needs of pupils after they leave school, and (7) the use of a syllabus prepared by the Committee on Education of the American Chemical Society in 1926, although it is not the result of objective evidence.

This whole list of suggestions again brings out the need of research into the field, the need for objective evidence to substantiate the material included in the high-school course. Some of the methods above have been used; many others have been suggested; but the teacher, for the most part, has not tried to answer the problem. To a large extent it should be answered by the product of his work, and as a result of co-operative effort on the part of all teachers dealing with this problem of high-school chemistry teaching.

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<sup>4</sup> J. O. Frank, No. 63

Thus far an attempt has been made to bring to view some of the ideas which are prevalent concerning the content of chemistry courses. It is evident that there is need for reorganization and, to a large extent, removal of the prevalent ideas which are not distinctly based on the aims and objectives as they have been previously outlined.

There are some later studies which seem to indicate the best trends in subject-matter content of chemistry, on the basis of the aims which are not existent.

Pandemic chemistry is the term which has been used by C. P. Stevens<sup>5</sup> in describing a type of chemistry for the layman which grows out of the results of his study of the professional literature and results of a questionnaire sent to 235 representative high schools. The principles of such a course are; stressing the material dealing with the dependence of civilization on chemistry in problems of health, home, defence, pleasure, agriculture, medicine, industry, and cultural aspects; making pupils the center rather than subject the center, making it only difficult enough for the average high-school student; stressing psychological principles; placing less stress on laboratory technique and demonstrations of the cook-book type.

Another study, in which a definite set of units has been selected is a distinct step in formulating content on the basis of concepts and in accord with recognized aims, was made by the subcommittee on

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<sup>5</sup> C. P. Stevens, No. 176

Chemistry of the North Central Association.<sup>6</sup> In the report appear the following units:

- "1. Chemical changes in everyday life.
- "2. Elements, the simplest form of matter.
- "3. The ten elements necessary to life.
- "4. Some simple compounds of the essential elements.
- "5. How simple compounds combine to form others.
- "6/ Some other useful and interesting elements.
- "7. The relation of chemistry to human health.
- "8. Uses of chemistry in the home.
- "9. How chemistry is applied in industries.
- "10. Applications of chemistry in our daily life.
- "11. How chemistry contributes to the welfare of society.
- "12. The chemistry of plant and animal life.
- "13. The relation of chemistry to the progress of civilization.
- "14. Generalizations and the solutions of problems."

The list of units here given are, in large part, the result of placing the emphasis on application and used of chemistry, without special emphasis on larger generalizations, but details are not worked out sufficiently to indicate that such units are not valuable.

It has been pointed out in the aims of high-school chemistry that the attempt to give the pupils general controlling concepts should be of primary importance; then, with this in mind, it would be well to describe a course based on controlling concepts, as ideal.

The details of such an ideal course are yet to be worked out, but the committee<sup>7</sup> in its report in the Thirty-First Yearbook has given some examples of major generalizations and an illustrative

<sup>6</sup> W. H. Lancelot, No. 116

<sup>7</sup> "A Program for the Teaching of Science", page 265.

outline for organization under such generalizations.

The generalizations suggested are:

"I. When a chemical change takes place, the substances that are involved are changed in such a way that they no longer behave as they did before the reaction occurred.

"II. In a chemical change, a quantitative relation exists between the amounts of the substances reacting and the amounts of the substances that are products of the reaction."

These generalizations are used as the fundamental bases upon which teaching units are build. Although the committee has done much in the field of improving high-school chemistry teaching, the amount of work in the determination of these materials which will contribute to placing the content of chemistry in a clearly organized form on the basis of ideas just set forth, has been very small. Here is a wide territory for experimental education, and these are important problems which need scientific methods of solution.

#### D. Summary and Conclusions.

Then regarding the question raised at the beginning of this discussion dealing with the content of high-school chemistry, concerning the influence of textbooks on chemistry teaching, the answer would be that it has had, in the past, a detrimental effect.

This has been due to factors which have controlled the material included in the texts, such as, College Examination Board, New York Regents, the State Departments of Public Instruction, the North

Central Association of Colleges and Secondary Schools, the Southern Association of Colleges and Secondary Schools, and others. But these are not the only factors; teacher training has in a large measure helped to determine the content, for the teacher will tend to emphasize that with which he has been impressed in his school work.

To continue with the problem of content of high-school chemistry courses aside from that presented in the textbooks, there has come, as a result of many factors, chiefly those which have revised the aims of high-school chemistry, a new concept of subject matter. This is the direct result of these changed aims which have placed chemistry in the class of those subjects which are pupil centered rather than subject centered. The content has not yet been worked out so that hard and fast rules concerning what has to be taught have been established; in fact, it is an almost unexplored field. However, it is clearly pointed out that what is to be taught should include items and units of material clustered around major controlling generalizations of chemistry.

#### IV. THE TRENDS IN METHODS.

The scientific methods of educational research have made a greater contribution to classroom teaching methods than to any other phase of instruction. The study of literature dealing with methods of instruction are quite helpful and also very numerous; in the articles included in this study, the bulk of the material dealing with research work has been that which deals with methods. It is not true, though, that all problems in this field have been completely and thoroughly solved; many researches have only been made once, and they need verification and modification. No attempt is made here to cover the whole field, or to reach definite conclusions on the many problems of teaching methods, but the idea has been to give some of the results of important investigations which may throw light on the better and generally accepted methods.

##### A. The Problem of Grouping.

In the teaching of high-school chemistry, as in all subjects, many problems come to the teacher. A very important one which is the first to confront some teachers is that of recognizing individual differences. The problem of grouping students on the basis of ability, intelligence, previous science training, or some other criteria or group of criteria is a difficult one. The majority of teachers do not have this problem, their schools do not have a large enough enrollment to warrant such segregation. Schools which have large chemistry departments have this problem, and it is met in ways devised, for the most part, by the instructor, who knows the actual situation and is the person most capable of handling it. An important feature to remember is that the bright

students should be given as great consideration as the dull students. Some of the various plans for segregation of pupils will be found listed in the bibliography.

#### B. The Use of Psychology.

The teacher of high-school chemistry should use the methods of psychology if he expects to make his teaching valuable. He should first of all, develop interest, for interest increases the efficiency of the learner. He should recognize mind-set, in the setting up of a problem. Questions and problems should be so developed as to bring satisfaction with the answers, thereby, increasing the strength of associations. He should use care in selecting only important and relevant associations for the pupils, so that they will not have to break a habit or an association. The principle of analogy should be recognized. Then, very important is the idea of strengthening associations by use and recency principles. To a greater extent these principles are coming into use, through the influence of educational psychology.

##### 1. The development of interest.

How is it possible to increase interest in high-school chemistry? This is a pertinent problem and the answer should be given to all teachers of high-school chemistry, if they do not already feel confident of their own ability to answer it. Some of the methods used as a result of studies by various men will give answers to the problem suggested here. Probably none of these methods suggested would work in all situations; they are just suggestions and results of the use of various plans in different

school systems.

Robert Collier, Jr.<sup>1</sup> discusses the methods used in his school and lists them; (1) make a more general course, (2) use of laboratory reports, (3) factory trips with discussion and report, (4) social trips, (5) chemistry club, (6) inviting outside speakers on chemical topics, and (7) the essay contest of the American Chemical Society.

R. E. Hoffman<sup>2</sup> also lists some aids in developing interest; namely, (1) let the pupil have a good time thinking and wondering, (2) get familiar things in the library instead of cut and dried things, (3) make interesting problems and questions, (4) occasionally give a thought quiz with textbooks open, (5) remember that the textbook is not complete, (6) visit industries, and (7) use magic. It always has an appeal.

B. F. Lamont<sup>3</sup> suggests the use of chemistry posters, projects and exhibits, freedom in the laboratory, qualitative analysis the second semester, science honor societies, a chemistry club, the essay contest, and a library for supplementary reading.

In an attempt to sell high-school chemistry to the community, R. C. Kistler<sup>4</sup> developed chemistry teams which had inter-school contests on essays, equations and formula writing, and displays.

The plans suggested here are just a few of the many that have been developed by teachers in actual situations and embody

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<sup>1</sup> R. Collier, Jr., No. 36

<sup>2</sup> R. E. Hoffman, No. 95

<sup>3</sup> B. F. Lamont, No. 115

<sup>4</sup> R. C. Kistler, No. 111



the major ideas used by all. It is probable that much space could be utilized to discuss the conditions of these methods used to stimulate interest. Only two seem important enough to warrant special consideration here—the chemistry club and the chemistry library.

## 2. Development of Chemistry Club.

Consideration of the chemistry club for use as an agent in increasing interest is mentioned here. It is doubtless the best aid of all outside activities for increasing interest. There have been several studies made of the values of chemistry clubs, and many have listed plans for the development of such a club. These studies point to the development of a functional group where the amount of value lies for the greatest part, in the set-up of the club, and, especially, the type of leader and programs given. Some teachers are skeptical over the value, but many feel that with careful consideration such a club will be an asset to the teacher and the pupils.

## 3. Importance of a Chemistry Library.

Another device for increasing interest, is a device which will also make for increased efficiency on the part of the pupils, and will materially aid the teacher. This is a library of chemistry books, or at least a section in the regular library of good reference books, histories, texts, theories and popular books on the application of chemistry to various phases of life. No teacher can afford to be without some sort of a library, and many lists of books have been developed with the idea of helping the teacher construct a chemistry library in his high school.

### C. The Study Problem.

Another phase of teaching technique should be mentioned early for it is ever a problem with the teacher, that is, the problem of study. Since science is very often a new field for the pupil, it is essential that the teacher instill in his students methods of study. The teacher should early in the work emphasize the necessity for continuous study if he intends to succeed in his teaching and to give the pupils the same idea. Much of the blame for lack of study on the part of the pupils can be traced to the teacher; for too few teachers give definite learning exercises, show students how to study, know of pupil's study conditions, select exercises which are of value in meeting aims, and attempt supervised study.

These factors in the study problem have also been met and considered from a scientific viewpoint by several research men, who show actual values of a result of experimental studies with these enumerated conditions. In order to give an idea of the importance of some of these factors, part of the studies will be given.

In an investigation of the study methods used by high-school students, O. A. Crosby sent a questionnaire to chemistry students in Detroit high schools and found that it was as much a question of how to study as it was of lack of study which was responsible for failure, although the majority of failing students spent only a few minutes each day in study.<sup>5</sup>

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O. A. Crosby, No. 45

K. M. Persing<sup>6</sup> attempted to determine the value to the pupils of teaching paragraph summarizing of textbook material and comes to the conclusion that there is fairly clear evidence that training in paragraph summarizing as applied to chemistry means a decided improvement in learning efficiency.

This same point, as well as the facts that specific training and practice in answering of thought questions based on the application of scientific principles is more efficient than incidental methods, and that training in ability to analyze the content increases the ability to interpret and reproduce, has been shown by Beauchamp's study.<sup>7</sup>

A study of the comparative values of the conventional recitation plan and the unit supervised-study method, according to J. C. Chapel<sup>8</sup>, shows the latter to be the superior.

#### D. The Means of Giving Information.

Thus far only the methods used in preparing a class for actual work have been mentioned; the next development will show the results of studies made into actual classroom and laboratory situations in attempts to determine the relative values of methods of instruction.

##### 1. Lecture Method.

In the past there has been a tendency to use the lecture method in teaching high-school chemistry, but for the most part it is an old system, although the wise teacher can today use this

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<sup>6</sup> K. M. Persing, No. 140

<sup>7</sup> W. L. Beauchamp, Studies in Secondary Education I, Supplementary Educational Monographs, No. 24, University of Chicago, 47-87, 1923.

<sup>8</sup> J. C. Chapel, No. 32

method very effectively. The majority of condemnation of this method is due to the lack of the use of other methods; the fact that this method is used for all material is the admittance by the teacher that this is the easiest and simplest thing for him. But there are other methods of teaching, much more effective for certain materials, which the wise teacher will use when he knows they will bring the desired results; he will recognize the limitations of the lecture method.

### 2. Demonstration Method.

The demonstration method of teaching also has long been used by teachers. It has been questioned and has been highly recommended; numerous researches have attempted to show the superiority of the demonstration over the laboratory method, and vice versa, but the researches have not yet decided the answer to this problem, for we find such results as the following.

"The lecture demonstration method of instruction yields better results than the laboratory method in imparting essential knowledge and is more economical of time and expense. This is true for both bright and dull pupils and for all types of experiments.---

The lecture demonstration method appears to be the better method for imparting skill in laboratory technique in its initial stages and for developing ability to solve problems."<sup>9</sup> However, E. R. Downing<sup>9</sup> goes on to point out that these are tentative conclusions and additional experiments are essential to proof.

### 3. Individual Laboratory Method.

R. E. Horton<sup>10</sup> and W. W. Carpenter<sup>11</sup> have presented studies of

<sup>9</sup> E. R. Downing, School Review, 33:688-97, 1925

<sup>10</sup>R. E. Horton, No. 99

<sup>11</sup>W. W. Carpenter, No. 31

this problem which are in advance of any others yet completed in regard to technique and statistical results. The former pointed out certain substantial advantages of the individual laboratory method over that of demonstration, listing the order of preference, as his study indicated, as; (1) individual laboratory without directions, the real problem method, (2) individual laboratory method with generalized directions, and (3) demonstration of experiments by teacher. Carpenter states that the majority of pupils succeed as well by the demonstration method as by individual exercises if success is measured by instruments used to measure specific information and ability to think in terms of chemistry.

As a result of a study of conditions in a California school, T. L. Nelson<sup>12</sup> pointed out that the demonstration method was the more effective and advocated wider use of this method.

W. W. Knox<sup>13</sup>, in a study of the relative value of demonstration and individual laboratory methods, shows that the demonstration method is the superior on the basis of immediate retention of subject matter; on the acquisition of the scientific attitude it offers the best opportunity to recognize individual differences; but that laboratory was slightly superior in the average inferior pupils work.

J. O. Frank<sup>14</sup> summarizes the condition by saying that the superiority of the demonstration method has not yet been proved; that failure of teachers to improve laboratory experiments has

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<sup>12</sup> T. L. Nelson, No. 133

<sup>13</sup> W. W. Knox, No. 113

<sup>14</sup> J. O. Frank, No. 63.

been the cause of condemnation of the laboratory system; that there is necessary a first hand contact with materials if the objectives are to be met; that some pupils learn by one method, some by others; and that it is essential to give first hand information to those who profit best by such a method. However, it is to be recognized that the demonstration method has a definite place.

#### 4. Relative Values of Methods.

In summing up the results of these various studies dealing with methods of imparting information, the writer finds that it is evident that no definite plan will always work, that demonstration is necessary at the beginning of a course in order to give the pupils some familiarity with apparatus; demonstration saves time which could be used valuably for other types of exercises; the demonstration method enables the teacher to present difficulty, dangerous, and other types of experiments which it would be impossible for the pupils to do. Here again it falls to a large extent upon the teacher as to the selection of methods for the various topics and subjects which he takes up. He knows best his abilities, the content of his laboratory, the pupils in his class, and, too, he will get the best results when he adopts methods to fit his situation. Many studies have given aids and suggestions in the types of experiments, demonstrations, and techniques for the methods which will be of value.

#### 5. Socialized Recitation Method.

There are two recognized methods of classroom teaching, the conventional question and answer recitation and the socialized recitation. Deciding which type to use is another problem for the teacher. The former method is of value if used correctly, that is,

to creat real problems, and to develop clear, connected thinking. The latter method is that kind of instruction for which many strive but are unable to reach because they are unable to conduct the discussion correctly. They cannot keep the pupils alert and attentive. They do not know when and where to guide thoughts and problem so that results will be produced. They expect the pupils to answer some questions and get enthusiastic over things about which they are not enthusiastic themselves. There is a special technique for the development of a good socialized recitation, suggestions can be found in much detail as to the features to watch and methods of conduction, in literature dealing with this method of teaching.

#### 6. Project Method.

Today there has been a tendency to change to another method of classroom teaching, the project method, a change which has increased the efficiency of teaching. At least, this is the stand taken by E. Bloom<sup>15</sup>, H. D. F. Haub<sup>16</sup>, M. Henkel<sup>17</sup>, S. D. Iaw<sup>18</sup>, O. E. Underhill<sup>19</sup>, and F. B. Wade<sup>20</sup>. However, this method also has limitations, and it would take a very gifted teacher to follow some of the techniques advanced by advocates of this method. However, most teachers can well apply some phases of the project method to their teaching.

#### 7. Visual Education.

Visual education has come into prominence over a period of

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- 15 E. Bloom, No. 110  
 16 H. D. F. Haub, No. 88  
 17 M. Henkel, No. 94  
 18 S. D. Law, No. 117  
 19 O. E. Underhill, No. 191  
 20 F. B. Wade, No. 195.

years; consequently it has been utilized in the teaching of chemistry. Several investigations have been made of the value of the use of slides and motion pictures in the science classroom, all pointing to the fact that these devices are not to be used to supplant present methods of instruction but only to supplement and then only when the teacher feels sure that the material will be such that it will focus the pupils' attention on desirable outcomes in terms of aims, and will not be merely entertainment.

#### 8. Methods for Improving,

The scientific teacher will not only exert effort to give his pupils the best methods of instruction he has for the various phases of work, but he will also be ever alert to diagnose pupils' difficulties and errors and thus improve the quality of his teaching. In order to appreciate some of the studies made by teachers in an effort to improve classroom instruction by diagnosing pupil difficulties and errors, some research studies will be mentioned.

The difficulties, according to A. R. Stewart<sup>21</sup>, are the lack of objective tests, too much material to cover, and lack of time.

H. L. Gerry<sup>22</sup>, pointed out that terminologh, misspellings, notations, and laboratory knowledge were the chief items which need correction.

The lack of definite assignments is, according to the results of J. C. Bennett's<sup>23</sup> investigation, the chief source of pupil difficulty.

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<sup>21</sup> A. R. Stewart, No. 177

<sup>22</sup> H. L. Gerry, No. 71

<sup>23</sup> J. C. Bennett, No. 9



Other studies also tend to point out the need for improvement in teaching methods, for objective tests, for testing and reteaching, for better assignment technique, and for better standardization of textbooks, especially pertaining to definitions and equation writing. All of which improvements will contribute to better results for the teacher.

#### 9. Summary and Conclusions.

The real value of these various investigations of methods of teaching in the classroom and laboratory lies in showing the classroom teacher that there are many good ways of presenting subject matter. That these methods are of value to the teacher, not as a panacea for former classroom difficulties, but as potentialities by which he can materially improve the efficiency of his teaching. In order to accomplish this end, it will be necessary for the teacher to master the varied techniques and adapt these techniques to situations calling for the recognition of individual differences in classroom instruction.

## V. A SUMMARY OF THE TRENDS

The purpose of this study is to discover the trends in the teaching of high-school chemistry; the present concepts in aims, content, and methods have been discussed from this viewpoint. But in order to collectively examine these tendencies so that some implications and needs can be determined, a review of the trends is here given.

First, there is a recognition of the necessity for the application of scientific methods of research into the problems confronting the high-school teacher. This field has hardly been touched; although many studies have been made, they are in need of verification and modification, and the number of problems that have not been considered is enormous. Here is an open field for educational investigation not only for the research man, but also for the teacher. The cooperation of the teachers as a result of their individual investigations could do much toward improving their general technique.

Second, there is a need for uniformity in aims, in order to establish a closer relationship between teachers, and to effect an improvement in instruction. Most important of all is the changed concept of aims. The changed concept in aims has had a most powerful effect on instruction, for it has changed the subject from a subject-centered to a pupil-centered one. Here, too, there is unlimited opportunity of investigation, in the determination of what the pupils need, what they can understand, and what their interests are.

Third, the change in aims has materially affected the content of the high-school chemistry course, as would be expected when the stress has changed to emphasis on interests and needs of the pupils, rather than on chemical facts. This has accordingly necessitated the development of new courses of study, and, most important, has brought the realization that present texts are not constructed with these aims in mind. Many analyses made of the present textbooks show the lack of logical arrangement, lack of recognition of prevailing aims, the attempt to cover too much material, and various other deficiencies; but only a few new texts have appeared which recognize and correct the deficiencies pointed out. There is need for the construction of new textbooks which will remedy these evils, as well as the need for the development of courses of study which will meet the new requirements and standards.

Fourth, there have been many investigations of the development of special methods for teaching high-school chemistry, there is room for many more, but these investigations have not brought a sure cure for classroom difficulties. The results have shown the teachers many devices for teaching which can be used as supplementary methods and are used to improve the quality of the whole instruction.

Fifth, an increasing interest in the measurement of the accomplishment of the pupils has led to various studies in the field of tests and measurements as pertaining to high-school chemistry. For these there is a great need; the special needs in

phases of work have been shown by diagnosis of pupil difficulties and errors. There is also recognition of the need for much more of this type of work if the technique of instruction is to improve.

Sixth, there is recognition that the principles of psychology can be used advantageously in the teaching of high-school chemistry. With the development of the use of these principles, especially the one dealing with interest, much improvement will be forthcoming.

One committee<sup>1</sup> has summarized the trends of science teaching in twelve topics, which are somewhat more specific than the trends resulting from the analysis of the literature. These are listed here and show a close correlation to the ones just mentioned.

- "1. A critical review and analysis of the investigations already reported of teaching procedure.
- "2. An attempt at refinement, better description and definition of science demonstrations as teaching devices.
- "3. An attempt at redefinition, better limitation and description of laboratory instruction, with attempts an evaluation of laboratory instruction as a means of producing certain definite outcomes in pupils.
- "4. A marked swing toward a unit organization of subject matter and instructional techniques in all high-school sciences.

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<sup>1</sup> "A Program for Teaching Science," (Bloomington: Public School Publishing Company, 1932.) p 269

- " 5. A critical review of existing science tests, accompanied by attempts to select and build tests to meet particular instructional needs.
- " 6. A movement for the diagnosis of pupil difficulties in the learning of science materials.
- " 7. A frank facing of the laboratory-instruction issue upon the basis of available apparatus and equipment now found in high schools.
- " 8. A revival of interest in simple, homely, and home made laboratory and demonstration apparatus.
- " 9. A beginning of experimental investigation upon the visual aids, especially motion pictures, to instruction.
- " 10. A continued development of the use of extensive reading for general instruction in science.
- " 11. A continued interest in the possibilities of science clubs.
- " 12. A general and spreading interest in the use of free and inexpensive supplementary material drawn into the school from outside sources."

After reading these summaries of the trends in the teaching of high-school chemistry, the reader will probably have the erroneous idea that the instruction should not be at a high peak. This is not true, for we are but entering the period where scientific objective methods are being used. The future is full

of promise and expectation. The fields are unlimited. Here is a challenge that awaits every teacher of high-school chemistry--the construction of real scientific methods and devices for improving the technique of instruction.

## VI. APPENDIX

### A. Bibliography

A cross-indexed bibliography on literature dealing with the teaching of high-school chemistry since 1923 is given.

In the following bibliography most of the general articles which would be of value to the teacher of high-school chemistry, articles of general nature on the teaching of laboratory sciences and such general references, are not included.

The alphabetic bibliography is annotated as well as numbered for use as a cross-reference index. No attempt has been made to evaluate the material of these articles, for it is quite evident that some are much better than others, according to the viewpoint one has.

#### 1. List of Abbreviations Used in the Bibliography:

- A. C. S.--American Chemical Society.  
Bureau Ed. Res.-----Bureau of Educational Research.  
C. Ed. Rev.-----Central Education Review.  
Cal. Q. Sec. Ed.-----California Quarterly of Secondary Education.  
H. Points-----High Points.  
H.S. Teacher----High School Teacher.  
J. Chem. Ed.-----Journal of Chemical Education.  
J. Ed. Res.-----Journal of Educational Research.  
N. Central Assoc. Q.----North Central Association Quarterly.  
N.Y. State Ed.----New York State Education.  
Peabody J. Ed.----Peabody Journal of Education.  
Report New England Assoc. Chem. Teachers----Report of New England  
Association of Chemistry Teachers.  
Sch. Sci. & Math.-----School Science and Mathematics.  
Sci. Ed.----Science Education.  
T.C. Bull., Columbia U. Bur. Pub.----Teachers' College Bulletin,  
Columbia University Bureau of Publications.  
T.C. Contributions to Ed.--Teachers' College Contributions to  
Education.

## 2. Annotated Bibliography.

1. Amick, C. A. "The Necessity of Chemistry in High-School Training" Sch.Sci.& Math. 25:385-9 Ap.1925  

A discussion pointing out need for chemists, value of teacher as help to public, and need for knowledge and appreciation of chemistry.
2. Ammindown, E. B. "Methods of Teaching Chemistry". Report, New Eng. Assoc. Chem., Teachers 33:85-8 1923.  

Analysis of methods used cause some questions, and experience seemed to indicate that the usefulness of students' knowledge varies with the methods used to teach him.
3. Anibel, F. G. "Comparative Effects of Lecture Demonstration and Individual Laboratory Instruction." J.Ed. Res. 13:355-65. My 1926.  

Results of an experiment carried on in the chemistry department of Central high school, Kansas City, Mo., 1922-3.
4. Astel, L. A. High-School Science Clubs. University of Illinois, Urbana, Illinois: University of Illinois Bulletin, 1932.  

Data on the science clubs of Illinois for 1930-'31; also an annotated bibliography.
5. Bagby, G. "Correlation of Laboratory and Classroom Work in the Teaching of High-School Chemistry." J.Ed.Res. 19:336-40, May, 1929.  

An experiment to determine the relative efficiency of methods of teaching chemistry as measured by immediate and delayed recall of subject matter. Points that low or average students might best profit by classwork before laboratory.
6. Baker, H. W., and L. I. Phares "A Chemical Exhibit." J. Chem. Ed. 9:501-9 1932.  

Deals with chemistry exhibit at Battle Creek school in May, 1932, giving some detail of work and importance of keeping material for future use.
7. Bayles, E. E. "A Beginning Course Based on the Principles of Chemistry." J. Chem.Ed. 7:1317-21 Je. 1930.  

Outlines a course on basis of giving student only systematic view he will have of chemistry: it may lead to vocation but is primarily for those who will not continue.



8. Beery, P. G. "The First-Year Chemistry Course." J.Chem.Ed. 8:1781-1861 1931.  
A discussion showing that the course has opportunity to be delightful or deadening; the value of J.Chem.Ed. and Chemistry leaflet along with bibliography for these is also shown.
9. Bennett, J. G. "A Study of Pupil Errors in Chemistry." J.Chem.Ed. 4:45-57 1927.  
A study of test errors to determine whether more carefully given and graded assignments would effect work of pupils. Shows that greater mastery is obtained.
10. Blanchard, W.M. "An Outstanding High-School Department of Chemistry." J.Chem.Ed. 5:1571-6 1928.  
Description of equipment and methods used in Shortridge High School, Indianapolis, Indiana.
11. Bloom, E.E. "The Technic for Teaching Physics and Chemistry." H.S. Teacher 2:224-7 1926.  
Present methods are wasteful; it would be advisable to use a combination of the Dalton and Winnetka plans.
12. Bothe, A. H. "An Analysis of High-School Texts in Chemistry." J.Chem.Ed. 2:785-91 1925.  
Comparison of content and methods of teaching as suggested by committee on reorganization of high-school chemistry, showing need for more carefully selected texts and other work.
13. Bowers, W.G. "Teaching Definitions in Chemistry." J.Chem.Ed. 4:1031-6 1927.  
An article showing that there is too little standardization, too many terms; but teachers should develop ability to think, understand, and imagine to help get definitions.
14. Bowers, W.G. "Why Use Textbooks in the Teaching of Chemistry?" Sch.Sci.& Math. 27:961-68 1927.  
Discussion of problems of textbook and values that are essential.
15. Bowers, W.G. "Some Suggestions as to Selection of a Laboratory Manual for High-School Chemistry." J.Chem.Ed. 2:605-9 1926.  
Suggestions as to points to note in selecting laboratory manual, being careful not to pick one that will destroy originality and suited to own ideals.

16. Bowers, W.G. "How to Tell Students How to Study Chemistry." Sch.Sci.& Math. 27:585-9 1927.  
Some important points in giving information on how to study, which cannot be overlooked by a good teacher.
17. Bowers, W.G. "The Importance of Laboratory Work as Compared with Textbook Work, Etc: in the Study of Chemistry." Sch.Sci.& Math. 24:606-13 1924.  
Points out that importance is due to industrial education and technical institutes, but for the most part opinions differ on values.
18. Bowers, W.G. "Grouping Students for Work in the Chemistry Laboratory." Education 25:429-38 1925.  
Conclusions of a study of fourteen years' experience, showing that pairing is best method, for it helps the weak and does not harm the strong.
19. Bowers, W.G. "The Handling of Material and Apparatus in the High-School Laboratory." J.Chem.Ed. 3:514-8 1926.  
Discussion of the problem of supplies, and the system used in the majority of schools surveyed.
20. Bowman, R.E., and Others. "Report of Committee on Chemical Education of the Non-College Type." J.Chem.Ed. 8:2446-52 1931.  
Discussion of the phases of vocational courses.
21. Boynton, I.C. "The Place of Bio-chemistry in High-School Chemistry. Curriculum." J.Chem.Ed. 4:503-5 Ap. 1927.  
Points out some arguments for and some against, but favors it in that it helps meet objectives of education and is closely related to life. Lists some fields which could be used.

22. Bradbury, G. M. and McGill, M.V. "Twentieth Century Practice Exercises and Objective Tests in Chemistry." Fowler, Indiana: Benton Review Shop: Exercises in thirty-two units made by references to standard textbooks.
23. Brauer, O.L. "What to Expect of High-School Students in Chemistry Formula and Equation Writing." J.Chem.Ed. 5:304-13 1928.  
Results of a questionnaire study of three parts, making a list of what author thought should be included and having this added to and subtracted from the lists of what teachers thought.
24. Brown, A.E. and Bowers, W.G. "Psychology Underlying Instruction in Chemistry." Sch.Sci.& Math. 23:715 1923.  
Importance of discovery method; need to create need and interest on pupils part; remove fears and use scientific method of instruction.
25. Browne, G.M. "Some Suggested Changes in High-School Chemistry." J.Chem.Ed. 2:447-8 Je. 1925.  
Chemistry foundation of living should be given in second year; need more emphasis on common good uses; no one to graduate without one year of high-school chemistry.
26. Brownell, H. "Psychology of High-School Science and Making of the Science Teacher." Sch.Sci.& Math. 26:529-34 My. 1926.  
The essential feature is the use and comprehension of the scientific method.
27. Bruce, G.V. "Attempt to Vitalize Chemistry Teaching in the High-School Through a Modified Form of Unit-Assignment Technique." Science Education 16:392-403 O 1932.

28. Card, J.H. "The Teaching of Chemistry in High-School." Report of New England Assoc. of Chemistry Teachers, 33:93-7 1932.  
The application of the electronic theory to equation writing.
29. Carpenter, W.W. "A Study of the Comparison of the Different Methods of Laboratory Practice on Basis of Results Obtained on Tests of Certain Classes in High-School Chemistry." J.Chem.Ed. 3:798-805 1926.  
For the majority, the demonstration succeeded as well as the individual experiment; the groups of two did not succeed as well as an individual in experiments.
30. Carpenter, H.A. and Others. "Why Teach Chemistry in New York High-Schools." N.Y. State Education 16:450-3 1929.
31. Carpenter, W.W. "Certain Phases of Administration of High-School Chemistry." T.C.Bull. Columbia U.Bur. Pub. 1925.  
Report of a study made from administrative viewpoint showing practices of schools and making recommendations; a good problem attacked in a scientific manner.
32. Chapel, J.C. "Unit Technique Vs. Recitation Technique in the Teaching of High-School Chemistry." Master's Thesis University of Chicago 1930.
33. Chicago Public Schools, "Course of Study in Chemistry." 1930.
34. Clinton, G. "The Problem of High-School Chemistry." J.Chem.Ed. 2:471-6 Je. 1925.  
A consideration of subject matter, arrangement, and method of teaching.
35. Collier, Jr. R. "New Type of Chemistry". J.Chem.Ed. 8:2214-26 1931  
Type of course given at South High School in Denver, in outline, for those not going farther into chemistry.
36. Collier, Jr. R. "Methods of Increasing Interest in High-School Chemistry." J.Chem.Ed. 7:2141-9 S. 1930.  
Summarizes conditions and need for less emphasis on college preparation and importance of activities; shows how to concentrate; stresses importance of best laboratory conditions possible.

37. Committee Report "The Professional Spirit among High-School Chemistry Teacher." J.Chem.Ed. 5:747-9 1928. Emphasis on the importance of the use of American Chemical Society and the Journal of Chemical Education for the progress of the teachers.
38. Committee Report A.C.S. "A Standard Minimum High-School Course in Chemistry." J.Chem.Ed. 1:87 1924. Preparation of an outline for student's general knowledge as well as for college preparation. Also lists eleven aims of course.
39. Committee Report "The Precedence of Laboratory and Recitation in General Chemistry." J.Chem.Ed. 5:1300-6 1928. Questionnaire study as to grades, length of periods, per cent of total registration in chemistry, order of laboratory and class. Results-2-1 think laboratory first is best.
40. Cook, C.A. "A Few Suggestions for Testing in High-School Chemistry." J.Chem.Ed. 5:1273 Oct. 1928. Method of testing, past subjective and present objective use of special method of testing for properties of substances.
41. Cook, C.A. "Use of the Iowa Chemical Aptitude Test in Foretelling Success in High-School Chemistry." Sci. Ed. 16:51-4 Oct. 1931.
42. Cope, H.F. "Chemistry Club Work." J.Chem.Ed. 7:1114-6 May 1930. Discussion of work during school hours, and a suggested program.
43. Cornog, J. and Colbert "A Quantitative Analysis of Aims in Teaching High-School Chemistry." Sch.Sci.& Math. 24:168-73 1924. Results of a questionnaire, analysis of texts, compilation of teacher opinion and analysis of exam. questions, good graphs of results.
44. Cornog, J., and G.D.Stoddard "The Chemistry Training of High School and College Students." J. Chem.Ed. 6:85-92 Jan., 1929. Results of chemistry aptitude and training tests; those with high-school training are better; high-school classes need division; student should be the reference point rather than subject matter.

45. Crosby, O.A. "Investigation of the Study Methods Used by High-School Chemistry Students." J.Chem.Ed. 7:587-8 Mr. 1930.  
Questionnaire study concerning methods showing that how to study is as much a problem as what, and too short a time is spent on the lessons by the failing students.
46. Cunningham, H.A. "Types of Thought Questions in Laboratory Manuals." J.Chem. Ed. 2:167-70 Mr. 1925.  
Analysis of laboratory manual questions; too many are pure memory, little for scientific thinking.
47. Currier, H.J. "High-School Chemistry-Student's Viewpoint." J.Chem.Ed. 2:113-8 Feb. 1925.  
Deficient in useful chemical facts, lack application, need for unit plan, outlines course in units.
48. Curtis, F.D. A Digest of Investigations in the Teaching of Science. Blakiston, Philadelphia Vd. 1; 1926 also Vd. II, 1932.  
Report of selected references on subject of learning and curricular type chronologically arranged.
49. Davy, W.P. "The Co-operation Between the Local Section of the A.C.S. and High-Schools of Their Territory." J.Chem. Ed. 4:964-8 1927.  
Need for much more co-operation in order to better develop professional training, and to get best for pupil.
50. Dinsmore, E.L. "The Teaching of High-School Chemistry." N.Y. State Ed. 20: 534 Ap. 1933.
51. Dunbar, R.E. "The Organization of High-School Science Club." J. Chem. Ed. 7:1327-31 Je. 1930.  
Suggested outline for school of 75-400 enrollment for club and bibliography of science club helps.
52. Dunbar, R.E. and I.J. Grandy, "Chemistry Tests Available for the Use in High-School Classes." Sch.Sci.& Math. 31:1100-2 1931.  
Lists of standardized tests, price, publisher, and description.
53. Dunbar, R. E., Holgate, C.H. and Harkness, J.T. "Term Paper Practice in the Teaching of High-School Chemistry in the United States." J.Chem.Ed. 5:1445-6 Nov. 1928.  
Questionnaire of length, frequency, type of oral or written reports; lists benefits of such practices.

54. Editorial, "Teaching Chemistry from the Factory Viewpoint." J.Chem.Ed. 7:1939-41 1930.  
Outlines ideas of such a plan and values of such.
55. Elliot, F.A. "Motion Pictures as an Aid in Teaching Chemistry." J.Chem.Ed. 1:190 1924.  
A survey of the application to teaching field;  
outlines process for producing own.
56. Fay, P.J. "The History of Chemistry Teaching in American High-Schools." J.Chem.Ed. 8:533-62 Aug. 1931.  
The changes in technique, position of chemistry, and application.
57. Ferguson, A.L. "The High-School Course in Chemistry." J.Chem.Ed. 1:60 1924.  
Points out that present idea is too liberal;  
should be more disciplinary; applications are only subsidiary.
58. Ferguson, A. "The Course in High-School Chemistry." J.Chem.Ed. 2:188-90 Mr. 1925.  
Should not be primarily for establishment of worthwhile interests but to develop moral character, stability, judgment, responsibility, etc: Too little effort on student's part.
59. Fiedler, A. Trans. Illinois State Academy of Science 17:417-20 1925.  
Summarizes a few devices which have been successfully used to teach principles and facts with reference to their application.
60. Fine, I. "Review Course of Study in High-School Chemistry." B.H.Points 13:13-18 1931.
61. Fliedner, L.F. "Equation Tests in High-School Chemistry." J.Chem.Ed. 8:939 1931.  
Device for testing which is easily checked, permits plenty of repetition and shows how to use the device.
62. Foster, O.R. "An Advanced Chemistry Course in High-School." J.Chem.Ed. 3:893-6 1926.  
Discussion of qualitative analysis and industrial processes given in Manual High School, Brooklyn; the content, method and material from experience and conviction.
63. Frank, J.O. The Teaching of High-School Chemistry. Oshkosh: J. O. Frank and Sons, 1932.  
Notes, suggestions, and information relating to all phases of the subject, also dealing with junior college. Is of great help to beginning teacher and attempts to solve many disputed points concerning instruction.

64. Frank, J.O. "The Nomenclature of High-School Chemistry." J.Chem.Ed. 6:72-5 Jan. 1929.  
Discusses the problems arising from lack of standardization, overlapping, faulty definitions, and incorrect and careless use of terms.
65. Frank, J.O. "Experiments in Visual Education." J.Chem.Ed. 10:90-1 Feb., 1933.  
Discussion of facts and ideas which make such work worthwhile.
66. Frank, J.O. "The Objectives of High School Chemistry." J.Chem.Ed. 2:50-7 Ja. 1925.  
The aims and objectives as a result of a study from authoritative sources.
67. Franklin, G.T. "A Common Sense Basis for Chemistry Teaching in the Secondary Schools." Sch.Sci.& Math. 32:857-62, 954-60 Nov., 1932. 32:81-6 Jan. 1933.  
The use and value of a good laboratory course with the individual method.
68. Gere, M.C., and Others. "High-School Chemistry Library." Sch.Sci.& Math. 29:859-63 Nov., 1929.
69. Gerry, H.L. "Measurement of Results of Teaching Chemistry." Sch.Sci. & Math. 24:793-804, 1924.  
Type of tests in past and present, use of Regents examination, and values of standardized tests.
70. Gerry, H.D. "A Test of High-School Chemistry." Harvard University Bulletin of Education No. 9 H.U. Press, 1929.  
Monograph describing method used to select test items and their evaluation and standardization.
71. Gerry, H.L. "What Are We Teaching in Chemistry." Sch.Sci.& Math. 24:361-6, 1924.  
Investigation of answers to 100 questions asked of students finishing high-school chemistry and analysis of errors, showing terminology, misspelling, chemical notations, and laboratory knowledge were most prominent.



72. Gerry, H.L. "Some of the Factors Determining the Common Content of High-School Chemistry." Sch.Sci.& Math 24:457-66 1924.  
Discussion of development of, showing causes as great success in college, to satisfy demand, practical application and transfer value.
73. Glasoe, P.M. "High-School Chemistry and the Periodic System." Sch.Sci.& Math. 24:700 1924.  
Immense value of system in teaching fundamentals.
74. Glenn, E.R. "An Investigation of the Types of Classrooms for Chemistry and Other Sciences in the Small High School." J.Chem.Ed. 6:634-64 Ap. 1929.  
Questionnaire survey of small schools of South Dakota showing various factors, particularly the need for alternation of subjects, training, texts, manual, minimum list of apparatus, and combined laboratory and classroom.
75. Glenn, E.R., and Walker, J. "Bibliography of Science Teaching in Secondary School." Bureau Education Bull. 13:161 1925.  
Titles, authors, in three parts for all science-general, chief, and periodicals.
76. Glenn, E.R. "The Need for Research on the Problem of High-School Chemistry Instruction." J.Chem.Ed. 2:670-76 1923.  
Analysis of magazine articles for past; very poor and not continuous; lists nineteen problems which need to be solved.
77. Glenn, E.R. and L.E. Welton, Instructional Tests in Chemistry for High-School and College. World Book Co., 1930. Yonkers-on-the-Hudson, N.Y.
78. Glenn, E.R. "Problems Associated with the Construction of High-School Chemistry Course." J.Chem.Ed. 1:80 1924.  
Lists and discusses major problems.
79. Graham, H.C. "Notebook Methods in High-School Chemistry." J.Chem.Ed. 7:1122-4 May, 1930.  
Survey of notebooks used in largest high schools in each state; 93% use the; 56% write in laboratory, 34% have formal notes; 40% brief notes, etc.
80. Gray, C.W. "A Minimum or Maximum Course in Chemistry." J.Chem.Ed. 2:235-40 Ap. 1925.  
Need more careful evaluation of subject matter for time is short, should have minimum essentials and give teacher time for emphasis on thought and less on routine.

81. Green, W.V. "Community Sources for High-School Instruction in Chemistry." H.Sch. 7:90-2 MR. 1930.
82. Guild, B.H. "Qualitative Analysis in High-School Chemistry." J.Chem.Ed. 5:84-6 Jan., 1928.  
Values of such a course is that it gives mental training, reasoning and its application. Use of such a course, and experience of the writer and methods used.
83. Guild, B.H. "Need for More Social Emphasis on Chemistry as Taught in High School." Sch.Sci.& Math. 31:1075-8 D. 1931.  
Need for emphasis on content and subject that are more adaptable to needs and nature of the pupil.
84. Hannen, F.S. "Summary of Records of Student's Work in Chemistry." J.Chem.Ed. 2:912-23 Oct., 1925.  
Point system worked out to get better objective measurement of pupils work, the system which centers around what the student does, not the old method of comparing him with the best.
85. Hart, F.T. "Experiment with Oral Recitation in Descriptive High-School Chemistry." J.Chem.Ed. 5:944-6 Aug., 1928.  
Attempts to make the course more interesting by oral descriptions of certain phases of work; also the use of specially designed assignment card, and current literature.
86. Hanske, C.F. "Sex Difference in High-School Chemistry." J.Ed.Res. 23:412-6 May, 1931.  
A study of relative performances of boys and girls in Manual High-School, Indianapolis, Finding is that there is no great difference except that there is more variability in boys; they have more science training which gives them some advantage over girls.
87. Haub, H.D.F. How to Teach Secondary Chemistry and Allied Sciences.
88. Haub, H.D.F. "Students Research in High-School Chemistry." J.Chem.Ed. 4:1241-59 Oct., 1927.  
Student should be incited to self activity, and course should be so organized as to permit each to approach the limit of his ability; a system of projects, illustrations and bibliography to meet this type of work should be developed.

89. Hawthorne, W.C. "On Teaching High-School Chemistry." Sch.Sci. & Math. 23:532-5 1932.  
Discussion of facts pertaining to course, material, aims, and training application. "A high-school chemistry course that does not make the boys and girls work--yes and make some of them fail--is not worth much."
90. Hendricks, B.C., and P.E. Johnson. "Finding Superior High-School Chemistry Students." J.Chem.Ed. 6:76-81 Jan., 1929.  
This is a Cooperative project to find them; not much from previous grades, or intelligence tests; advocates the use of the Iowa chemical aptitude test. Lists correlations.
91. Hendricks, B.C. "High-School Chemistry Library." J.Chem.Ed. 5:861-7, 1928.  
Discussion pointing out that most libraries do not have much material and that this phase of teaching is neglected.
92. Hendricks, B.C., and J.S. Chambers. "Chemistry Teaching in Nebraska." Sch.Sci.& Math. 29:138-41 1929.  
Survey of situation.
93. Hendricks, B.B. "Salvaging the Superior High-School Chemistry Student." J. Chem. Ed. 3:1380-84 Dec., 1926.  
Not enough emphasis on bright pupil; sectioning is needed to give all a better chance.
94. Henkel, M.I. "A Method of Teaching Chemistry." Sch.Rev. 34:591-8 1926.  
Use of the project method gives better results with less work; allows teaching of pupils rather than of subject.
95. Hoffman, R.E. "Creating Interest in Chemistry." Sch.Sci. & Math. 23:30-3 1923.  
Methods are too cut and dried; more interesting questions to stimulate thinking; texts not conducive to interest, and industrial visits are all factors.
96. Hopkins, B.S. "The Training of Chemistry Teachers, Prospective and in Service." Sch.Sci. & Math. 25:233-8, 1925.  
Need knowledge, interest and ability to impart knowledge and interest. Need to keep continually improving, reading and associate with others who have similiar problems through societies and organizations.

97. Hopkins, B.S. "A National Standard Minimum Course in Chemistry." Sch.Sci.& Math. 24:233-7 1924.  
Results of committee of A.C.S.; the objectives.
98. Hopkins, I.T. "A Study of Magazine and Newspaper Science Articles, with Relation to Courses in Science for High School." Sch.Sci.& Math. 25:793 1925.  
Survey of Denver papers and magazines; analysis measurement and tabulation. Biology most common; Chemistry third; should be last in curriculum: topics not like texts.
99. Horton, R.E. "Measurable Outcomes of Individual Laboratory Work in High-School Chemistry." T.C. Contributions to Ed. No. 303 1928.  
Four problems and research work done on them; the manipulative skills, habits and their importance the relative value of laboratory and demonstration, the relative value of individual laboratory and the demonstration method; relative value of individual laboratory under different types of directions.
100. Howard, R.S. "Some Aspects of the Unit Method of Teaching Chemistry." J.Chem.Ed. 8:910-18 1931.  
Values, objectives, need for and an example.
101. Humphrey, H.H. "Make Chemistry a Required High-School Subject." J. Chem.Ed. 3:217-8 1926.  
Need of common knowledge should be sufficient, for everything has a chemical aspect; also chemistry offers a foundation on which to increase knowledge and an optimistic philosophy.
102. Hutchins, R.B. "Should the Electron Theory be Included in High-School Chemistry?" J.Chem.Ed. 1:145-51 1924.  
Results of questionnaire in New England schools showing that it is essential for background.
103. Hutchins, R.B. "The Value of Tests in Writing Chemical Equations." J.Chem.Ed. 3:915-9, 1926.  
Necessary for good teaching of principles, but becomes individual problem, for texts and manuals are not uniform or standardized.

104. Jackson, M.W. "What Sort of Chemistry Should be Taught in High School?" J.Chem.Ed. 4:58-65 1927.  
Too much overlapping of college and high school subject matter; latter should change, be inclusive, base on everyday experience, and be an intensive appreciation course. Lists values of such a course.
105. Jacobs, A.H. "Chemistry and the Student." Sch.Sci.& Math. 25:51-3 1923.  
Ideas of course as developed in Germantown High School in Philadelphia; based on development of special skills, knowledge and appreciation.
106. Jensen, J.H. and J.H. Norton, "Report of Committee on Minimum Equipment." J.Chem.Ed. 5:749-54 1928.  
Study of minimum equipment necessary for sixteen pupils working in groups of two or eight individually, and a list on the basis of use in common texts.
107. J.Chem.Ed. "A Standard Minimum Course in High-School Chemistry." J. Chem.Ed. 1:87 1924.  
Lists objectives to govern teaching and outlines work by topics. Chief factor for bringing high-school chemistry to the point it is today.
108. J.Chem.Ed. "Research Problem of High-School Chemistry Instructors." Bibliography of articles in J.Chem.Ed. on High-school chemistry instruction. 7:2156-7, 1930.
109. Kelsey, T.D. "Social Values of High-School Chemistry." Sch.Sci. & Math. 25:378-84 1925.  
Should build character, develop truth, accuracy, open-mindedness, weighing of evidence, honesty, regard for others, inspiration from chemists and self government.
110. Kelsey, T.D. "Teaching of Qualitative Analysis in Secondary Schools." J.Chem.Ed. 6: 1929.  
One-half year of such work could make distinctive contribution to science program; summary of some current practices; and suggestions for such a course.
111. Kistler, R.C. "Selling High-School Chemistry to the Community." J.Chem.Ed. 7:1324-6 1930.  
Plan adopted by three schools in central Pennsylvania, using chemistry teams and inter-school contests.
112. Klosky, S. "High-School Chemistry as Proposed by A.C.S." C.Ed.Rev. 26:170-3 1926.  
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117. Law, S.D. "High-School Projects in Chemistry." J.Chem.Ed. 6:1139-43 1929.  
Detailed report with illustrations, topics and exhibits.
118. McAlpine R.K. "Some Aims in Teaching Elementary Chemistry." Sch.Sci.& Math. 28:154-63 1928.  
Lists some aims. "Real aim of chemistry is to teach chemistry."
119. McGill, M.V. "The Course in Chemistry Being Developed at Lorain High-School, Lorain, Ohio." J.Chem.Ed. 1:59 1924.  
Size, length of period, type of work, reports, club, library, in this school.
120. McGill, M.V. "A Live Chemistry Club in High School." J.Chem.Ed. 1:31 1924.  
Programs and meetings of the club at Lorain, Ohio.

121. Mahannah, J.E. "Chemistry Projects in High School." J.Chem.Ed. 5:1112-6 1928.  
Values of essay contest and interest aroused by it.
122. Malin, J.E. Construction of Diagnostic Tests in Mechanics, and Relative Fundamentals, of High-School Chemistry. Williams Brothers, Philadelphia, 1932.  
Confined to various test materials on principles, a careful and extensive study of pupil errors with good results.
123. Malin, J.E. "Brief Survey of Mechanical Fundamentals of High-School Chemistry Taught in the United States." Sch.Sci.& Math. 32:149-55 Feb., 1933.  
Questionnaire and interview study on textbooks and laboratory manuals, and tables of results.
124. Mattern, L.W. "What Chemistry Shall be Taught in High Schools and How Shall It Be Correlated with College Chemistry." Sch.Sci.& Math. 23:665-71 1923.  
Discussion of points to emphasize, and an outline of minimum content.
125. Mickle, R.S. "High-School Chemistry and Everyday Life." J.Chem.Ed. 3:104 1926.  
Importance of chemistry to many sciences and things of common occurrence, need to develop this phase and give students responsibility, make them altruistic, forward looking, and eager to solve problems.
126. Miller, L.P. "Teaching High-School Chemistry Teacher." J.Chem.Ed. 8:524-6 1931.  
An actually workable outline on valence, formulas, and equations for bringing a beginning teacher to the pupil.
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No laws established that chemistry as well as sciences have to be taught in their respective classrooms, science teachers as well as all others should cooperate.
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Research study of pupil, combination, and instruction methods of teaching.
131. Nathanson, J.N. "Common Processes in High-School Chemistry--a Qualitative Analysis," Sch.Sci.& Math. 26:628-33 1926.  
Study of texts and selection of fifty items sent to teachers to grade, finding that there is little correlation between authors and teachers, and between teachers. Should be more selective and emphasize fewer things.
132. Naudain, G.G. "Administrative Study on the Teaching of Chemistry in the Secondary Schools of South Carolina." J.Chem.Ed. 8:559-64 1931.  
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Measured by standardized test in Yuba schools, 1929-1930, pointing out that demonstration was most effective and should be used to greater advantage.
134. Oppe, G.A. "Status of Chemistry in Texas High Schools." J.Chem.Ed. 6:1748-58 1929.  
Results of questionnaire study to find conditions.
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Discussion of a chemistry course better fitted to pupil needs.
136. Osborne, C.E. "Making High-School Chemistry Worthwhile." J.Chem.Ed. 1:404-9 1924.  
Discussion of teacher, purpose, equipment, boy, plan, and product of course.



137. Osborne, R.W. "Some Suggestions for Modification of the Content of High-School Chemistry to Better Serve the Purposes of a Liberal Education." J.Chem.Ed. 2:737-42 1925.  
Discussion of factors to be considered.
138. Parker, D. "Segregation of High-School Chemistry Pupils." J.Chem.Ed. 8:1598-9 1931.  
A plan based on previous achievement, intelligence, initiative, originality and arithmetical ability. The courses in chemistry are given on this plan at Shortridge High School, Indianapolis.
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Research in Illinois schools, finding that recitation first was superior, but that the teacher's preference had marked influence on success, and also the size of school.
140. Persing, K.M. "A Practice Study in Paragraph Summarizing in Chemistry." Sch.Sci.& Math. 24:598-604 1924.  
Influence on learner of giving definite instruction and drill in, showing that means a decided improvement in learning efficiency.
141. Persing, K.M. "New Type (Objective) Examinations in High-School Chemistry." J.Chem.Ed. 8:2227-37 1931.  
Development has been slow due to many factors; discusses types and lists published, standardized tests and classifies them.
142. Persing, K.M. "Present Specific Objectives in High-School Chemistry?" J.Chem.Ed. 6:1958-78 1929.  
Study of the field and list of objectives shown in texts, courses of study, and curricular investigations.
143. Persing, K.M. "Testing Laboratory Technique in High-School Chemistry." J.Chem.Ed. 6:1321 1929.  
Construction and giving of a test designed to measure technique.
144. Phelan, E.W. "Status of Chemistry and Chemistry Teaching in Ohio High Schools." J.Chem.Ed. 6:2196-202 1929.  
Questionnaire study showing conditions.

145. Powers, S.R. "Objectives of High-School Chemistry." Sch.Sci.& Math. 25:882-3 1925.  
Survey of texts and courses of study; a list of objectives is set up.
146. Powers, S.R. Powers General Chemistry Tests. World Book Co. 1924.  
Two forms of tests with keys and record chart, with thirty items on range of information, and thirty-seven items on formulas, equations, names and problems.
147. Powers, S.R. "Some Problems of Curriculum and Method of Instruction in High-School Chemistry." J.Chem.Ed. 2: 998-1007 1925.  
Experimental investigation showing need for more investigation, objectives, methods and laboratory procedure and practices.
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Study of texts to determine the unfamiliar words in biology, general science and chemistry. Biology had the most, which were most difficult, were of technical nature and were used only once in the book; but on the whole they were not much worse than other texts.
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Lists and frequencies of terms, pointing out importance of but says there are too many for a high-school pupil.
150. Powers, S.R. "A Diagnostic Study of Subject Matter of High-School Chemistry." T.C.Contributions to Ed. No. 149 1924.  
Study shows need for critical study on adjustment of curriculum to needs, and tests for this, by means of representative items selected from texts and minimum course essentials.
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Measured by eight test forms with 350 items to find student's ability. Shows that students low in one are low in most; some schools' work is futile and reorganization is essential to progress.
152. Pruitt, C.M. "Activities of Chemistry Clubs." J.Chem.Ed. 4:1037-42 1927.  
Analysis of activities in Pittsburg high schools and Lincoln School Teachers College.

153. Pugh, D. B. "A Comparison of Lecture Demonstration and Individual Laboratory Methods of Performing Chemical Experiments as Measured by New Standardized Objective Tests." H.S. Teacher 3:384-7 1927.
154. Radcliffe, H.H. "Making Laboratory the Basis of High-School Science." Sch.Sci.& Math. 25:749-52 1925.  
Discussion of methods used as result of experience and conviction.
155. Rademacher, E.E. "Making Posters for Chemistry." J.Chem.Ed. 8:688-98 1931.  
Value of such in increasing interest, and illustrations of ten as used by author.
156. Rauth, J.W. "A Study of Achievement of High-School Students in Chemistry." C.Ed.Rev. 23:289-92.  
Excellent lists of questions and study of answers which allow enumeration of student weaknesses.
157. Reed, R.D. "High-School Chemistry Demonstration." J.Chem.Ed. 6:1905-9 1929.  
Findings of investigators and list of experiments suitable for lecture demonstration.
158. Replogle, L.K. "An Aid in Keeping High-School Chemistry Classwork Interesting." Sch.Sci.& Math. 23:118-21 1923.  
The plan used in Parker High School, Dayton, outlines unit on sulphur to vary regular procedure, develop thinking, and demand more extensive reading.
159. Rich, S.C. Rich's Chemistry, Tests. Bloomington, Indiana: Public School Publishing Co., 1923.  
Two forms and a manual for giving and scoring tests, well selected to test achievement but much is informational.
160. Rivitt, B.J. "A Comprehensive Chemistry Test." Sch.Sci.& Math. 23:377-86 1923.  
Study to make test for pupil's knowledge of principles at Northwestern High School, Detroit. Lists questions and results.
161. Robinson, E.L. "An Inspiring Course in Introductory Chemistry." J.Chem.Ed. 7:1100-2 1930.  
Teacher should use all available help to develop appreciation and inspiration.

162. Rogers, T.A. "A Survey of Chemistry Teaching in Wisconsin High Schools." J.Chem.Ed. 5:1415-24 1928.  
Conditions existing show need for better methods more than any other factor effecting teaching.
163. Salter, C.H. "Report on Evaluation of Objectives in Chemistry by Teachers in Cleveland Ohio Schools, and Informational Test of Pupils." Sch.Sci.& Math. 25:467-74 1925.  
Conducted by School masters club. Shows lack of agreement as to objectives, course should be given in later years of school; methods are not uniform and everyday experience is not utilized, and other factors.
164. School and Society "Teaching Chemistry in the High School." 26:264 1927.  
Status of chemistry teaching and courses.
165. Segerbloom, W. "Recent Advances in Teaching of Elementary Chemistry." J.Chem.Ed. 4:497-502 1927.  
Discussion centering around minimum course, tests, College Entrance Examination Board, texts, with more emphasis on teaching methods.
166. Segerbloom, W. "Methods and Helps in Teaching High-School Chemistry!" Sch.Sci.& Math. 24:467-80 1924.  
Ideas advanced by different men on various phases of teaching and devices to use.
167. Segerbloom, W. "Composition of Chemistry Textbooks." Sch.Sci.& Math. 29:277-85 1929.
168. Sheean, J.L. "Application of Psychology to Teaching of High-School Chemistry Teaching." J.Chem.Ed. 6:2181-8 1929.  
Values and ideals which are not used enough by teachers, as well as a list of objectives.
169. Sister Mary Angelica, "Stimulating Interest in High-School Chemistry." J.Chem.Ed. 7:834-5 1930.  
Devices used, exhibit, P.T.A. programs, and others including projects.
170. Smith, H.R. "The Response of High-School Pupils to Chemical Education." J.Chem.Ed. 1:12 1924.  
Interest and dependence on chemistry for progress, a few good practical books, and need of inspiration.
171. Smith, H.R. "Objectives in Teaching Chemistry." J.Chem.Ed. 2:585-7 1925.  
The Objectives set by the Chicago Association of chemistry teachers.

172. Smith, H.R. "Some Fundamentals of Laboratory Instruction." J.Chem.Ed. 4:359-63 1927.  
Faults of laboratory instruction due to too little mental work and training, and pupils letting others do work. Teacher should emphasize principles and have oral introduction to laboratory.
173. Smith, H.R. "Effectiveness of Laboratory Work in Chemistry." Sch.Sci.& Math. 27:267-71 1927.  
Too little enthusiasm on teacher's part, poor textbooks, routine, and revision of experiments reduce present effectiveness of laboratory.
174. Spencer, M.A. "Chemistry in the Vocational High-Schools of the Middle West." J.Chem.Ed. 8:712-16 1931.  
Recognition of value of chemical training shown by development of trade courses as demanded.
175. Spurgin, W.H. "The Use of True and False Tests in Chemistry Teaching." J.Chem.Ed. 2:936 1925.  
Study showing advantages of new type tests, and correlation of true and false question answers with real knowledge tested by other means.
176. Stevens, C.P. "New Courses in High-School Chemistry." Sch.Sci.& Math. 32:244-9 1932.  
Course outlined from study of professional literature and queries to 235 representative high schools. Pandemic, for laymen, which centers around pupils and their needs.
177. Stewart, A.R. "A Study of Difficulties in Chemistry." Sch.Sci.& Math. 28:838-48 1928.  
Errors, difficulties, and methods for overcoming them in Pennsylvania High School, Greenville, Pennsylvania.
178. Stone, C.H. "A Method for Teaching Equation Writing." J.Chem.Ed. 7:1332-33 1930.  
Use of reaction to show pupils; reagents which make good examples; colors make interesting and are easily explained.
179. Stone, C.H. "Definitions." J.Chem.Ed. 2:778-9 1925.  
Importance of good, clear, accurate and correctly used definitions.

180. Stone, C. H. "Environmental Chemistry in the Classroom." Report New. Eng. Assoc. Chem. Teachers 28:108 1927.  
Use of visits to local industries to enliven work, constant reference to everyday experiences, thought provoking questions, and lists of experiments which will be helpful.
181. Stone, C.H. "The High-School Chemistry Course Vs. College Requirements." J.Chem.Ed. 1:55 1924.  
In the past too much emphasis has been placed on college preparation; high-school course should meet all needs; suggestions for a course to do this.
182. Stone, C.H. "Some Needed Improvements in Chemistry Texts." J.Chem.Ed. 2:203-6 1925.  
Texts confuse ideas, lack uniformity, have poor definitions, do not emphasize important principles equally, and do not clinch ideas developed.
183. Stone, C.H. "A New High-School Course in Chemistry." J.Chem.Ed. 1:233-38 1925.  
A course as developed in English High School, Boston, more chemistry but not of college preparation type. A list of important psychological factors which aid in teaching.
184. Stubbs, M.F. "The Place and Problem of Chemistry in the High-School Curriculum." Sch.Sci.& Math. 27:741-8 1927.  
The need for reorganization due to change of type of students in high schools; analysis of course and needs and problems to be met.
185. Stubbs, M.F. "Laboratory Notebooks in High-School Chemistry." J.Chem.Ed. 3:716-8 1926.  
Pupils should not be burdened with notebooks which are just questions, but the notebooks should have real value as a result of experiment and observation and be answers to a definite problem on which the experiment was based.
186. Stubbs, M.F. "An Experimental Study of Methods for Recording Laboratory Notes in High-School Chemistry." Sch.Sci.& Math. 26:233-9 1926.  
Investigation of methods used on basis of analysis of laboratory manuals and students notebooks, showing values and disadvantages of different types of notebooks.
187. Stuit, D.B., and Englehardt, M.D., "A Critical Summary of Research on Lecture-Demonstration Vs. Individual-Laboratory Method of Teaching High-School Chemistry." Sci. Ed. 16:380-91 1932.  
Investigation of two methods and the values found.

188. Sy, A. P. "A Plea for a Pedagogical Scrapheap in Chemistry."  
J.Chem.Ed. 1:25-31 1924.  
Discussion of existing situation in that there is a low ratio of chemistry students to those in other sciences which is due to too much tradition, texts, too much memory, confusing terminology and poor definitions.
189. Symposium, "What Are Our Objectives in Teaching Chemistry?"  
J.Chem.Ed. 2:971-97 1925.  
Results of a discussion at A.C.S. meeting in 1925, and objectives as set forth by W.C.Morgan, J.E.Bell, and L. F. Forester.
190. Thompson, F.G, and F.A. Rantz, "The Status of Chemical Education in the High Schools of the State of Washington."  
Sch.Sci.& Math. 28:68 1928.  
Results of survey to determine status, enrollment, uniformity of subject matter, and teacher training.
191. Underhill, O.E. "Some Notes on Chemistry Projects."  
Sch.Sci.& Math. 26:634-7 1926.  
The results of experience in project teaching, a list of good projects, use of references, comments on projects, and keeping of work ahead of recitation.
192. Van Horne, D. "The Lecture Demonstration Method in High-School Chemistry." J.Chem.Ed. 7:109-16 1930.  
Outline of technique for demonstrations, types to use, results of experience with this method, and need for experiments to determine the relative value of this method.
193. Wade, F.B. "Chemistry as a Vocation--a Bit of Vocational Guidance for the Inquiring High-School Student."  
J. Chem. Ed. 9:1058-62 1932.  
Dialog between inquiring student and professor on prospects of chemistry as a vocation.
194. Wade, F.B. "A Method for Using the History of Chemistry as a Teaching Aid." Sch.Sci.& Math. 28:877-80 1928.  
Outlines a method for study of certain men and use of oral reports and papers to get some facts that this science was worked out by real men.
195. Wade, F.B. "The Project Method," Sch.Sci.& Math. 23:471-6 1923.  
List of possible projects, use of reports and remarks concerning procedure for this method.

196. Walker, H. "The High-School Chemistry Club." Sch. Sci. & Math. 28:833-40 1926.  
Questionnaire sent to 112 schools, finding decrease in clubs, purposes of, programs activities and problems met by them.
197. Walrath, "Is A High-School Chemistry Club Worthwhile?" J. Chem. Ed. 8:2238-40 1931.  
Many skeptical over value, but in Bloomfield High School, New Jersey, the time and energy spent is thought to be well justified. The type of activities they have are discussed.
198. Walton, J.H. "Chemistry Books for High-School Library." Sch. Sci. & Math. 25:390-4 1925.  
List of books for teacher and student, also list of texts, laboratory manuals and popular books showing applications.
199. Webb, H.A. "Starting a Small Chemical Laboratory." Peabody J. Ed. 1:251-9 1924.  
An answer to a letter asking for instructions concerning equipment necessary to build a laboratory with limited means. An inclusive list of essentials.
200. Webb, H.A. "What College Men Think of High-School Chemistry." Sch. Sci. & Math. 23:155-62 1923.  
Discussion showing need for good introduction to this science by proper methods, etc.
201. Wilson, H.R. "Teaching of Chemistry in a High-School Cooperative Industrial Course." J. Chem. Ed. 5:425-32 1928.  
The course as developed by help and request of industries in Lansing, Michigan, describing the interesting, but difficult for teacher, work.
202. Wood, L.J. "Laboratory Reports in Beginning Chemistry." J. Chem. Ed. 3:1313-22 1926.  
Development of method in St. Louis medical school which could well be used to advantage by both teacher and student in high school.
203. Woolley, M.I. "A Chemical Exhibit Used to Increase Interest in High-School Chemistry." Sch. Sci. & Math. 31:67-9 1931.  
Methods used in Murphy High School, Mobile, Ala., to get more pupils to take chemistry.



204. Worstel, R.A. "Chemical Education in Iowa High Schools."  
J. Chem. Ed. 6:1503-11 1929.  
The status of chemistry as determined by  
extensive study.

205. Zimmerman, J.A. "Lesson Planning in Chemistry." Sch. Sci. &  
Math. 27:293-7 1927.  
Need for better procedure, through questions,  
and the use on the board of an outline which  
all can follow.  
Example of plan for study of chlorine.

2. CROSS-INDEXED BIBLIOGRAPHY. OF LITERATURE DEALING WITH TEACHING  
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Twenty-Four Headings Under Which References Are Cross-Indexed.

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1. Importance of Chemistry Teaching
11. Teaching Technique
111. Increasing Interest in Chemistry
- IV. Teacher Helps and Suggestions

B. AIMS AND OBJECTIVES

- V. Specific Aims of Chemistry Course
- VI. Laboratory Aims.

C. METHODS

VII. General

VIII. Grouping of Students

IX. Laboratory

1. General
2. Laboratory vs. Demonstration
3. Laboratory vs. Classroom
4. Laboratory Notebooks
5. Laboratory Practices
  - a. Industrial and Vocational
  - b. Project

X. Classroom

1. Psychology
2. Supervised Study
3. Unit Plans
4. Project Method
5. Visual Education
6. Papers

XI. Pupil Difficulties and Errors

D. SUBJECT MATTER

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1. Content and Use
2. Analysis
3. Criticism

XIII. Courses of Study

XIV. Laboratory Manuals

E. TESTS

XV. All Types

F. SURVEYS

XVI. National

XVII. State

XVIII. City

XIX. Particular Schools

G. ACTIVITIES

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XXII. Exhibits and Posters

H. EQUIPMENT

XXIII. Laboratory

XXIV. Library

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For example, suppose the reader desires some information on the importance of chemistry teaching; he would note that the first section deals with that topic and that all numbers under that head deal with the topic, beginning with 1, 17, 18, etc.

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