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The status of instruction in high school chemistry in Montana

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THE STATUS OF INSTRUCTION
in
HIGH SCHOOL CHEMISTRY
in
MONTANA

by

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CHAPTER I

INTRODUCTION

Aims and Objectives of the Investigation. During the past six years the Division of Chemical Education of the American Chemical Society thru its official publication, Journal of Chemical Education, has encouraged and, in a few instances, has sponsored attempts to determine thru questionnaires and other means the status of education in high school chemistry. Eight such investigations have been reported in this journal.[1] States in the East, Middlewest, Southwest, and on the Pacific Coast have been surveyed. As far as the writer is aware such an investigation has not been made for any of the Rocky Mountain States. This is desirable, and hence is the purpose of this investigation.

Specifically, the aims and objectives are as follows:

1. To gather a more comprehensive body of data than has been previously available on the status of instruction in chemistry in the state of Montana.

2. To tabulate, analyze and report these data.

3. To make comparisons with such data as is available.

4. To lay a foundation of facts that may point to the desirability of studying more intensively certain phases of instruction in chemistry in Montana.

5. To draw such conclusions and make such suggestions as seem warranted by the facts presented.

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1. See bibliography.

6. To make available to the educational journals of the states of Montana and Nevada, and to the Journal of Chemical Education a report of the findings and conclusions of the investigation.

The Investigation is General in Nature. The letters and the questionnaire circulated by the writer will be found reproduced in appendix B. Inspection will show the questionnaire to be general in nature. Considerable thought was given at the time the investigation was decided upon whether a general survey or a more intensive study of a narrower field would be the more desirable. The general investigation was chosen because, (a) it was felt that if the general status were not known the meaning of the findings in the narrower field would lose much of their significance; (b) no comparative data would be available as the more intensive studies of the status of instruction in chemistry have not yet been undertaken; (c) those who were consulted in the matter - persons acquainted with educational matters in the state - advised that there was greater need for the general study.

The Phases Chosen for Investigation. Upon analysis the problem presented a number of different phases. These are listed below:

1. Administrative restrictions placed upon enrollment.

2. Teacher qualifications through education and experience.

3. The extent to which students enroll in chemistry and

the progress they make.

4. The general method of carrying on class work.

5. Efforts made to make chemistry more interesting (and valuable) through other means than the study of the text book.

6. The local interests that would aid in the motivation of the subject.

7. The efforts made by the teacher to meet recognized standards.

8. The extent to which the general aims and purposes as outlined by the Committee on Reorganization of Science in Secondary Schools are achieved.

9. Laboratory equipment available.

10. The values derived from laboratory work.

11. Cost of instruction in chemistry.

12. Achievement of students as measured by tests, final grades, success in college chemistry, etc.

13. Methods of testing for achievement.

14. A detailed study of library facilities.

15. Suggestions for improvement of instruction.

16. A determination of the amount of permanent and replaceable equipment in laboratory and classroom.

With this outline of possible phases for investigation numerous questions were formulated for each phase. In all, these amounted to about 250 in number. Selection was then made of those phases and questions that seemed most promising from the standpoint of importance of information sought, objectivity, and ease of answering. As a result of this selection the first ten phases of the problem, as outlined

above, were retained, and 62 of the original 250 questions. However, many of the questions asked were made up of two or more items that required an answer so that if all of the information requested was given about 110 answers were made.

Validity and Reliability of the Questionnaire. Only an estimate can be given as to the validity and reliability of the questionnaire. Before formulating the questions a close study was made of the following sources: (a) Course of Study in Science for Montana High Schools (1928); (b) Reorganization of Science in Secondary Schools, Bureau of Education Bulletin, No. 26; and, (c) the questionnaires circulated in previous studies and reproduced in the Journal of Chemical Education. In addition to the above sources the following books on the teaching of science and curriculum construction were consulted:

Smith and Hall, The Teaching of Chemistry and Physics[2]

Twiss, Principles of Science Teaching

Woodhull, The Teaching of Science

Bobbitt, The Curriculum

Charters, Curriculum Construction

To the extent that the opinions of the above authorities are valid as to what is fundamental and desirable in the teaching of chemistry, and of the writer's ability to choose from these opinions, the questionnaire may be considered valid.

2. Consult the bibliography for publishers and dates of these books.

A more objective answer may be given with regard to the reliability of the questions asked. Upon analysis it is found that of the 62 questions asked, 9 require approximations; 31 are distinctly and wholly objective; 9 ask for an opinion based upon the best judgment of the teacher; 12 are objective in nature but might involve considerable error in answering. The large number of questions asked is a factor in favor of increasing reliability. Added to this is the fact that conclusions are drawn from groups where the smallest number of schools is five (first class district schools).

A recent bulletin[3] issued by the National Education Association provides criteria by which the validity and reliability of questionnaires may be determined. The first criterion states that "The conclusions based upon the questionnaire blanks are seldom final and hence make little if any contribution to educational advance." This criterion does not affect greatly the validity of this study as finality is in no way claimed. The primary purpose of this study is that of exploration and providing a basis upon which other studies of a final nature may be based. Criterion number two states "That the respondents to a questionnaire may not be a random sampling of those addressed." In a discussion of this criterion the bulletin states:

3. These criteria were taken from Research Bulletin of National Education Association, Vol. VIII, No. 1, p. 9, Jan., 1930.

> "Objective appraisals of this factor . . . suggest that the danger of a selected response has been overestimated. Until evidence to the contrary is forthcoming, it seems reasonable to conclude that this factor is probably not decisive in affecting the results of the typical questionnaire, particularly if a reply of more than fifty percent is received."

Since the response to the questionnaire was over fifty percent, representing more than sixty percent of the students in schools teaching chemistry for this year, it is thought that the sampling was a random one. Criterion three states that, "Respondents to a questionnaire consciously or unconsciously modify their replies to give the investigator what he wants." If the above is true with respect to this questionnaire then it is very much in its favor. What the writer tried to get was facts. In formulating the questions every effort was made to avoid anything that might indicate his own point of view. Criterion four states that, "Carelessness in reporting and difficulty in securing information requested invalidates the study." Undoubtedly this criticism applies to this investigation as it does to every study of its nature. The amount that this tendency would vitiate the results can not be estimated easily. There is evidence in a few cases that the respondents did not give a great deal of thought to the answers made. However, in this investigation, as stated above, small differences are not significant, and extreme nicety in original data is not essential. It is the opinion of the writer that in most cases

the answers were sincerely and conscientiously given, and that the teachers felt they were making a contribution to the advancement of teaching in this state.

Sources of the Data. The sources of the data upon which this report is made are as follows:

1. The responses to a questionnaire mailed to the principals of the high schools of Montana and Nevada that were teaching chemistry during the school year 1928-29.

2. The files of the State Department of Public Instruction at Helena, Montana.

3. Educational directories of the state of Montana for school years 1927-28, and 1928-29.

4. Journal of Chemical Education, General Science Quarterly, School Science and Mathematics, and other periodicals containing comparative data.

Response to Questionnaire. Responses were received from all of the high schools of the first class districts except Butte High School. Only one third of the third class districts responded. Considering all of the schools of the state teaching chemistry in Montana for the school year 1928-29, fifty percent of the schools answered the questionnaire. These schools represent sixty percent of the enrollment of those schools teaching chemistry. Data showing to what extent the questionnaire was answered is presented in the table on the following page.

Table I. *Extent to Which Questionnaire Was Answered.

	Number of Schools	% of the schools in this division teaching chemistry	% of the enrollment of schools in this division teaching chemistry
First class districts	5	83	75
Second class districts	17	53	65
Third class districts	11	33	33
County high schools	9	60	70
Total - all divisions	42	50	60

*A complete list of schools will be found in appendix A - master tabulation.

Method of Presenting the Data. For the most part the data will be presented in the form of a series of tables preceded or followed by a discussion evaluating and explaining their significance in light of comparative data available. In every case the data for Montana may be compared to that of Nevada since the questionnaire was circulated in both states.

For the purpose of tabulation the Montana schools are frequently divided into the same administrative units as those used by the State Department of Public Instruction, that is: (a) first class districts, or those having a population of eight thousand or more; (b) second class districts, or those having a population of one thousand and less than eight thousand, excepting those districts that are incorpor-

ated as county high schools; (c) county high schools; (d) third class districts or those having a population of less than one thousand. In practically every case data for these divisions will be grouped and considered as a whole for that group. In schools of the first class one exception was made to the above classification, that in the case of Missoula County High School. In almost every respect this school more closely resembles a city school system that a county school.

In order to preserve the original data a master tabulation has been prepared of all data collected through the questionnaire. This will be found in appendix A.

This report is divided into seven chapters. The first chapter deals with the introduction, chapter two with administrative practices and enrollment, chapter three with the outcomes of instruction, chapter four with qualifications of teachers, chapter five with utilization of class period, chapter six with laboratory equipment and practices, and chapter seven with a final discussion and general summary of results, together with suggestions and recommendations for improvement of instruction.

CHAPTER II

ADMINISTRATIVE PRACTICES - ENROLLMENT

Extent to Which Chemistry is a Required Subject. Data on this point are available from two sources, (a) the reports of the principals of Montana High Schools to the High School Supervisor,[4] (b) the questionnaire circulated by the writer.[5] For the reason that the data from the two sources show considerable difference both are given here.

Table II. Extent to Which Chemistry is a Required Subject in Montana High Schools.

Reports to High School Supervisor.

	No. of schools	Percent
Chemistry elective	61	78.2
Chemistry required	12	15.4
Chemistry required or elective	5	6.4

Extent to Which Chemistry is a Required Subject in Montana High Schools.

Questionnaire Results.

	No. of schools	Percent
Required in scientific course, elective in others	15	
Required for graduation	3	52.6
Required for college prep.	1	
Required of all except commer.	1	
Elective in all courses	16	47.4

Since the enrollment of students in the scientific course will not be a very large percentage of the total enrollment for that school, it is likely that the principals

4. Department of Public Instruction High School Report, Part B. (1928-1929)
5. See question 8 of questionnaire--Appendix B.

in schools where chemistry is required in the scientific course would designate it as elective in the report to the High School Supervisor. Assuming this to be true and adding these schools to those in which chemistry is entirely elective it is found that about 85 percent of the schools answering the questionnaire would report chemistry elective to the High School Supervisor. This percentage is fairly close to that obtained from the principals' reports.

Comparative data are available to show to what extent chemistry is required in several other states. This is shown in Table III.

Table III. Extent to Which Chemistry is Required in Other Sections of the United States.

	Chemistry Purely Elective		Chemistry Required in Some or All Courses	
	No. of Schools	%	No. of Schools	%
Wisconsin Survey[6]	55	76.4	17	23.6
Texas Survey (Greta Oppe)[7]	71	83.0	14	17.0
Powers Survey[8]	48	56.0	38	44.0
Nebraska Survey[9]		75.0		25.0
Totals of above surveys(a)	174	71.6	13.4	28.4

(a) Does not include Nebraska Survey.

6. T.A.Rogers, A Survey of Chemistry Teaching in Wisconsin High Schools. Journal of Chemical Education 5:1416,(1923)
7. Greta Oppe, The Status of Chemistry in Texas High Schools Affiliated with the Southern Association of Secondary Schools. Journal of Chemical Education 6:1749, (1929)
8. R. S. Powers, Report of Chemistry Survey. School Science and Mathematics 15:814, (1915)
9. B. Clifford Hendricks and John S. Chambers. Chemistry Teaching in Nebraska. School Science and Mathematics 29:140 (1929)

It is apparent that chemistry is a required subject in Montana to about the same extent that it is in other states. In Montana it is required for graduation in only a few schools, (See Table II). These schools have a small enrollment.

The Number of Schools Teaching Chemistry in Montana.

Since chemistry is not required for graduation to any great extent in Montana High Schools it will be of interest to know to what extent chemistry is offered in these schools. Very complete information was obtained from the reports made by the principals to the High School Supervisor, and from the educational directory for the school year 1928-29.[10] This information has been tabulated and presented in Table IV.

Table IV. Number and Percent of Schools Teaching Chemistry.

	1st Class Dist.	2nd Class Dist.	3rd Class Dist.	*Co. High Schls.	Totals
High Schools in State	6	54	119	19	198
High Schools teaching chemistry	6	42	44	16	108
Percent teaching Chem.	100	78	37	84	545

*Does not include Missoula County High School

The following facts are of primary importance in Table IV:

(a) All first class district high schools teach chemistry.

(b) Only 37 percent, or about one in three, of the third class district high schools teach chemistry.

10. Montana Educational Directory, 1928-29. Published by State Superintendent of Public Instruction, (Helena, 1928)

(c) Considering all schools, 54 percent, or about one in two, teach chemistry.

(d) All but three county high schools teach chemistry. These schools were small schools having enrollments of 75, 81 and 116.

A simple calculation shows that 41 percent of all the schools teaching chemistry are the smaller third class district schools; however, it can be seen from the table that chemistry is not a subject commonly found in these schools since only 37 percent teach the subject.

To Show to What Extent Schools in Other States Teach Chemistry. Comparative data is available in two cases. In the Nebraska Survey[11] it is found that 23.7 percent of the schools of the state offer chemistry; in the Oregon Survey[12] it is found that 42 percent of the schools teach chemistry. In these states, as in Montana, the small high school is characteristic. If it is desirable that a large percentage of the schools of a state teach chemistry then it may be concluded that Montana, with 54 percent, is considerably ahead of two neighboring states in this respect.

Extent to Which Students Enroll in Chemistry. The percentage of the total enrollment taking chemistry is another measure of the effort made by the schools of the state to teach the subject. Once more the reports of the principals[13]

11. Hendrick and Chambers, op. cit., p. 138.
12. A. Swartz, A Survey of Chemistry Course in the Oregon High Schools, Journal of Chemical Education, 3:818 (1926).
13. Department of Public Instruction, High School Report - Part B. (1928-29).

provide very complete data. This has been tabulated in Table V.

Table V. Number and Percent of Students Enrolled in Chemistry in Montana, 1928-29.

	1st Class Dist.	2nd Class Dist.	3rd Class Dist.	Co. High Schls.	Total
Total number of students enrolled in dis.	5700	6857	4671	5159	23,352
Students enrolled in chemistry	637	567	366	404	1,974
Percent of total enrollment (all schools) taking chemistry	11.2	8.3	7.9	7.8	8.5
(a) Percent of the enrollment of those schools teaching chemistry	9.7	12.6	17.0	9.1	10.7

(a) as shown by the questionnaire, see Table I, Appendix C for original tabulation.

In Table V it should be noted:

1. That about 8.5 percent of all Montana high school students take chemistry.

2. That 10.7 percent of those who have the opportunity take chemistry.

3. That a larger percent of students in first class district schools take chemistry than in any of the others.

4. That a surprisingly large percentage of students in second and third class district schools that are teaching chemistry are enrolled (12.6 and 17.0% respectively).

The fact presented in four above can be explained in light of the data presented in Table VI.

Table VI. Schools Teaching Chemistry Every Year and Alternate Years.

	1st Class Dist.	2nd Class Dist.	3rd Class Dist.	Co. High Schls.	All schls.
Number of schools teaching chemistry	6	42	44	16	108
Schools teaching chemistry every year	6	18	6	15	45
Schools teaching chemistry alternate years	0	24	38	1	63
No. of schools teaching in alternate years teaching in 1928-29	--	10	27	1	38
No. of schools teaching in alternate years that taught in 1927-28	--	14	11	0	25

In second and third class districts the common practice is to teach chemistry in alternate years. For example, in 1928-29 only 18 of the 42 second class district schools, and 6 of the 33 third class district schools teaching chemistry, teach it every year. The remainder teach it in alternate years. From Table VI it can be seen that 10 of the former schools and 27 of the latter have in their classes for 1928-29 students for two years, and since only those schools actually teaching chemistry were considered in calculating the percentage, it naturally would be large.

Table V shows that 366 students are enrolled in chemistry in third class district schools. This is an unusually large number because 27 of the 38 schools of this group teaching chemistry in alternate years are teaching in 1928-29. In considering enrollment of these schools this must be kept

in mind.

Considerable comparative data are available with which the percent of enrollment in Montana may be compared. This is given in Table VII.

Table VII. Comparative Data to Show Percentage of Enrollment in Chemistry.

Sources of Data	% of total school enrollment	% of enrollment those schools teaching chemistry
Montana	8.5	10.7
Division on Chem. Ed., Am. Chem. So., (1928 report)[14]		10.15
Division in Chem. Ed., Am. Chem. So., (1929 report)[15]		10.67
Bul. 35671 U.S. Bureau of Educ. (1928)	7.3	
Nebraska Survey in Chemsitry[16]	7.3	
Bul. No. 7, U.S. Bureau of Ed. (1924)	7.3	
Wisconsin Survey[17]		10.2
Quinquennial Survey of N.C.A.[18]	8.8	
California Survey[19]		10.7

The number of students enrolled in chemistry in Montana is close to that for the country as a whole.

14. Committee on Chemical Education of American Chemical Society, Order of Precedence of Laboratory Work and Recitation, Journal of Chemical Education, 5:1307 (1928).
15. Committee on Chemical Education of American Chemical Society, Professional Spirit Among High School Teachers, Journal of Chemical Education, 6:1367 (June, 1930).
16. Hendricks and Chambers, op. cit., page 140.
17. Rogers, op. cit., 1416.
18. 1925 Quinquennial Study by North Central Association of Colleges and Secondary Schools, published under title, Our Secondary Schools, by Calvin O. Davis, p. 47.
19. Elizabeth L. Bishop, "The Status of Science in California High School Programs of Studies, Master's thesis (1924) unpublished.

Perhaps a better measure of the effort made by Montana high schools to instruct their students in chemistry is to determine to what extent juniors and seniors are enrolled in chemistry. Questions 2 and 24 of the questionnaire were asked to provide data to make these calculations.[20]

Table VIII is a tabulation of the responses.

Table VIII. Extent to Which Juniors and Seniors Register in Chemistry.(a)

	Juniors taking chem.		Seniors taking chem.		Jrs. and Srs. taking chem.	
	No.	%	No.	%	No.	%
1st Class Dists.	205	22.1	206	29.6	411	25.4
2nd Class Dists.	178	37.5	173	37.3	351	37.4
3rd Class Dists.	54	41.2	59	64.1	113	51.1
County H. S.	70	11.6	177	40.0	247	23.6
Totals	507	23.8	615	36.3	1122	29.4

(a) Data taken from original tabulation, Table I, Appendix C.

From this table it may be concluded that in those schools in which chemistry is taught three of every ten juniors and seniors take chemistry, and that in first class districts and county high schools one in every four take chemistry. The unusually large percentage of juniors and seniors in second and third class districts taking chemistry can be explained as was done on page 15 to account for large enrollment in chemistry for these schools.

Data were not available by which it could be calculated what percentage of the total junior and senior enrollment in second and third class districts take chemistry. Within the

20. See questionnaire, Appendix B.

limits of the information available it may be stated that juniors and seniors are enrolled in chemistry in about the ratio of 2.7:10. It is asked if this is not a small percentage? Comparative data are desirable on this point, and are given in Table IX.

This information was obtained from quinquennial report of North Central Association, pages 24 and 76.[20a] It is assumed that there were no sophomores enrolled in chemistry. While this is not true the number of sophomores enrolled in chemistry would be small and would not change the results materially.

Table IX. Juniors and Seniors Enrolled in Chemistry in North Central Association.

	Kont.	Mo.	Kans.	Nebr.	All N.C.A. Schools
Boys enrolled in chem.	549	1999	1170	799	33,685
Girls " " "	360	1163	1428	551	25,541
Totals	909	3162	2598	1350	59,426
Number of Jr. & Sr. boys	1925	7794	7069	4589	127,650
No. of Jr. & Sr. girls	2429	8709	8652	6216	148,910
Totals	4354	16503	15721	10806	276,560
% boys taking chem.	28.6	25.6	16.4	17.5	26.5
% girls " "	14.8	13.3	16.5	9.1	17.2
Totals	20.9	19.2	16.5	12.5	21.5

It will be observed from Table IX that:

(1) Montana has a larger percent of its juniors and seniors enrolled in chemistry than certain other states of the association.

(2) The enrollment is 0.6 percent less than the average

20a. C. E. Davis, Quinquennial Report, op. cit., 24, 37.

of all schools in the association.

(3) The enrollment of boys is 2.4 percent more than the average for the association, but that for girls 2.4 percent less.

Why is Not Chemistry More Generally Taken by Juniors and Seniors in High School? Certainly there are few subjects of greater worth in the high school curriculum. It is valuable because of its bearings on our everyday life in the home and the community, in health and in industry, in its training value as a school subject and, by no means the least in importance, the avocational interests, cultural values and pleasurable use of leisure time that result from a knowledge of chemistry even such as that learned in high school. Certainly much has been written and said as to the merit of chemistry as a school subject. This can be determined by reading books on the construction of the curriculum for high schools, scientific magazines, or even current periodicals. Might not the small enrollment in chemistry be due to factors in the school organization that can be determined? Do administrators discourage students registering in chemistry? Do they encourage them? What is the attitude of the teachers toward increased enrollment? Is there a tendency on the part of teachers and principals to place a taboo on the subject by giving the impression that the subject is difficult, requires exceptional ability, or that it is dirty and messy? Is there a tendency to a great deal of talk in an effort to

"scare out" weaker students so that the "standards of the department may be maintained"? These questions - others could be asked - are results of the observations and experiences of the writer as a teacher of chemistry. Certainly he has been guilty of many of these artifices to have only good students enroll in his classes. Something of this may have dictated the wording of questions 6 and 7 of the questionnaire. It is recognized now that the questionnaire would have been much more unbiased if an additional question had been asked: What efforts do you make to increase enrollment in chemistry?

Qualifications Required for Enrollment in Chemistry.

Questions 4, 5, 6, and 7 of the questionnaire were formulated to obtain data by which this could be determined. That it is desirable to have some science training previous to taking chemistry is well substantiated by the statements of those qualified to pass judgment. The Revision Committee of the Committee of Chemical Education of the American Chemical Society[21] "anticipates that teachers will encourage placement of chemistry in third and fourth year of high school after the students have had a year of general science and of biological science or physics, or both." In the course of Study in Science for Montana High Schools, page ten,[22] it is recommended:

21. See report of this committee, Journal of Chemical Education, 4:642 (May 1927).
22. Prepared and issued under the direction of the State Department of Public Instruction (1928) published by The Tribune Printing Co., Great Falls.

"In view of the importance of science study that at least one, and preferably two, units of credit in science be required for graduation. Partly for this reason, but principally because of the inherent value of general science study the recommendation here made that all Montana high school pupils be required to complete one year's work in general science in the ninth or at latest in the tenth grade."

In light of these strong recommendations conditions, as found in Montana with respect to requiring general science as a prerequisite to taking chemistry, became more significant.

Table X. Schools Requiring General Science for Enrollment in Chemistry.

	Yes	No
First class district schools	1	4
Second class district schools	7	10
Third class district schools	8	3
County High Schools	3	4
Totals	19	21

Schools not answering, 2.

The results indicate that where the number of elections is large (in the larger schools) that general science is not required as preparation for the more advanced sciences - for example, chemistry. There are more schools that require general science for enrollment in chemistry than there are schools that do not require it.

To a teacher experienced in teaching chemistry the desirability of at least one year's instruction in science before taking chemistry is not questioned. Naturally, the preferred science is physics, but not much less desirable is

a year's instruction in general science. The amount of chemistry taught in general science is not the important factor in this preparation, but rather the development of scientific attitude and appreciation of scientific methods. Other desirable outcomes of this preparatory course are, (a) something of general technique in laboratory manipulation, although the course may be taught mostly be teacher demonstrations; (b) a distinct realization on the part of the student of whether his interest and enthusiasm is such that he wishes to continue in a more difficult science; (c) an appreciation, and in many cases the development of considerable ability, to apply the methods of problem solving and rational thinking.

The writer is thoroughly of the opinion that the students of the second and third class district schools, where general science is required to a considerable extent, will make better progress in chemistry than those in the other groups if other factors are equal. It is realized that in schools where there is not a rule requiring preparation in some science previous to taking chemistry, that many of the students will get get this preparation, and that if the larger systems were to have such a rule it would mean the hampering of the flexibility of the curriculum which is so desirable; yet the importance of this freshman science is such that in order to prevent the chance of it being omitted by leaving

it elective, a course in general science should be required of all.

The question of which subject should precede, physics or chemistry, when both will be taken by the student, is still debated with little evidence of an objective nature to guide in making a specific recommendation. In giving their opinions not infrequently teachers and educational authorities are swayed to favor placing that subject in the senior year in which they have been primarily interested or of which they know most. There is a distinct need to make a study of the difficulty of the subject matter of the two sciences as taught in high school. Some effort has been made in recent years to determine more closely the methods, aims, and objectives of instruction in chemistry from a psychological point of view.[23]

The attitude of the State Department of Education on this debated question is shown by the quotation which follows, taken from the Course of Study in Sciences:[24]

> "Since the large majority of Montana High Schools are to be classed as of medium of small size, it is recommended here that the first sciences introduced be general science, biology, chemistry,

23. Max D. Englehart, A Psychological Basis for Objectives, Journal of Chemical Education, 4:364-69 (1927).
Brown, E. A., and Bowers, W. C., Psychology Underlying Instruction in Chemistry, School Science and Mathematics, 23:715-724.
Neil F. Gordon, Application of Educational Psychology to Chemical Education, School Science and Mathematics, 21: 862-67.
24. Course of Study in Sciences, op. cit., p. 10.

and physics, the sequence by high school grades may well be as given above. Not infrequently, however, physics is given before chemistry; in small schools, however, it is recommended that physics and chemistry be combined in eleventh and twelfth grade classes, and that these subjects be alternated by years. . . ."

Making a somewhat different recommendation is the committee on Chemical Education of the American Chemical Society[25] that "chemistry be taught the fourth year following physics."

In Table XI the practices in Montana are tabulated with that of other sections of the country so that comparisons may be made.

Table XI. To Show in What Years High School Chemistry is Taught.

	11 year		11-12 year		12 year	
	No.	%	No.	%	No.	%
Montana[26] (a)	7	18	20	51	12	31
California[27]	142	51	118	42	16	5.7
Committee of Chemical Education report (1928)[28]	15	24	25	39.7	23	36.5
S. R. Powers Survey	47	31	49	32.5	55	36.4
Nebraska	--	9	--	44	--	47.0

(a) Any distinct tendency was taken here as the measure of what year chemistry was taught.

Four facts stand out from Table XI.

25. Committee of Chemical Education of American Chemical Society, Correlation of High School and College Chemistry, Journal of Chemical Education, 6:642, (May, 1927).
26. Data obtained by tabulation of responses to question 16 of questionnaire. See master tabulation, Appendix A.
27. Bishop, op. cit., p. 26.
28. Committee report, op. cit., p. 130.
29. Powers, op. cit., p. 814.
30. Hendricks and Chambers, op. cit., p. 140.

1. In more than one-half of the Montana schools chemistry is taught to classes made up of about equal numbers of juniors and seniors.

2. In a third of the schools, classes are made up primarily of seniors. In this respect Montana is in rather close agreement with results obtained in two other surveys.

3. In a comparatively few schools (only seven) chemistry is taught to classes composed mostly of juniors.

4. If required to classify chemistry as a junior or senior subject the more correct answer would be senior subject. The extent to which this is true is indicated in Table VIII where it is seen that 507 juniors and 615 seniors were taking chemistry in 1928-29.

In only a few schools in Montana is there a rule (administrative) that chemistry must precede physics or vice versa. In answer to question 5 of questionnaire only one school indicated that chemistry must precede physics, and three that physics must precede chemistry.

Efforts Made to Direct Students in Enrolling in Chemistry. In a previous paragraph (page 19) a series of questions was asked, answers to which would indicate the attitude of teachers and administrators towards chemistry as a school subject. Answers to these questions cannot be made in every case, and with the finality that is desirable, but a tabulation and interpretation of the answers to question 5 of the questionnaire may shed some light. Table XII classifies the responses.

Table XII. Extent to Which Students Are Advised in Registering for Chemistry.

(a) No. of schools in which no effort is made	25
(b) Make no effort - poor students do not take	1
(c) Only when classes are full	1
(d) Advise weak students not to take it	2
(e) Only capable students permitted to enroll	3
(f) Must have permission of teacher	1
(g) Required of all juniors or seniors	2
(h) Answer vague	1
(i) Not answering	6

In twenty-seven schools (a, b, and c above) no recognized effort is made. In six schools an effort is made at guidance. Others cannot be classified except that no conscious effort is made. There is but one way to interpret the data. Instead of too careful selection and too much elimination to regulate the size of enrollment, just exactly the opposite tendency seems to be true. Direction and guidance are at a minimum; efforts to increase enthusiasm in, and interest for the course probably are present to about the same extent. It seems to be pretty much a matter of the student taking a chance, prejudiced by the reports he has had of chemistry from others. Or perhaps he is guided by the requirements of the school, or by a desire to be better prepared to carry some course that he plans to take in college. Certainly much lost motion and efficiency must result from such a system.

Tests are available for predicting performance in the

chemistry.[31] While not infallible these tests are certainly more reliable than the opinions of the principals, teachers, or students as to what success may be had in the course. In not a single response to the questionnaire was mention made of any such objective measure to determine aptitude for the study of chemistry. One teacher made selection on the basis of past success in mathematics. Some knowledge of the industry and application of the student in past work, mental ability, and natural bents - all of which it is within the powers of teacher and principal to observe - would be helpful in advising students to enroll in chemistry. But even this, apparently, is not used as a basis for judging in at least 90 percent of the schools.

In one respect, however, there is very marked restriction of enrollment, that in the matter of permitting sophomores to enroll in chemistry. Of the schools answering question 6 of the questionnaire, 36 will not permit sophomores to enroll under any condition; 4 will permit if students have high I. Q.'s and are especially interested in the subject.

Extent to Which Students Fail to Make Passing Grades in Chemistry. In Table XII the responses for the separate schools to question 24, 25, and 26 of the questionnaire have

31. Iowa Placement Series: Chemistry Aptitude, CA-1, Revised, Form A and B. See:
Geo. D. Stoddard, Iowa Placement Examination, University of Iowa, Studies in Education, Vol. III, No. 2, (1925): 103 pages.

Table XIII
To Show Number and Percent of Juniors and Seniors Enrolling in Chemistry

Schools	Total Enrollment	Juniors			Seniors			Total No. taking Chemistry	% of comb. Jrs & Srs taking chem.	Total % taking chem.
		No.	Taking Chem.	% taking chem.	No.	Taking chem.	% taking chem.			
First Class Districts										
Anaconda	431	129	2	1.6	100	56	56.0	62	25.3	14.4
Billings	970	260	180	52.0	175	35	20.0	165	38.8	17.0
Great Falls	1341	218	56	25.7	170	56	32.9	112	28.9	8.4
Helena	578	104	16	15.4	100	24	24.0	42	19.6	9.3
Missoula	965	225	1	0.5	150	35	23.3	36	9.6	3.7
Totals	4285	936	205	22.1	695	206	29.6	417	25.4	9.7
County High Schools										
Beaverhead	283	78	2	2.6	46	28	61.0	30	24.2	10.6
Chouteau	138	30	8	26.7	20	8	40.0	16	32.0	11.6
Dawson	310	85	18	21.2	47	19	40.4	37	28.0	12.0
Fergus	686	116	4	3.4	85	38(a)	44.7	40	20.9	7.0
Gallatin	541	120	2	1.7	106	24(b)	22.6	26	11.5	4.8
Granite	95	20	16	80.0	18	0	0.0	16	42.1	16.7
*Jefferson	60	—	—		—	—		—		—
Park	414	100	0	0.0	70	38	54.3	38	22.4	9.2
Powell	263	55	20	36.3	52	22	40.8	42	40.0	16.6
Totals	2780	604	70	11.6	444	177	40.0	258	23.6	9.1
Second Class Districts										
Big Sandy	118	23	23	100.0	26	5	19.2	28	57.2	23.7
Chinook	225	37	13	35.1	23	3	13.0	16	26.7	7.1
*Conrad	172	40(b)	—		25(b)	—		—		—
Forsythe	145	28	14	50.0	27	1	3.7	15	27.3	10.3
Glasgow	280	60(b)	?		35	?		41	—	14.6
Hamilton	219	34	16	47.1	43	10	23.2	26	33.8	12.3
Hardin	224	27	6	22.2	32	14	43.8	22	34.0	9.9
Havre	445	70	33	47.1	75	9	12.0	42	29.0	9.5
Huntley project	156	35	12	34.3	27	16	59.3	18	45.1	11.5
Lodge Grass	36	8	8	100.0	11	11	100.0	19	100.0	52.8
Malta	166	38	0	0.0	28	10	35.8	10	15.1	6.0
Polson	204	54	19	35.2	48	6	12.5	25	24.5	12.2
Poplar	96	20	7	35.0	13	6	46.1	13	39.4	13.6
Scobey	150	19	11	57.9	26	14	53.8	25	55.5	16.6
Sidney	220	38	0	0.0	50	44	88.0	44	50.0	20.0
Twin Bridges	71	14	6	42.9	9	6	66.7	12	52.2	16.9
Whitehall	151	30	0	33.3	26	18	69.2	28	50.0	14.5
Totals	3056	475	178	37.5	464	173	37.3	384	37.4	12.6
Third Class Districts										
Clyde Park	30	8	3	100.0	3	2	66.7	5	83.3	16.7
Ismay	40	8	2	25.0	10	2	20.0	5	22.2	12.5
Lima	39	11	0	0.0	6	5	83.3	5	29.4	12.8
Nashua	50	9	6	66.7	3	2	66.7	8	66.7	16.0
Noxon	28	10	10	100.0	5	3	60.0	13	86.6	46.4
Stanford	92	20	3	15.0	15	9	60.0	12	34.3	13.0
Superior	41	9	1	11.1	6	5	83.3	6	40.0	14.6
White Sul. Spr.	49	6	4	66.7	8	5	62.5	9	64.2	18.4
Richey	74	20	0	0.0	11	12	100.0	12	38.7	16.2
?	(c)	16	14	88.0	16	10	62.4	24	75.0	(c)
?	85	17	11	64.7	9	4	33.3	15	58.0	17.6
Totals	528	129	54	41.2	92	59	64.1	90	51.1	17.0
Totals all Schools	10,649	2134	507	23.8	1695	615	36.3	1129	29.4	10.7

(a) 6 post graduates counted as seniors
(b) 2 post graduates counted as seniors
(c) not counted in averages
* not teaching chemistry 1928-29

been tabulated. In the first column of this table is given the number of the school as numbered in the master tabulation - Appendix A. The total number enrolled is taken as the number enrolled at the end of two weeks rather than the largest number enrolled because considerable transferring and dropping is done in this period of time. It was desired to know what enrollment could be considered permanent. It was assumed that any student dropping after this time did so because of the difficulty of the course. This may not correspond to actual facts in all cases, but probably the number dropping for other reasons would be compensated for by the number of students entering late. The number of students entering the second semester or the number failing the second semester was not asked for in the questionnaire. It was assumed that the difference between the net enrollment (after two weeks) and the number finishing the year (estimated by the teacher) was the number failing for the year. It is acknowledged that the data presented in Table XII is not exact. It is believed, however, that errors introduced are balancing errors (errors due to chance variation) and that the final results sought may be considered reliable. In order that the results of Table XII may be more easily understood a recapitulation of the results is offered in Table XIV.

Table XIV. Recapitulation of Table XII.

	% failing 1st Sem.	% failing for year.	Highest % failing.	Lowest % failing.
1st class dist. schools	4.7	18.1	22.7	8.2
2nd class dist. "	1.9	7.5	19.2	0.0
3rd " " "	0.9	12.8	20.0	0.0
County High Schools	4.5	9.7	29.8	0.0
All Montana schools	3.4	12.4	-- -	- -
Nevada schools	8.1	12.9	27.0	0.0

Comparative data was found in one case, that of Nebraska.[32] In this survey it was reported that 10.6 percent of the students enrolled failed the first semester.

In the matter of failures Montana certainly makes a good showing. It is true that the percentage is but little smaller than that for Nevada, but it is much better than that for Nebraska. Twelve and nine-tenths percent of failures is considered a low rate of failures in subjects much less difficult than chemistry. Attention is called to the especially fine showing made by Montana in rate of failures the first semester. Even tho the student does not accomplish enough to be given credit for the course if the student may be held in the course for the year some good must result from the association.

In the case of the first class district schools the percentage of failures is relatively high. With schools numbered 2, 3, and 4 (see Table XII) this is especially true. Any explanation offered in the absence of any concrete

32. Hendricks and Chambers, op. cit., p. 139.

knowledge can be nothing more than a conjecture. Large classes and no effort at guidance or direction of the student in enrolling in chemistry, characterize these schools and (probably) has something to do with the large percentage of failures.

A rather large percentage of failures is found in the case of third class district schools when compared to second class district, and county high schools. Once more any explanations can be nothing more than conjectures, but it is suggested that poorer equipment, smaller knowledge on the part of the teacher in knowing how to handle slow students, and poorer teaching through lack of knowledge of the subject matter of chemistry may account for some of this difference. As will be shown in other parts of this report lack of equipment, lack of teaching experience, and lack of preparation on the part of the teacher to teach chemistry characterize the third class district schools.

Evidence is at hand that not only is the percentage of failures in chemistry small in Montana but that achievement is high. Some 62 schools in Montana participated in the Every Pupil Scholarship Contest, conducted by the Kansas State Teachers College,[33] in April 1930. Tables were com-

33. This information was obtained from Bulletin of Information, Every Pupil Scholarship Contest, conducted by E. C. Deputy and Howard McIntosh. May be obtained from Bureau of Educational Measurements, The Kansas State Teachers College, Emporia, Kansas.

piled to show the scores made by three states, Montana, Missouri, and Nebraska. The results of the test for chemistry are given in Table XV.

Table XV. Percentile Distribution of the Class Scores for Missouri, Montana, and Nebraska.

	Montana	Missouri	Nebraska
Possible score	103	103	103
Highest score	97	97	85
99 %	96	95	85
90 %	85	80	73
75 %	74	67	58
50 %	59	57	49
25 %	45	46	38
10 %	37	38	35
1 %	23	28	27

Table to be read 99% of Montana scores did not exceed 96; 75% of scores did not exceed 74, etc.

Montana schools rank first of the three states with Missouri a close second. Nebraska is considerably below both of these states.

The test was written by R. Schukmann, Professor of Chemistry, Western State College, Gunnison, Colorado. Apparently no attempt was made to validate the test or determine its reliability. The test is entirely and wholly factual and objective. It attempted to test the factual matter of the text-book.

Summary and Conclusions.

1. Of the 99 schools answering the questionnaire only five may be considered to make chemistry a strictly required subject although about half of the schools require chemistry to some extent for graduation. This is about the same proportion in which chemistry is required in other states.

2. Fifty-four percent, or slightly more than half of the high schools of Montana, teach chemistry. Almost half of these schools (41%) are third class district schools; however, only about a third of the third class district schools teach chemistry. It is probable that a slightly larger percentage of Montana schools teach chemistry than is found in neighboring states.

3. About 8.3 percent of all the high school students in Montana are enrolled in chemistry, while about 10.7 percent of those in schools having chemistry in the curriculum are enrolled. This compares very closely with the enrollments found in other sections of the country. Due to the fact that 33 of the 63 schools in Montana teaching chemistry in alternate years were teaching the subject in 1928-29, the percentages given above may be slightly higher than the normal enrollment in Montana.

4. Approximately three of ten juniors and seniors in high schools teaching chemistry are enrolled in the subject Why is it that a larger percentage of these students is not

registered in a subject playing such an important part in the lives of all Americans?

5. Little is done by the principals of schools to encourage or discourage enrollment in chemistry. A more desirable arrangement for Montana would be to encourage enrollment in chemistry by making students aware of its importance in their daily lives and activities, at the same time making a much greater effort to select those students who, through ability and interest, would get marked returns from the course.

6. While, in all likelihood, many of the students enrolled in chemistry have had previous preparation in some course or courses in science it is desirable that this should not be left to chance, but that general science should be made a required subject in the first or second year of high school. There is no marked tendency toward this in Montana.

7. There are very few cases where physics is required before taking chemistry where a student will take both subjects, although from the data compiled to determine the extent of enrollment (Table VIII) it was determined that chemistry may better be designated a senior subject than a junior subject. The most common arraggement is to find about equal numbers of juniors and seniors enrolled. This is the only practical method of procedure in the numerous small high schools of Montana.

8. The number of failures in chemistry in Montana is not excessive. As a matter of fact it may be termed small considering the little effort that is made in guidance or direction in enrolling students in the subject.

9. As measured by the test in chemistry of the Kansas State Teachers' College "Every Pupil Scholarship Contest" Montana students make a somewhat better showing than the pupils of the states of Missouri and Nebraska. This test was limited entirely to facts of chemistry as they would be found in a textbook of chemistry.

CHAPTER III

THE OUTCOMES OF INSTRUCTION

Aims and Objectives of Instruction. Much has been written and many lists of desirable outcomes have been formulated in an effort to get a clear statement of just what it is hoped will result from taking a course in high school chemistry. In the opinion of many teachers the best statement that has yet been made of the objectives of science teaching--which of course, includes chemistry--is that advanced by the Committee on Science appointed by the Commission on the Reorganization of Secondary Education.[34] Since the appearance of this report it has been accepted widely in educational circles in the United States as a worthy expression of the goals of science instruction. The report of this committee is the result of years of study and observation in the field of science teaching. Among the members of the committee are included prominent teachers of science from universities and colleges, successful high school teachers and supervisors, and authors of textbooks on high school science.[35]

34. Reorganization of Science in Secondary Schools, Bureau of Education Bulletin No. 26 (1920), pp. 12-15 and 36-37. This is a report of the Commission on the Reorganization of Secondary Education, appointed by the National Education Association.
35. Ibid., p. 3. (List of the names of the members serving on this committee.)

Question 45 of the questionnaire consists of nine abbreviated statements of the aims and objectives of science teaching as proposed by the committee. Inasmuch as these statements are somewhat difficult to keep in mind, and since it is probable that those reading this report will want to refer to them from time to time, they are reproduced here as they appeared in the questionnaire.

Question 45.

Below are listed some of the values to be derived from a course in chemistry. Indicate to what extent you think you have achieved these for your class as a whole this year. (1) Would indicate to a marked amount; (2) in considerable amount; (3) moderate amount; (4) small amount; (5) negligible.

(A) The development of interests, habits and abilities.

(B) The development of direct and effective methods of solving problems that might arise in real situations.

(C) Development of a higher appreciation by the student of the pleasure and profit to be obtained by the exercise of his own abilities.

(D) Control of an appreciable body of facts and principles of significance in the home and community.

(E) The building up of an intelligent understanding of the conditions, institutions, demands and opportunities of modern life.

(F) Development of clearly defined points of view, intensified powers of insight, and points of departure for new attempts for future study.

(G) Appreciation of the contributions of chemistry to health, and in the control and elimination of disease.

(H) Appreciation of the privileges, duties and responsibilities that living in this age of science involves.

(I) Aesthetic appreciation to the degree that the eyes are open to the perception of new beauty, and power to understand and enjoy.

Tabulation of Responses Made by Montana Teachers. In Table XVI a tabulation of the responses made by the teachers of Montana is presented.

Table XVI. Extent to Which Teachers Achieve Aims and Objectives of Chemistry.

Item	Marked Amount		Considerable Amount		Moderate Amount		Small Amount		Negligible Amount		Averages[36]
	No.	%	No.	%	No.	%	No.	%	No.	%	
A	10	25.6	10	41.0	12	30.8	0	0.0	0	0.0	2.05
B	6	12.8	10	25.6	15	38.4	6	15.4	2	5.1	2.66
C	4	10.2	13	33.3	16	41.0	5	7.7	0	0.0	2.50
D	8	20.5	10	25.6	16	41.0	3	7.7	0	0.0	2.38
E	10	25.6	18	46.2	6	15.4	5	12.8	0	0.0	2.15
F	2	5.1	9	23.1	18	46.2	6	15.4	0	0.0	2.80
G	9	23.1	12	36.8	12	30.8	5	12.8	0	0.0	2.34
H	12	30.8	14	35.9	12	30.8	1	2.6	0	0.0	2.05
I	6	15.4	7	17.9	16	41.0	6	15.4	3	7.7	2.82
Totals	66	18.8	109	31.0	123	35.0	35	10.0	5	1.4	

Of special interest in the above table are the following facts:

1. That the averages found in the last column, and calculated as described below, in no case fall below 3, the measure of moderate achievement.

36. The averages were calculated for the above table in the following manner: If a teacher indicated that he achieved any item in a marked amount this was given a stress of 1. If in considerable amount a stress of 2, etc. In the case of Item A above, a stress of 1 was given 10 times, a stress of 2 sixteen times and a stress of 3 twelve times. The number of times any particular stress was given for an item was multiplied by the number of the stress and the sum of these (stress x frequency) obtained. In the case of Item A: (10 x 1) + (16 x 2) + (12 x 3) = 78. This was then divided by the number of teachers responding, thus giving the average. $\frac{78}{38} = 2.05$

2. That only 11.4 percent of the stresses indicate that achievement is small or of negligible amount.

3. That about one-fifth (18.8 percent) of the stresses indicate achievement of marked amount.

4. That the largest percentage of stresses for any one step (36 percent) indicates only moderate achievement.

Interpretation of the Responses. Examination of the column headed averages in Table XVI shows clearly:

1. That the teachers for the state as a whole feel that they achieve the objectives in amounts between considerable and moderate.

2. That the items themselves fall into three groups. (These will be designated Group I, upon which greatest emphasis was placed by Montana teachers; Group II upon which second emphasis was placed. In Group III upon which least emphasis was placed. In Group I will be found items A, E, and H; in Group II will be found items C, D, and G; in Groups III will be found items B, F, and I. (Refer to Question 45 reproduced above.)

Analysis of the items within the groups is a rather difficult proposition. The writer would classify those items in Group I as the intangibles. By intangibles is meant those things which are not the direct results of the application of the facts, principles, and theories learned in chemistry, but rather those that come as secondary or tertiary results; They are the aura or subtle, invisible emanations that the committee assumed would result from instruction in chemistry. They are subjective in nature and would be difficult to determine and measure. They are the interests that will be paramount in the betterment of the home and community, and the development of economic resources such as can be better

understood from having studied chemistry.

In the second group are found those objectives that require for their attainment considerable grasp of the facts and subject matter of chemistry. It will be noted that in this group is found the objective of health, and the control and elimination of disease. This is one of the most important of the objectives of chemistry. It is desirable to have this objective achieved to the greatest extent. Apparently, in the opinion of the teachers, it is not in Montana. It is to be regretted that very little is written in our high school textbooks that has bearing upon this most important objective.

From the items found listed in Group III it seems that in the opinion of the teachers their students will be least successful in the immediate and direct application of what they have learned in chemistry to the problems of their everyday life. This is indicated by item B. Also, that just what the subject of chemistry has been about may be a bit hazy to the student. This is indicated by the stress placed on item F. Aesthetic appreciation is not to be expected in very large amount.[37]

To summarize the discussion on the three groups of objectives it may be said that in the opinion of Montana

37. The answers of three teachers to item I is well characterized by that of one of them who wrote opposite the item "Bunk—pure bunk!"

teachers of chemistry, they achieve success in considerable amount in those values that will contribute to the making of better and more progressive citizens of their students in the community in which they live, but that these students will be only moderately well prepared to make direct and practical application of the facts of chemistry they have learned to their own personal needs.

The Tendency of the Responses as Shown by Graph. In the case of a distribution such as that given inTable XVI it is desirable not only to know the average of the results, but also to know the trend. In order to determine clearly what this trend was for the various objectives a series of graphs was prepared. These are reproduced here.

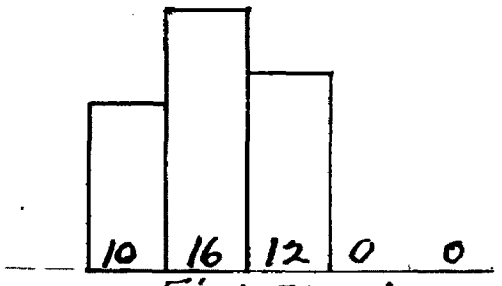

Fig. 1, Item A

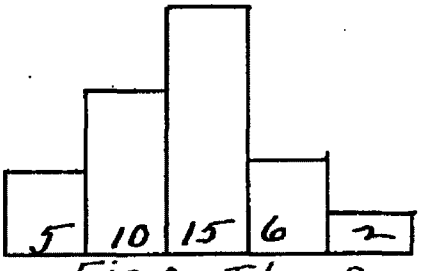

Fig. 2, Item B

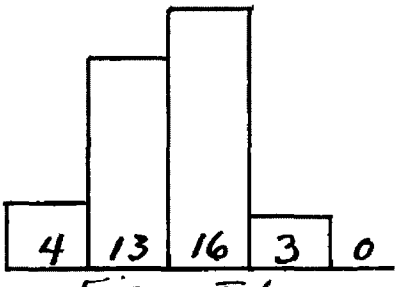

Fig. 3, Item C

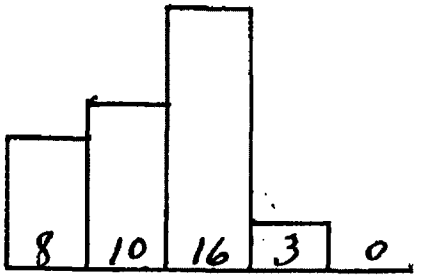

Fig 4, Item D

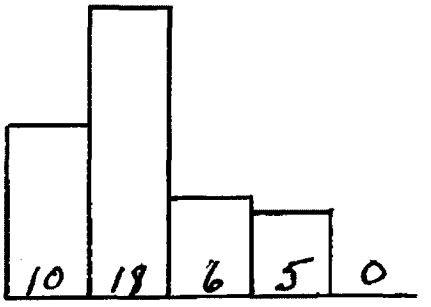

Fig. 5, Item E

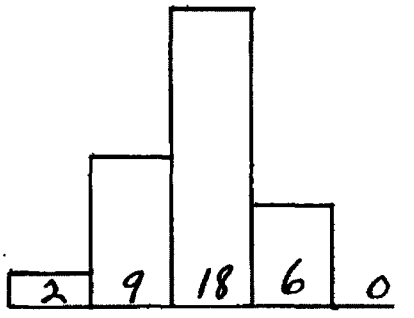

Fig. 6, Item F

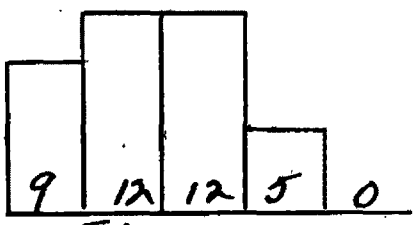

Fig. 7, Item G

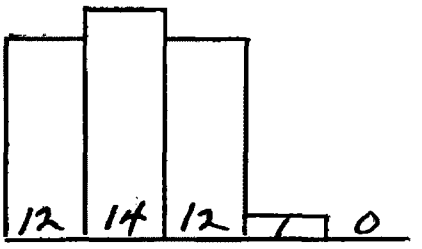

Fig. 8, Item H

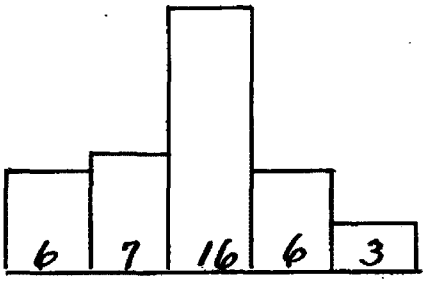

Fig. 9, Item I.

Divisions from left to right correspond to marked amount, considerable amount, moderate amount, small amount, negligible.

Scale is 10 cases to 20mm.

In four cases—items D, E, F and I a decided trend is apparent. This may be interpreted to mean (1) in case of item D that control of an appreciable body of facts and principles of significance in the home and community is obtained in moderate amount in the teaching of chemistry in Montana; (2) in the case of item E that the building up of an intelligent understanding of the conditions, institutions, demands, and opportunities of modern life is developed in considerable amount; (3) in the case of item F that the development of clearly defined points of view, intensified powers of insight, and points of departure for new attempts for future study is obtained only in moderate amount; and (4) that aesthetic appreciation to the degree that the eyes are open to the perception of new beauty, and power to understand and enjoy is developed only in mod-

erate amount.

In the case of two items—B and C—emphasis is placed about equally on considerable and moderate achievement, with a slightly greater emphasis upon moderate achievement. Item B was that on the development of direct and effective methods of solving problems that might arise in real situations; item C on the development of a higher appreciation by the student of the pleasure and profit to be obtained by the exercise of his own abilities.

In the remaining three cases—items A, G, and H—about equal emphasis is placed on marked, considerable, and moderate achievement with slightly more stress placed upon considerable achievement than on the other two. In other words, it was with the objective (a) of development of interests, habits, and abilities, and (b) contribution of chemistry to health and elimination of disease that the teachers had the most varying success.

Criticism of the Method of Obtaining the Data. The adverse criticism may be made that such data as that given above is not objective, and that in this particular case is mere opinion given on a subject exceedingly difficult to judge. The writer recognized that the data are not objective and that the personal equation enters to a large extent; that the human factor of appearing in the best possible light must vitiate the responses of some teachers. On the other

hand, there are equally strong traits counterbalancing these tendencies; for example, those of fair play and fairmindedness; also there is a strong dislike by most people for hypocrisy; add to this the very strong professional feeling that to misrepresent such data is not ethical, and one can well believe that the tendency would be to underrate rather than to overrate.

Criticism of the Objectives. The writer wishes to criticize adversely certain of the objectives listed above. These objectives are C, E, H, I. They are criticized on the grounds that they are:

(1) Little more than platitudes.
(2) The objectives may apply equally well to any of the school subjects.
(3) They have small objective value because they indicate no specific outcomes of instruction in chemistry, and hence have small validity.

In preparing the first draft of question 45 a rather extensive list of objectives much more specific in nature was derived. In trying out this first draft - it was sent to friends of the writer - it was found that the list was too long, and was difficult to apply for large classes. It was desirable that some expression of the outcomes of the teaching should be obtained. Believing that the list as first proposed was not good the writer adopted the expedient of accepting the recommendations of the Committee on the Reorganization of Secondary Science, assuming that the prestige of the members

serving on the committee was assurance of the merit of their recommendations. To what extent this is true must be left to the readers of this report to judge. This is the basis upon which the data were submitted.

The Outcomes of Laboratory Instruction. The outcomes of instruction in chemistry as discussed above may well be classified as the social outcomes. They are of importance primarily as they aid the student to make adjustments to his environment and society. Much more tangible and objective outcomes than these are recognized as coming from the study of chemistry. These outcomes are commonly referred to as laboratory values, and must be taken into consideration if a complete picture is to be formed of the results of teaching.

The outcomes were taken from a report made by a committee appointed by the President of the Division of Chemical Education of American Chemical Society.[38] The data for this report were obtained by circulating a questionnaire. Replies were received from sixty-five schools having an aggregate enrollment of 88,934 pupils. Seventy-one teachers from fifteen states are represented. These states include all of the New England states, New York, Pennsylvania, Ohio, Illinois, Wisconsin, Michigan, Iowa, Indiana, and Kansas. Of the

38. Order of Precedence of Laboratory Work and Recitation in High School Chemistry, Journal of Chemical Education. 5: 1300-1306 (Oct. 1928).

seventy-one teachers answering, forty percent have graduate degrees, and have had a fraction over thirteen years of teaching experience. The qualification of these teachers is such that their opinions should have marked validity. A number of possible values to be derived from laboratory work was submitted to them with the request that they be ranked in the order that they (the teachers) thought them to be of importance in high school teaching. The eight values that were ranked highest by these teachers were chosen by the writer and submitted to the teachers of Montana with the request that they be ranked in the order of their importance as achieved in their teaching. The responses were tabulated and are shown in Table XVII.[39]

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39. So that those reading this report may have better in mind what the laboratory values are that were ranked, they are reproduced here.
Following are eight educational values that may be derived from laboratory work. List them as you think they are of importance in your teaching of chemistry, the most important (1) the second in importance (2), etc.
( ) (a) Acquirement of manipulative skill (laboratory technique).
( ) (b) Training in habits of accurate observations.
( ) (c) Appreciation of the scientific method of thinking.
( ) (d) Development of initiative and resourcefulness.
( ) (e) Increased interest.
( ) (f) Concrete, or first hand, knowledge through direct contact with the material studied.
( ) (g) Training in habits of accuracy and neatness.
( ) (h) Cultivation of ability to reason and draw conclusions.

Table XVII. Distribution to Show How Laboratory Values Were Ranked.

Rank	Item A	Item B	Item C	Item D	Item E	Item F	Item G	Item H
1	2	8	5	4	6	4	0	2
2	2	7	4	3	2	7	1	5
3	1	2	4	5	6	3	3	7
4	4	5	3	6	3	2	3	5
5	4	4	0	2	3	6	6	5
6	3	3	6	2	2	4	5	3
7	3	2	4	4	6	1	8	0
8	10	0	5	3	2	3	2	3
Ave. Rank	5.65	3.22	4.55	4.24	4.17	4.00	5.54	4.02

Table XVII is to be read that item A was ranked first by two teachers, item B by eight teachers, etc. The line marked "M" would show the mid-point of the curve each side of which would include one-half of the measures.

Discussion of the Tabulation. In order that the rankings made by Montana teachers could be better kept in mind, the true averages of rankings were calculated as described on page 37, footnote 36. These will be found in Table XVII.

The fact which stands out in this tabulation is that no value predominates in laboratory work as done in Montana high schools. In the case of values A, B, and C, however, a tendency to vary from the middle measure is found.

In the case of value A it may be concluded that the acquirement of manipulative skill (laboratory technique) is not an important factor in laboratory work in this state. This is significant because it is this value that the teachers of Eastern and Middlewestern states consider of greatest import-

ance.[40] The question may well be asked, Why do Montana teachers place but small emphasis upon this value in their teaching? Three possible explanations are advanced.

1. That Montana schools are not well equipped in laboratory apparatus, and that little stress is placed on laboratory technique.

2. That in certain schools large laboratory classes are the rule so that the instructor cannot give the supervision necessary to master technique.

3. That the teachers themselves have not had the proper training in laboratory technique, and are conscious that they cannot give the proper training to their classes.

Fortunately, data are available to check these possible explanations. In question 46 of the questionnaire the teachers were asked to classify their laboratory equipment as (a) very complete, (b) adequate, (c) such that you can just get along, (d) such that you must omit important experiments. The responses were tabulated and are shown in Table XVIII.

Table XVIII. To Show the Relationship That Exists Between adequacy of Equipment, Size of Class, and Ranking of Value A.

First Class District Schools				County High Schools				Second Class Dist. Schools				Third Class District Schools			
Very complete	Adequate	Get Along	Omit Exps.	Very Complete	Adequate	Get Along	Omit Exps	Very complete	Adequate	Get Along	Omit Exps	Very complete	Adequate	Get Along	Omit Exps.
1					1/13				1/9						
2								1/22	1/11						
3											1/18				
4						1/15, 1/21				1/20, 1/2					
5		1/30						1/28		1/24, 1/14					
6													1/11	1/12	1/5
7									1/18				1/12, 1/15		
8	1/15	1/15	1/30		1/20	1/20			1/15, 1/13				1/5		1/7

40. The value assigned by the teachers of these states will be found tabulated in Table XIX, page 50 of this report.

Table to be read that in first class district schools there was one school having an average enrollment of 30 in laboratory classes that had equipment such that they could just get along. Read other cases in a similar manner.

In case of the first class district schools it is seen that two schools having very complete or adequate equipment and small classes of 15 give a rating of 8 to the value, while another school having equipment such that they can just get along, and large classes give the item a value of 5. It is quite evident that the explanations do not hold good with these schools. In the case of county high schools and third class districts, the schools with adequate equipment and classes that are not too large for efficient laboratory instruction give the value a rating of 8. With second class districts those schools with poor equipment and comparatively large classes give the value a high rating. The conclusion must be that the adequacy of equipment and size of laboratory sections does not determine the rating given to this value. It will be shown in a later chapter that the preparation of the teachers is, as a whole, good, so that the explanations offered above are not substantiated. Other explanations that the writer cannot offer must be advanced to account for the low rating of value A.

In the case of value B it will be seen that slightly higher than middle rating is given. This item is that of

"training in habits of accurate observation" and is placed first in importance by Montana teachers as determined by the calculated average rating. This value was found to rank third in the American Chemical Society survey (see Table XIX). The high rating of this value is a little surprising when it is noted that item G--"training in habits of accuracy and neatness"--is placed seventh (see Table XIX). To one trained in laboratory technique it is difficult to understand how a student can observe accurately if the laboratory work is not accurately and neatly done.
It should be noted that value G agrees closely in ranking with value A (ranked 8). Both of these values are measures of laboratory technique and manipulation as actually done in the laboratory.

The remainder of the items--C, D, E, F, H, show the ratings spread rather evenly over the entire range of rating possible. This means that there is little agreement among Montana teachers as to the importance of these values in teaching as done in this state.

How Eastern and Middlewestern, Montana, and Nevada Teachers Ranked the Laboratory Values. This relationship is shown in Table XIX.

Summary and Conclusions.

1. When teachers of chemistry in Montana measure the achievement of their classes with the aims and objectives of science teaching as proposed by the Committee on Reorganization of Science in Secondary Schools they achieve success in moderate to considerable amount for their classes as a whole.

2. Only 11.4 percent of the stresses indicate success to a small or negligible amount; almost 19 percent of the stresses indicate marked achievement. Over one-third (35 percent) of the stresses indicate moderate achievement.

3. Analysis of the responses indicate that greatest success is had with those objectivesthat may be termed "the intangibles". More emphasis is placed upon the cultural aspects of the subject than upon the professional. Well defined tendencies can be recognized in six of the nine objectives listed.

4. The objectives and aims as submitted to the teachers are open to criticism on the grounds that they are indefinite and lack validity.

5. As far as the teachers themselves are concerned they seem convinced that they are doing a good job of teaching chemistry. There seems to be considerable justification for this attitude as far as mastery of subject matter is concerned. As will be shown in a later chapter, however, much could be done to achieve the social aims of education in

Table XIX. Distribution to Show Ranking of Laboratory Values.

Order of Importance	1	2	3	4	5	6	7	8
As Listed by A. C. S. Survey	A	F	B	H	D	E	G	C
As Listed by Mont. Teachers	B	F	H	E	D	C	G	A
As Listed by Nevada Teachers	H	F	C	B	D	E	G	A

To be read item A of question 62 of questionnaire was ranked first by A. C. S. survey, eighth by Montana teachers, and eighth by Nevada teachers.

It will be noted that in three cases there is entire agreement between the A. C. S. survey, Montana teachers, and Nevada teachers where rank was determined by the method of averaging described above. The coefficient of correlation between the rankings of A. C. S. Survey and Montana teachers was calculated. It was found to be 0.26 ± 0.22 which means no significant correlation. The coefficient of correlation (Spearman rank formula by difference) between the rankings of Montana teachers and Nevada teachers was $0.71 \pm .113$ which would mean considerable correlation; the P. E. in each case was large due to the small number of rankings taken.

It was thought probable that the small amount of correlation between the American Chemical Society survey rating of laboratory values and the Montana teachers' ratings was due to the widely divergent importance assigned to laboratory value A. To see what correlation existed between the other values another calculation was made using values B, C, D, E,

F, G, and H. The coefficient of correlation was found to be 0.77 ± .097. This signifies marked correlation, so that it may be concluded that with the exception of the one value, that of laboratory technique, laboratory practice in Montana agrees closely with that considered of greatest worth by Eastern and Middlewestern teachers who are qualified to judge.

chemistry.

6. There seems to be little agreement between the different schools as to the desirable outcomes of laboratory instruction.

7. That with one notable exception there is close agreement between the values to be derived from laboratory instruction as determined by Eastern, and Middlewestern teachers of chemistry, and actual outcomes in Montana. Even when the laboratory value A is included there is a high and significant correlation (0.71 ± .113) between the outcomes of laboratory instruction in Nevada and Montana.

8. There seems to be no connection between the small achievement in laboratory technique and size of laboratory classes, adequacy of equipment and teacher preparation in chemistry as separate factors; it may be that all three of these factors combine to become the determining factor.

9. There seems to be some discrepancy between the ratings given to the laboratory values and the activities that the laboratory presents upon analysis. This apparent discrepancy can be found in the case of the ratings reported by the A. C. S. survey as well as with those made by Montana teachers.

CHAPTER IV

TEACHER QUALIFICATIONS THROUGH EDUCATION AND EXPERIENCE

General Discussion. From the standpoint of the development of the theory of secondary education, one of the oldest and most tenacious ideas has been that a thorough knowledge of the subject matter that one is to teach, qualified him to teach that subject. The idea still persists with some of the teachers in our colleges and universities. The newer theories of education would agree with this only in part. They would modify this by adding that a knowledge of subject matter is not all that is required, but that a knowledge of psychology, leadership, and ability to "put over" the knowledge of subject matter is just as essential. As recently as 1922, an educational leader in the United States found it necessary to say:

> "There are certain features of scholarship or mastered subject matter--taken by itself--which get in the way of effective teaching unless the instructor's habitual attitude is one of concern with its interplay in the pupil's own experience. The training of the teacher in his special field can be no indication as to what he does with it as a school subject."[41]

Hence, in judging the qualifications of the teachers of chemistry in Montana, it is necessary to take into consider-

41. John Dewey, "Democracy and Education", p. 215, (New York, 1922)

ation the preparation that the teachers have in chemistry, psychology, methods of teaching, in the general field of education, and the subjects related to chemistry, such as physics and mathematics.

The Schools From Which the Teachers Have Graduated. Not only must the teacher have such preparation as discussed above, but he must have adequate preparation. If the teacher has taken certain desirable courses much can be determined as to the adequacy of the preparation, if the standards of the schools in which the preparation was made are known. In judging the qualifications of teachers, principals and superintendents, give consideration to the schools from which the teachers are graduates. Certainly the teachers themselves recognize the advantages of matriculating in institutions of recognized merit. The born teacher is a rare find. The large majority of those achieving success have done so because of careful training, diligent effort, and ability to profit from experience.

In considering the schools from which teachers have graduated, teachers of first class districts, second class districts, and county high schools have been grouped together with the teachers of third class district schools in a separate group. Only those schools from which the teacher has received the B. A. degree will be taken into

consideration. A large number of institutions are represented. The 45 teachers of chemistry in third class district schools are graduates of 32 different institutions. The 48 teachers of the first and second class districts and county high schools have graduated from 34 different schools. A detailed list of these schools with the number of teachers graduating from each will be found in Table II, Appendix C.

In order to see to what extent the teachers were a cosmopolitan group they were classified according to the section of the country from which they came. The result is shown in Table XIXa.

Table XIXa. Location of Schools From Which Teachers Graduated.[42]

	No.	%
From Eastern and Southern States	6	6.4
From Middle Western States	50	53.2
From Pacific Coast and Rocky Mountain States other than Montana	11	11.7
From Montana	27	28.7

It is quite apparent from Table XIXa that chemistry, as taught in Montana, must have a decided middlewestern complexion. Kansas and Minnesota schools each furnish 9 of the teachers; Iowa 8; South Dakota, Missouri and Nebraska 4 each; North Dakota and Wisconsin 3 each; Michigan, Indiana and Illinois 2 each.

42. Data obtained from Reports of High School Principals to Superintendent of Public Instruction, Op. cit. Part B.

A tabulation was next made to see from what type of institutions these teachers graduated. This is shown in Table XX.

Table XX. Classes of Institutions from which Teachers Graduated.

	1st, 2nd Class Dist. Co. H. S.		3rd Class Dist.		All Schools	
	No.	%	No.	%	No.	%
State Universities and Colleges	24	52.2	18	39.1	42	45.6
Universities and Colleges of first rank, not state institutions	3	6.5	0	0.0	3	3.3
Small private and denom. Colleges	15	32.6	21	45.7	36	39.1
Normal Schools--Teachers' Colleges	4	8.7	7	15.2	11	12.0

Some facts of interest may be noted from Table XX.

1. The relatively large percentage of teachers who are graduates of state colleges and state universities in schools of first and second class districts, and county high schools.

2. The small number (4) of teachers in this group who have graduated from normal or state teachers' colleges.

3. That only about forty percent of the teachers in third class district schools are graduates of state universities or state colleges.

4. That forty-six percent of the teachers are graduates of small colleges.

5. That one of seven of third class district teachers (fifteen percent) are graduates of normal schools or teachers' colleges.

Data comparable to that given in Table XX is available in one instance, that of the Texas survey.[43] From this source it is learned that 51.4 percent of the teachers were graduates of state universities and colleges, 16.8 percent from small private and denominational colleges, and 32 percent from normal schools or state teachers' colleges.

The Montana teachers of first and second class district schools and county high schools seem to rank a little better than Texas teachers in the matter of graduating from schools of high rating, but the teachers of the State of Montana as a whole, may be considered to rank slightly below those of Texas.

Degrees Held by the Teachers of Chemistry. The method of judging from the degrees held by the teachers as to their qualifications to teach is a common one. Preparation of Montana teachers in this respect is shown in Table XXI.

	BA & BS		MA & MS		Normal Diploma No Degree		Others	
	No.	%	No.	%	No.	%	No.	%
1st, 2nd Class Dist. Co. H. S.	43	89.6	1	2.1	2	4.2	2	4.2
3rd Class Districts	42	87.5	2	4.2	4	8.4		
All Montana	85	83.5	3	3.1	6	6.2	2	2.1

43. Orsha Oppe, op. cit. p. 1750

Considerable comparative data is available. This is given in Table XXII

Table XXII. Comparative Data on Degrees Held by Teachers of Chemistry.

	BA & BS		MA & MS		Normal & No degree		Others	
	No.	%	No.	%	No.	%	No.	%
Texas Survey[44]	65	83.3	9	11.5	3	3.9	1	1.3
Report of Committee A. C. S. (1928)[45]	40	56.3	23	39.4	3	4.2		
Wisconsin[46]	40	65.6	10	16.4			11 (a)	18.0

(a) Includes a number of Ph. D. degrees.

From the tabulations above it will be seen that Montana has a larger number of teachers with the B. A. and B. S. degree than the other groups compared, but its percentage of advanced degrees is much smaller. When the advanced degrees are added to the bachelor degrees it is found that the total for Montana is 91.6 percent while that for the other groups is in no case below 95 percent. With the exception of Texas, however, the data represents only those teachers of larger schools and is not strictly comparable. (See the bibliograph for a summary of how the data were obtained in each of these cases.) The number of teachers

44. Greta Oppe, op. cit. p. 1750.
45. Op. cit., p. 1301.
46. Rogers, op. cit., p. 1418

having normal school diplomas, or no degree, is somewhat larger for Montana than the other groups. This is due to the number of cases found for third class district schools. However, six and two tenths percent of chemistry teachers with normal diplomas or without degrees is not to be considered excessive as a study of Table XXIII will show. The data for this table were obtained from the Quinquennial Report of the North Central Association of Colleges and Secondary Schools.[47] In considering the facts, it must be remembered that the schools represented are likely to be the best in the states and hence the data would be selected.

Table XXIII. Degrees Held by Teachers in Schools Accredited by North Central Association in Certain States.

	Ph. D		MA & MS		BA & BS		Without	
	No.	%	No.	%	No.	%	No.	%
Montana	0	0.0	24	7.0	300	87.7	18	5.3
Iowa	8	0.6	130	9.5	1173	85.6	59	4.3
Kansas	4	0.4	145	13.5	872	80.9	57	5.3
Missouri	33	3.2	153	14.8	759	73.5	88	8.5
Nebraska	0	0.0	35	8.4	391	91.9	2	0.5
North Dakota	2	0.2	100	11.6	738	86.2	21	2.4

One state, Kansas, has the same percentage of teachers without degrees and one state, Missouri, has a markedly higher proportion.

47. Quinquennial Report, op. cit., p. 32

Extent to Which Teachers in Chemistry Have Majored in Chemistry. This is a much better measure of the preparation of the teacher than the two criteria taken above. However, it must be remembered that a major in a subject means a certain fixed minimum number of hours credit in a subject in which a student is supposed to have mastery. The fixed number of hours credit required for the major is generally exceeded to varying amounts so that a major in the subject is not to be taken as a quantitative measure of preparation in the subject.

In the Principals' Reports to the Superintendent of Public Instruction,[48] the teachers are required to list their major subjects. The information presented in Table XXIV was obtained from this source.

Table XXIV. Extent to Which Teachers of Chemistry in Montana Have Majored in Chemistry.

	1st Class	2nd Class	3rd Class	Co. H. S.	Totals
Chemistry alone	7	3	4	5	19
Chemistry & some other subj.	0	4	4	0	8
Science, or science with some other subject	0	5	8	5	18
Education, or education with some other subject	0	3	9	0	12
All others	0	11	21	3	35
% having chemistry majors	100	26.9	17.4	38.4	29.3
% having chemistry or science majors	100	46.2	34.8	76.9	48.9

48. Principals' Reports, op. cit., Part B.

Some facts of a rather startling nature are presented in Table XXIV.

1. That fewer than three teachers in ten teaching chemistry in Montana have majors in chemistry.

2. In third class district schools fewer than two in ten have majors in chemistry.

3. Assuming that in the majors termed "science" sufficient chemistry is taken to meet a "minor requirement, only half of the teachers have majors or minors in chemistry.

If the facts of Table XXIV are accepted, only one conclusion is possible, that with the exception of first class district schools and county high schools, much is to be desired in the way of preparing chemistry teachers in Montana to teach chemistry.

The majors for teachers of second class district schools and third class district schools listed under the headings "education or education with some other subject", and "all others" in Table XXIV were listed in an effort to determine the exact status with regard to the majors held by teachers in these schools. Detailed tables will be found in Appendix C. All that will be reported here is a summary of the tables. It is found that with the second class district schools, 3 teachers have education majors alone, 4 in sciences chemical in nature, 3 in sciences non-chemical in nature, and 3 in other subjects. With the third class district schools, 3 have education majors alone, 7 with education

and studies non-chemical in nature, 3 with sciences chemical in nature, 1 with science non-chemical in nature and 16 with majors in other subjects.

The extent to which teachers of chemistry in Montana are deficient in majors in that subject may be shown by means of available comparative data. In the Texas survey,[49] it was found that teachers having

(a) chemistry majors alone.....27.5%
(b) chemistry plus some other subject.....17.5
(c) science, or science plus some other subject.....32.0
(d) others.....23.2

In the Wisconsin[50] survey it was found that 57 percent of teachers had majors in chemistry; in Ohio,[51] 50.2 percent; in Oregon,[52] 53 percent; and, in the Powers[53] survey, 56 percent. In every case almost twice the percent in Montana.

It will be of interest to know what portion of the teachers of chemistry are graduates of Montana institutions. This information is given in Table XXV.

49. Greta Oppe, op. cit., p. 1751
50. Rogers, op. cit., p. 1419
51. Phelan, op. cit., p. 2199
52. Swartz, op. cit., p. 819
53. Powers, op. cit., p. 814

Table XXV. Number of Graduates from Montana Institutions Teaching Chemistry Who Are Majors in Chemistry.

	U. of Mont.	Mont. State College	Inter-Mt. Union
Have a major in chemistry	3	1	1
Do not have major in chemistry	7	6	6

Of the 24 graduates of Montana institutions teaching chemistry, only 5, or 20.9 percent, are majors in chemistry. Much of the deficiency in providing specialized teachers to teach chemistry is due to graduates of institutions of Montana teaching the subject.

In view of the data presented above, the question arises of whether the principals of Montana high schools prefer to have teachers specialized in other branches, and teach chemistry somewhat as a side line, or whether qualified teachers are not available. This report does not pretend to answer the question, but in its consideration it must be kept in mind that for the most part high schools in Montana are small and that the teacher of chemistry in these schools will be obliged to teach from one to five other subjects. This condition would greatly decrease the likelihood of finding the highly specialized teachers, and it also means less efficient instruction in chemistry.

The Amount of Credit Teachers Have in Chemistry and in Subjects Related to the Teaching of Chemistry. Other than chemistry, those subjects that best indicate the preparation of the teacher to teach chemistry, are physics, mathematics and education. Facts were collected through question 12 of the questionnaire that gives the information regarding the preparation of the teachers in these subjects.[54] This is presented in Table XXVI.

Table XXVI. To Show Average and Median Number of Credits Teachers Have in Certain Subjects. (Calculated on quarter hour basis.)

	Educ.		Chem.		Physics		Math	
	Ave.	Med.	Ave.	Med.	Ave.	Med.	Ave.	Med
1st Class Dists. Co. H. S. (a)	28.7	27.9	45.0	43.8	19.9	17.5	21.5	17.5
2nd Class Dists. (b)	39.6	37.5	39.4	45.0	23.4	18.3	22.1	20.0
3rd Class Dists. (c)	30.8	31.3	29.0	17.5	7.4	7.5	18.3	17.5
All Mont. Schools	33.4	32.2	38.6	33.7	17.7	15.3	20.9	18.3
Median Deviations		7.4		19.1		11.2		10.5
Nevada (d)	52.0	51.0	35.6	27.0	12.0	11.0	12.0	12.0
Nebraska Survey[55]	34.0		31.5		14.1		19.0	
Report of Comm. on Educ. 56			41.1		18.3		22.3	

(a) 13 teachers; (b) 14 teachers; (c) 10 teachers; (d) 9 teachers.

54. The data presented may show conditions in Montana somewhat better than they actually are due to the fact that only about one-third of the third class district schools teaching chemistry responded. Preparation of teachers in these schools is poor as shown by the returns to the questionnaire.

55 and 56 continued on next page.

In Table XXVI, allowance must be made for the factors listed below that could not be controlled, and which may cause the results obtained to vary through considerable range:

1. The credit given for the same subject covering the same amount of work will differ among different schools.

2. Teachers do not remember accurately how much credit they have in particular subjects and frequently do not have records that they may consult. This is especially true of the older teachers in the service.

3. The extremes were so great and the number of cases so small that the averages and medians may not be very accurate.

The comparative data show that teachers in Montana have somewhat better preparation in education, chemistry, physics, and mathematics than Nebraska and Nevada teachers except in hours of education in the latter case. The teachers are less well prepared, however, than those represented in the committee on Chemical Education report.[57]

Within the state of Montana the table shows:

1. That first and second class district school teachers have markedly better preparation than third class district teachers, this being especially noticeable in the case of chemistry and physics.

2. The teachers of first class districts and county high schools are better prepared than teachers of second class districts only in chemistry.

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55. Hendricks and Chambers, op. cit., p. 139
56. Committee on Chemical Educ. Chemical Data in United States Journal of Chemical Educ. 4:911-13 (July,1927)
57. See bibliography for selected nature of these data.

Courses in Chemistry that Teachers Have Taken. In consideration of this question, allowances must be made for inaccuracies due to the fact that the same courses given in different schools may differ considerably in the length of time devoted to the course and the subject matter covered. Some of the teachers who did their undergraduate work a number of years ago may have forgotten about courses studied, or have studied courses asked for in the question under different names. The data available are given in Table XXVII.

Table XXVII. Extent To Which Teachers Have Taken Certain Courses in Chemistry.

	H.S. Chemistry	Gen. Chemistry	Qual. And.	Quant. Ana.	Organic	Physical	Industrial	Biological	Teaching
	%	%	%	%	%	%	%	%	%
Teachers of:									
1st Class Usts	80	100	100	100	80	60	20	0.0	40
2nd " "	76.5	94.1	76.5	71.0	76.5	23.5	17.8	23.5	29.4
3rd " "	80.0	100	50.0	30.0	40.0	10.0	10.0	20.0	0.0
Co. H. S.	66.7	100	88.8	88.8	88.8	22.2	22.2	55.5	44.4
All Rpt. Schs	75.5	97.5	75.6	68.3	70.7	24.4	17.1	26.8	26.8
			Comparative Data						
Nevada	60.0	90.0	70.0	50.0	70.0	10.0	10.0	10.0	20.0
Oregon [58]	-	100	83.0	69.0	77.0	31.0	-	-	61.0
Ohio [59]	-	98.0	82.1	62.8	64.3	33.7	-	-	90.0
Texas [60]	-	100	62.5	62.5	84.7	20.9	-	-	-
Committee Report ACS ('30) [61]	-	100	73.7	65.0	83.9	51.6	21.7	15.2	-

58. Swartz, op. cit., p. 819
59, 60, 61, on next page.

It will be seen from Table XXVII that teachers of chemistry in Montana have taken courses in chemistry to about the same extent as teachers in other parts of the country with the exception of two courses, organic chemistry and a course in teaching of science or chemistry. It would seem that if 71 percent of Montana's teachers have taken courses in organic chemistry, that they are fairly well qualified, although the average of the country as a whole is nearer 80 percent. In the matter of having had a course in the teaching of chemistry or science, Montana teachers are seriously behind teachers of other states. Next to the general college course in chemistry, in the opinion of the writer, no other course is more important than this one. Much of the criticism, well deserved, is directed at the teaching of chemistry in high school courses from the lack of knowledge on the part of the teacher of what he is to do in the course. In lack of this knowledge, the inexperienced teacher calls upon the only fund of knowledge he has of teaching chemistry--the way it was taught in college --and puts it into effect. Upon one point in the teaching of chemistry, there is practically unanimous agreement: the course desired in high school is not a reproduction

59. Phelan, op. cit., p. 2199.
60. Oppe, op. cit., p. 1751
61. Committee report A. C. S. op. cit., p. 1368, (1930)

of a course in college chemistry. The inexperienced teacher may be aware of this but, unless he has had a course in teaching chemistry, he has no idea what else to do. After a matter of three or four years of trial and error, the teacher may be able to work out a course desirable from the viewpoint of high school chemistry. Much of this lost motion could be avoided if a properly formulated course has been taken by the teacher.

It was seen in Table XXVII that Montana teachers have not been prepared to any appreciable extent to teach chemistry by having had a course in its methods. The principal contributor to this lack of preparation is the State of Montana itself. The results of the questionnaire show that of the 42 teachers represented in the responses, 17 are graduates of Montana schools. Not a single one of these teachers have had a course in the teaching of chemistry. In the case of third class district schools where graduates of Montana institutions seem to predominate, not a teacher has had such a course. When it is taken into consideration that these teachers are inexperienced for the most part, and very limited in their preparation to teach chemistry, it must be admitted, that a course in methods of teaching would add greatly to their efficiency and effectiveness. It is true that

many of these teachers had no idea when they were preparing to teach that they would be called upon to teach this subject, consequently they would not have taken the course even tho they had had the opportunity. But the fact remains that they are required to teach the course. If these teachers wish to improve their teaching by taking a course in the teaching of chemistry, it will be necessary for them to attend some school outside of the state as no provision is made for such a course in Montana.

Weeks of Summer School the Teachers Have Had in the Past Five Years and Courses in Chemistry They Have Taken During This Time. If certain of the teachers are not well prepared to teach chemistry, what effort are they making to get such preparation? Table XXVIII throws light on this question.

Table XXVIII. Courses in Chemistry Taken by Teachers in Summer Schools.

	No. of Teachers Tabs.	Attended Summer School	A.V. length of time Attended	Courses in Chemistry taken
1st Class Dists.	5	3	13 wks	Adv. chem. research 1 yr. Meth. of teaching 1 teacher
Co. H.S.	9	7	21 "	Physiological 2 teachers; Volumetric 1 teacher; Qual and Quant 1 teacher
2nd Class Dists.	17	11	15 "	1 yr. grad. work in educa 2 t.; Meth. 1 t.;1 man 9 week in Org., Phys., Quant.
3rd Class Dists.	11	2	6	None
All Mont. Schools	42	23(a)	16	

(a) Plus 3 doing 1 year's graduate work.

It is perfectly clear from Table XXVIII that the teachers appear to be satisfied with the chemistry they have, and do not try to take more in summer school. As poorly qualified as the teachers of third class districts are to teach chemistry, not a single one responding had made an effort to take more chemistry to improve his preparation.

Years of Experience. Questions 16 and 17 of the questionnaire were asked so as to get this information. The results are tabulated in Table XXIX.

Table XXIX. To Show Total Teaching Experience and Experience in Teaching Chemistry.

Months Experience	Total Teaching Experience - 1st class dists.	2nd class dists.	3rd class dists.	Cty. H.S.	Totals	Percent	Experience Teaching Chemistry - 1st class dists.	2nd class dists.	3rd class dists.	Cty. H.S.	Totals	Percent
0-10 mo.		2	7	2	11	26.8	1	4	7	3	15	39.6
11-20 mo.		1		1	2	4.9		4	3		6	15.0
21-30 "	1	5	1	1	8	19.5	1	2		2	5	13.2
31-40 "		2	1	1	7	9.7		3			3	6.0
41-50 "		1	1		2	4.9						
51-60 "		3			3	7.3						
61-70 "	1			2	3	7.3		2		1	3	68.0
71-80 "		2			2	4.9						
81-100 mo.	1			1	2	4.9	1	2		1	4	10.5
101-150 mo.		1			1	2.4						
151 or more months	2			1	3	7.3	2				2	5.3

The facts listed below are of special interest in this table:

1. Over one-fourth of the teachers are teaching their first year.

2. Forty percent are teaching chemistry their first year.

3. Seventy percent of third class district teachers are

teaching chemistry the first year.

4. None of these teachers have had over two years experience teaching chemistry.

Comparative data are available to which the teaching experience of Montana teachers of chemistry may be compared. This data is given in Tables XXX and XXXI.

Table XXX. Teaching Experience of Montana Teachers of Chemistry as Compared to Other States

	1 years Exp.	2 years or less	3 years or less	5 yrs. or ls.	More'n 5 yrs.
Montana	26.8%	31.7%	51.2%	65.8%	34.2%
Wisconsin[62]		47.2%		82.0%	18.0%
Powers, Survey[63]				37.1%	62.9%
Texas[64]	16.4 %	32.8%		49.2%	50.8%

It will be seen from this table that in the matter of teaching experience the teachers in Montana make a somewhat better showing than those of Wisconsin, but rather poor when compared to teachers of Texas and those represented in the S. R. Powers' survey.

In the matter of experience in teaching chemistry the Ohio survey is the only one providing comparative data. This is shown in Table XXXI.

62. Rogers, op. cit., p. 1419.
63. Powers, op. cit., p. 815.
64. Oppe, op. cit., p. 1750.

Table XXXI. Teaching Experience in Chemistry of Montana Teachers as Compared to Teachers of Ohio.

	One year Exp.	Two Years or less	3 years or less exp.	5 years or less exp.	More than 5 years exp.
Montana	39.6%	45.6%	63.8%	76.8%	23.2%
Ohio[65]	25.0%	40.0%	52.8%	68.1%	32.0%

This table shows that in the matter of teaching experience in chemistry Montana teachers have had considerably less experience than the teachers of Ohio. The significance of the differences found in Tables XXX and XXXI will become more significant after the discussion of tenure.

Tenure of the Teachers. The length of service in the system must have much to do with determining the efficiency of instruction. Especially is this true of the teacher of high school laboratory sciences. The following reasons are advanced to support this contention:

1. If the teacher is to return to a school he will order laboratory supplies so that they will be on hand for the beginning of the next school year.

2. Laboratory equipment and apparatus will be kept in repair and in place, thus minimizing the effort necessary to put it into operation the next time the course is taught.

3. If the requirement and standards of the teacher in a course are known to the students - and they will be if the teacher is a returning teacher - there is much lost motion prevented through registering in the course and then dropping it because "it was not what the student thought it was."

4. The students and teacher will be acquainted to some

65. Phelan, op. cit., p. 2199

some extent at least. This makes much easier the socialization, freedom in discussion, and exchange of ideas and experiences that characterize any successfully conducted class.

5. The spirit of the department, what principals describe as "constantly increasing interest in science" comes only to skillful teachers after several years of effort.

In summary it may be said that all of the social aims that form such a large part of the objectives of chemistry rest vitally upon this better acquaintance and understanding between teacher and student. The experience of the writer has been that this does not come to the desired extent the first year the teacher is in the system, nor the second, and that it comes many times easier after a few years teaching experience.

The length of tenure of the teachers, responding to the questionnaire, in their present schools is shown in Table XXXII.

Table XXXII. Tenure in Schools Where Teachers are Teaching.

	1st yr.	2nd yr.	3rd Yr	4th & 5th yrs.	More than 5 years
1st Class Dists.	0	0	2	1	2
2nd " "	5	3	3	2	3
3rd " "	7	2	1	1	
Co. H. S.	3	3	0	1	2a
All Mont. Schools	15	8	6	5	7
Percentages	36.6	19.5	14.6	12.2	17.1
Nevada	0	4	2	4	1
Percentages	0.0	36.4	13.0	36.4	9.1

(a) One teacher 20 years.

Seventy-one percent of the teachers have been in their present school three years or less. More serious than this, however, is the fact that nine of eleven (82%) of the teachers of third class districts have been in their schools two years or less. In the second class district schools, one-half of the teachers have been in their schools two years or less. Certainly these schools are not achieving those things so desirable that come with long tenure. In comparison with Nevada, Montana does not compare favorably in the matter of tenure of chemistry teachers.

Extent to Which Teachers Make Chemistry First, Second, or Third Choice When Applying For a Position. It is a well recognized practice in educational circles that in making application, those teachers who feel that they are primarily prepared to teach a subject will make it first choice; that those who are fairly well prepared to teach a subject, but do not have primary interest in it, usually designate second choice; those not prepared to teach a subject and who would teach the subject only because it was necessary to designate the subject third choice or not at all.

The teachers of chemistry in Montana designate their choice of chemistry as shown in Table XXXIII.

Table XXXIII. Extent to Which Montana Teachers Make Chemistry First, Second or Third Choice When Applying.

	1st Choice		2nd Choice		3rd Choice	
	No.	%	No.	%	No.	%
1st Class Dists.	5	100				
Co. H. S.	5	63	2	25	1	12
2nd Class Dists.	11	68.7	4	25	1	6.3
3rd Class Dists.	5	45.5	3	27	3	27
Totals	26	65.0	9	22.5	5	12.5
Nevada	6	60.0	2	20.0	2	20.0

In the absence of reliable comparative data, just how significant the above table is, is difficult to determine. If the premises assumed in introducing the question are correct, then it may be concluded that only two out of three chemistry teachers in Montana feel that they are primarily qualified to teach chemistry, and that less than half of the teachers of third class districts feel they have the best qualifications. One out of eight teachers feel that they are not qualified to teach chemistry and that one of four in third class districts feel that they are teaching chemistry when they should not. The table indicates clearly that there is much to be desired especially in third class districts.

Experience of Teachers in Chemical Industries. The teacher who has had experience in chemical industries must be a better teacher for this experience. From this exper-

ience a foundation may be laid that will give a practical turn to the teacher's instruction that is lacking in most cases in the teaching of high school chemistry. The teacher can increase interest by telling something of his experiences, of the requirements of a commercial chemist, and can present the subject so as to present better its vocational possibilities. This experience provides a point of departure from which to get the socialization of the course upon which much of its success must depend.

The number of teachers having had experience in chemical industries is shown in Table XXXIV.

Table XXXIV. Experience of Teachers in Chemical Industries.

	Experience	No experience	No answer
First class district schools	1	3	1
Second class district schools	8	6	2
Third class district schools	2	9	0
County high schools	5	1	2
All schools	16	19	5

More of the teachers have not had experience than have had. Few (only 18 percent) of the teachers of third class district schools have had this chemical experience.

The industries that are represented with the number of teachers having experience in each follows:

(a) Four teachers have worked in steel mills and foundries.

(b) Three teachers have worked in sugar mills
(c) Two teachers have worked in smelters
(d) Two teachers have worked in mines or mills
(e) One teacher in each of the following: ore analysis, artificial ice plant, canning factory.

The longest experience reported was fourteen years as assistant chief chemist in a sugar factory and the shortest, "a little" in a steel foundry.

Summary and Conclusions

1. More than fifty-percent of the teachers of chemistry in Montana are graduates of Middle-western schools. About 29 percent are graduates of Montana Institutions with the next largest group from other Rocky Mountain and Pacific Coast States.

2. Forty-nine percent of the teachers of chemistry are graduates of state universities, state colleges or other institutions of first rank. Sixty-one percent of the teachers in third class district schools are graduates of denominational, private, normal schools or teachers' colleges.

3. Few of the Montana teachers have advanced degrees. About 83.5 percent have the B. A. or B. S. degree with 6.2 percent not having a degree (or having a normal diploma). It is likely that some of the other states in the North Central Association area have a larger percentage of teachers with diplomas or without degrees.

4. A comparatively small proportion of the teachers in Montana teaching chemistry have a college major in that subject. If a major indicates mastery of the subject much must be done to improve the qualifications of the teacher of chemistry if efficient instruction is to be had. This is especially true of teachers in third class districts.

5. In the number of hours credit in chemistry and subjects related to instruction in chemistry, Montana teachers

compare well with the comparative data available. Teachers in third class districts have considerably less credit in physics and chemistry than the teachers in the other administrative groups.

6. In the matter of courses in chemistry the teachers of Montana have taken, favorable comparison may be made with comparative data available; one notable exception is in the case of a course in the teaching of science. The low percentage of teachers who have had such a course in Montana is due to lack of preparation of graduates of Montana Institutions in such a course.

7. The few courses in chemistry taken by teachers in summer school indicate that the teachers are very well satisfied with the preparation they have to teach this subject. The facts as found in this study, indicate that third class district teachers are not well prepared, and that they make no effort to improve themselves.

8. Fifty-one percent of the teachers teaching chemistry have not had more than three years of teaching experience, and 56 percent have only had two years of experience teaching chemistry. Other states show that their teachers have somewhat more experience than those in Montana.

9. Some 56 percent of the teachers of chemistry do not stay in one school over two years. Tenure in the case of third class district schools is rarely more than two years.

This is to be regretted as much of the efficiency of instruction, and achievement of the aims and objectives of teaching chemistry are lost.

10. Sixty percent of the teachers give chemistry first choice and twenty percent second choice when applying for teaching positions. It is very probable that the 12 percent giving chemistry third choice are not prepared to teach the subject and have little interest in its teaching. Twenty-seven percent of these teachers are in third class districts.

CHAPTER V

GENERAL METHODS OF TEACHING - MOTIVATION

Having discussed the objectives desirable as outcomes of teaching chemistry, and the qualifications of the teachers to achieve these objectives, the methods employed by the teachers to obtain their results may be logically discussed. Since the textbook must form the foundation upon which the teacher is to build, this factor will be discussed first.

The Textbooks Used. Perhaps in no other high school study is the subject matter undergoing greater change than in chemistry. Every three or four years new editions of the most commonly used textbooks have appeared, incorporating changes that have resulted from the new developments of chemistry, and the changes in the methods of teaching the subject. Numerous excellent texts have been written for high school use, any one of which would be a good adoption. If the number of adoptions may serve as a criterion of what the teachers consider the desirable outcomes of teaching the subject, then these must be found in the textbooks written by the following authors: (a) Brownlee and others,[66] (b) McPherson and Henderson,[67] and (c) Black and Conant.[68] Analysis of the subject matter of the recent editions of these books is not

66. Brownlee and others First Principles of Chemistry, New York, 1926.
67. McPherson and Henderson Chemistry and Its Uses, New York 1927.
68. Black and Conant, Practical Chemistry, New York, 1929.

available, but the publishers of at least one of these - Brownlee and Others - make the claim thru their advertising that their book is written with the expressed intention of meeting, to the greatest extent possible, the aims and objectives as laid down by the Committee on Reorganization of Secondary Education.[69]

Of the schools teaching chemistry in Montana in 1928-29 adoptions were as follows:

Brownlee	40
McPherson and Henderson	18
Black and Conant	9
Others	9

In most cases these books were of the most recent edition.

Time Given by the Student to the Classroom and Laboratory. It was possible to get complete data on this point from the reports of the principals to the High School Supervisor.[70] The length of class periods with the number of times the class meets per week is given in Table XXXVI.

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69. Analysis of the subject matter in the older editions of the textbooks cited above will be found in:
(a) Arthur E. Bathe, An Analysis of High School Texts in Chemistry, Journal of Chemical Education, 2: 785-791, (Sept. 1925).
(b) J.Coenog and J.C.Colbert. A Quantitative Analysis of Aims in Teaching High School Chemistry, School Science and Mathematics, 24: 168-173 (1924).

70. Reports of principals to High School Supervisor, op.cit. Part B.

Table XXXVI. Number of Recitations Per Week and Length of Periods in Minutes.

Length of Period	2 times per week	3 times per week	4 times per week	5 times per week
40-43 inc.	2	21		7
44-46 inc.		31		6
50-60 inc.	1	5		2
80-90 inc.		2		

It will be noticed that the predominant tendency is to have the 43 or 45 minute recitation three times per week. Eighty-seven percent of the schools have the 43 or 45 minute period, and 67.5 percent have the 43 or 45 minute period three times per week. The predominating tendency over the country as a whole is for the same arrangement. In Chapter VI it will be shown that the well defined tendency in Montana is to have the 90 minute laboratory period 2 times a week. Since 36 weeks is the customary length of the school term in Montana, a simple calculation shows that the student devotes not more than 190 hours to class recitation and laboratory work for the year.

Size of Classes. Large chemistry classes in Montana are the exception to the rule. Two reasons account for this: (a) there are few large schools; (b) associations accrediting schools in Montana place the upper limit at 30 pupils. Table XXXVII is presented to show the size of classes.

Table XXXVII. To Show the Largest, Smallest and Median Sized Classes in Various Supervision Units

	Small.	Large.	Median	Med.D.	No. of Cases
First class districts	14	31	28.3	3.3	16
Second " "	13	28	19.9	3.6	15
Third " "	5	15	9.0	3.2	12
County High Schools	6	30	18.7	4.9	14
All Montana Schools	5	31	18.9	6.5	57

In discussing the results obtained from his survey, S. R. Powers,[71] (see bibliography under this survey for the states represented) assumed that the optimum sized class for an efficient and well prepared teacher was 24. In his survey it was found that 67 percent were of this size or smaller. In Montana it is found that 81 percent of the schools would fall into this group. With the exception of the schools in the first class districts, where the classes are as a rule as large as will be permitted by the accrediting association, the median size of classes for the other administrative divisions is under 20.

How the Class Period was Utilized. In answering question 30 of the questionnaire the teachers were asked to approximate the time given to various class activities. The answers cannot be very exact because of the nature of the information sought. The purpose of the question was to determine if the teachers recognized the procedures listed as being part of their class work, and to get some rough idea as to the importance attached to the procedure as measured by

71. Powers, opt.cit. p. 815

the amount of time devoted to them. Considering the nature of the question the writer was surprised at the number of teachers answering; 38 of 42 responded. Several of the teachers qualified their answers by writing in that the question was difficult to answer because the time given to each activity varied so.

Assignment of the lesson should be a very important part of the class procedure. Much of the subject matter of each lesson will be entirely new to the student. In the ordinary high school text this subject matter at best will be much condensed. To get the best results the teacher must supplement the text, either by making assigned outside readings, or by drawing on his own experience. Enough time should be devoted at this point so that when the student studies the lesson for himself he will feel that he is building upon a foundation that is already a part of his experience. To be done properly this "clearing up" process may well take from 10 to 12 minutes of a 45 minute period.

Of the 38 teachers answering this item of question 30, it was found that:

Table XXXVIII. Time Given to Assignment of Lesson.

4 teachers give	1 - 2 minutes
24 teachers give	3 - 5 minutes
10 teachers give	5 - 10 minutes
1 teacher gives	more than 10 minutes

The pronounced tendency is to give from three to five

minutes. The writer is firmly of the opinion that in chemistry more time should be given to this very important part of the lesson. To make the assignment properly the teacher must prepare ahead of time, and this many teachers will not do.

If the assignment of the lesson has been properly made, the time required for the discussion of student difficulties will be much reduced. The purpose of this activity should be to discuss those difficulties that have been general for the class. However, if the assignment has not been made properly, the teacher will find it necessary to discuss many difficulties that the students would have been able to clear up for themselves if they had had some foundation upon which to build.

In answer to the item of how much time was devoted to discussion of student difficulties the teachers' responses were as shown in Table XXXIX.

Table XXXIX. Time Given to Discussion of Student Difficulties

10 teachers devote	3 - 5 minutes
14 teachers devote	6 - 10 minutes
1 teacher devotes	11 - 20 minutes
7 teachers	vary
5 teachers	do not answer

The tendency is to take from 3 to 10 minutes of the class time for this procedure with about half of the teachers taking from 6 to 10 minutes. This is probably not more time than should be taken to obtain the best results, providing the time is devoted to class difficulties rather than to in-

dividual student difficulties.

The two activities asked for next -- time devoted to question and drill work -- may well be discussed together. Many teachers do not distinguish between them. Tables XL and XLI show how the teachers divide their time between these procedures.

Table XL. Time Devoted to Questioning.

7 teachers take	6 - 10 minutes
12 teachers take	11-15 minutes
6 teachers take	16-20 minutes
11 teachers take	more than 20 minutes
3 teachers	vary

Table XLI. Time Devoted to Drill Work.

10 teachers take	0 - 5 minutes
13 teachers take	6 -10 minutes
4 teachers take	11-15 minutes
3 teachers take	16-20 minutes
2 teachers take	more than 20 minutes
2 teachers	vary
5 teachers	do not answer

The approximate medians in minutes of time taken for these two activites are 15 and 8 minutes respectively. For those teachers not distinguishing sharply between the two activities 23 minutes are consumed in what has been termed "rehashing". The criticism made of these activities is that this time is devoted to learning with minimum student effort in the classroom what the student was supposed to have learned outside of class; or, it is relearning what the student has been too indifferent to master by his own efforts. Much time

may be wasted here and inefficient instruction results. From the results obtained in the tabultaions above it may be stated conservatively that on the whole from one-third to one-half of the class period is given to questioning and drill work by teachers of chemistry in Montana. A direct question was not asked as to what form drill work took, altho it was recognized at the time the questions were formulated that this information would be desirable. Drill work, where the whole class participates, is recognized as a most desirable form of class activity. The use of work books by the students, and the use of supplementary materials such as those listed in question 31 of the questionnaire provide this means. Surprisingly few teachers use this type of material.

Item "e" of the question was formulated to determine to what extent the work of the student was supervised by the teacher. The answers indicate clearly that very little time is given to this individualized mode of procedure. Only 10 teachers indicate that they have supervised study; eight of the ten teachers are in systems having the 60 to 80 minute period. The time devoted to supervised study varies from three minutes to twenty as shown in Table XLII.

Table XLII. Time Given to Supervised Study.

3 teachers take	3 - 5 minutes
3 teachers take	6 -10 minutes
3 teachers take	15-20 minutes
1 teacher	varies

The writer believes that the supervised work mode of class procedure is just as feasible with the 45 minute class period as with the longer 60 and 80 minute period. In making recommendations - Chapter VII - this will be discussed in more detail.

Perhaps one of the most constructive activities of the class room is the use of demonstrations. Very little can be determined with regards to the teachers' answers to this item of the questionnaire. About the best that can be done is to determine if this procedure is a recognized part of the class room work. Surely with those teachers that indicate five minutes or more of the class period given over to demonstrations it may be assumed that it is an important part of the classroom technique. For those teachers who indicate less than five minutes, very, or who do not answer, it may be assumed that this activity plays a minor part. Recognizing the serious limitations of the data the responses to the item have been tabulated and are presented in Table XLIII.

Table XLIII. Time Devoted to Classroom Demonstrations.

8 teachers devote	0 - 3 minutes
5 teachers devote	4 - 5 minutes
10 teachers devote	6 -10 minutes
1 teacher devotes	11-15 minutes
2 teachers	use laboratory periods
8 teachers	very
6 teachers	do not answer

Accepting the limitations made above on the reliability of this data, it may be assumed that 16 of the 40 responses

(40 percent) indicate that class demonstrations play an important part in their method of conducting the class.

The Extent to which Review and Drill Books are Used. Question 31 of the questionnaire was formulated to get this data. In common with other high schools subjects supplementary teaching material is available in chemistry. Much of this material is very good and its use would enhance greatly the value of the course. Especially is this true in the case of inexperienced teachers, or teachers who have not had special training in chemistry. In a later chapter the writer will discuss in more detail the use that can be made of this type of material.

Of the 42 teachers answering the questionnaire only five made use of a review book such as the Oxford;[72] a question book such as Cook's 'New Type Questions in Chemistry',[73] and four used practice material in problems such as Dinsmore's "Chemical Calculations".[74] Only 10 percent made use of this supplementary material. Considering the great potential value of these books to the teachers by relieving them of much of the drudgery of review, drill, and quizzing, and their decided value in organizing and systematizing the course it is surprising that they are not used more generally.

72. J. E. Stannard, Chemistry Review Book, (New York, 1924)
73. Charles G. Cook, New Type Questions in Chemistry, New York, (1927)
74. Ernest L. Dinsmore, Chemical Calculations, (New York, 1927)

Three teachers in Montana, teachers of a number of years' experience, have this material that they have made up themselves.

Student Reports as a Regular Feature of Class Work. No attempt was made to determine to what extent these reports were required. This information would be valuable without doubt, but because of the length of the questionnaire, and the almost universal lack of any system of requiring reports by teachers, no effort was made to determine this. The question as asked in the questionnaire (Question 32) asked for a yes or no answer to the question of whether reports were a regular feature. The extent to which they are required is shown in Table XLIV.

Table XLIV. Extent to which Class Reports are Required.

22 require reports as a regular feature
6 require occasional reports
13 do not require reports
41 total

The purpose of the teacher in requiring these outside reports is (a) to encourage outside reading, (b) to increase interest and enthusiasm, (c) to give the student a better conception of the importance of chemistry in industries, health, and in everyday life, and (d) to provide for the worthy use of the leisure time of the student. In other words the student report is made an important part of the methods used in developing what some writers have termed a

"Pandemic" or "Cultural" course in chemistry.[75] Those teachers whose primary aims are to develop the facts and theories of chemistry - wh t may be termed the "Professional" aspect of chemistry - will make but limited use of this device. Little time will be available in which to make reports.

Is the writer to take the next step and conclude from Table XLIV that only a few more than half of the teachers of the state stress the cultural aims which are in fact the aims as outlined in Chapter III? Hardly on the evidence of this question alone. It will be recalled that it was these cultural aims that the teachers felt they obtained in greatest amount.[76]

The Extent To Which the Teachers Make Use of Projects in Their Teaching. In proposing the aims and objectives desirable as outcomes of a course in chemistry the Committee on Reorganization of Secondary Science presupposed the rather extensive use of the project method. On page seventeen of their report is found the following statement:[77]

> "The pupil should be encouraged to bring in materials to test in various ways and, whenever time permits, to perform additional experiments,

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75. John R. Sampey, An Outline of Pandemic Chemistry, Journal of Chemical Education, 5: 1243-49, (Oct. 193).
76. Of interest on this point is a quotation taken from the report of the Committee on Reorganization of Secondary School Science, op. cit., p. 40. "The study of special topics and reports upon them by individual members should be encouraged along the line of their special interests ... By this plan individual initiative and ability may be given encouragement and the whole class stimulated".
77. Ibid., p. 17

> the results of which may be reported to the class. ... In this way the work of the class will have a breadth and scope that will make the results more significant".

The extent to which the teachers encourage the students to "develop effective methods of solving problems that might arise in real situations, or to "control an appreciable body of facts and principles of significance in the home and community, or to "develop a higher appreciation ... of the pleasure and profit to be obtained by the exercise of his own abilities,"[78] is indicated in part by the number of these independent problems or projects worked out. This information is given in Table XLV.

Table XLV. Extent to Which Projects are Done.

Schools reporting that projects are done ----------	13
Schools reporting that projects are not done --------	25
No. of schools in which two projects are done -------	2
No. of schools in which three projects were done ----	2
No. of schools in which five projects were done -----	3

The table shows that few teachers have their students do projects, and that the few that do, work very few projects.

Effort Made by Teachers in Agricultural Communities to Make Application of Their Teaching to the Problems to Be Met in Such a Community. The writer has often wondered just how the high school course in chemistry might be modified to meet best the conditions found in an agricultural community.

78. Items, B, C, and D of question 45 of the questionnaire.

Certainly little is learned in the ordinary college course to aid in making this application, and there is still less in the ordinary high school textbook in chemistry to apply it with. Because many of the communities in Montana are of the agricultural type the course in chemistry in these communities could be greatly vitalized if more than passing attention was given to the problems to be met here. Even if they desired to do so, few teachers of chemistry would know how to go about attacking the problem, except possibly those who have studied agricultural chemistry. It is suggested that this phase of chemistry should form one of the cornerstones upon which a course in the teaching of chemistry should be based.

The data collected does not show quantitatively to what extent application is made, but does show to what extent the teachers recognize that application of their teaching in chemistry is pertinent to the problems of the community.

Table XLVI. Effort Made to Apply the Teaching of Chemistry in Rural Communities.

Number teaching in agricultural communities	35
Number of avove making direct application of their teaching	25
Number answering "in a general way" or "some"	4
Number answering no application	5
Number not answering	1

This certainly is a very fine showing and the teachers of chemistry are to be complimented. It shows, at least,

that they have the proper attitude whatever their preparation may be to teach this type of chemistry, or what the outcomes of their teaching might be. It is worthy to note here that four of the five teachers indicating that they made no application of their teaching to the problems to be met were teachers of third class district schools. (See master tabulation, Appendix A).

Extent to Which Teachers Make Use of Visual Education in Their Teaching. Unfortunately this question of the questionnaire was so worded that many of the teachers may have thought that visual education was limited to the use of motion picture and slides. This is far from true as is shown by a definition for visual education proposed recently.[79] "The representation of an object, a situation or relationship in either two-dimensional line or three-dimensional form, which, when it accompanies language, tends to make the latter more interesting, intelligent, and impressive." In explaining this definition the author of the article said any of the following might be included: blackboard, chart, excursion, exhibit, map, model, picture, actual specimen of whatever form, films, film-slides, stereopticon slides, stereopticon pictures, opaque projection appartus, and dramatizations.

Recommendations will be made in Chapter VII as to the possibilities of making greater use of visual education in

79. James J. Weber, Is the Term Visual Education Scientific? The Phi Delta Kappan, 11:78-9, (Oct. 1928).

teaching chemistry in Montana. At this time it need only be said that to the writer it seems that in visual education there is an opportunity to make instruction in chemistry of vital interest to the student, and of direct value to the community. In Table XLVII a summary is made of the responses made by the teachers to the question on visual education.

Table XLVII. Use of Visual Education in Teaching.

34	made no use of visual education
2	made use of visual education
4	made use of some visual education, but not much
2	do not answer

The interpretation of the data in Table XLVII should be that only two schools make use of slides or films. All of the teachers of course use visual education to the extent that they illustrate on the board, study the pictures in the text book, make demonstrations of raw material, etc. In general, however, it may be stated that Montana teachers make very little use of that very powerful teaching agency.-visual education.

Industries of a Chemical Nature in the Community. A paragraph from the Report of the Committee on Reorganization of Science in Secondary Schools prompted this question. The paragraph is quoted:[80]

80. Report of Committee, op. cit., p. 35

"In the past, chemistry courses over-emphasized theories, concepts and information of value principally to those who will pursue advanced courses. A course which emphasizes the chemistry of industry, of commerce, of the soil and of the household, furnishes a wider outlook, develops a practical appreciation of the scope of chemical service, and moreover arouses an interest which leads naturally to further study."

Every teacher should be anxious to make application of his teaching to such industries as are present in the community. Fortunately, even tho the teacher does not make this application, the alive and wide-awake student is likely to. Table XLVIII shows to what extent industries of a chemical nature were present in the communities in which the teachers that responded to the questionnaire were teaching.

Table XLVIII. Industries of a Chemical Nature in the Communities Where Chemistry is Taught.

Teachers responding there were no such industries ----	13
Teachers responding there was one such industry ------	15
Teachers responding there were two such industries ---	9
Teachers responding there were three such industries -	4

The industries reported are:

Smelters and reduction works --- 6 times
Water softening plants --------- 6 times
Sugar factories ---------------- 6 times
Oil refinery ------------------- 4 times
Flour mill --------------------- 2 times
Mines -------------------------- 2 times
Assay office ------------------- 2 times
U.S. grain laboratories -------- 2 times
Each of the following: -------- 1 time
gas works, gold flotation plant, gypsum plant, canning factory, manganese mill, car shop, cheese factory, cement factory, ice plant, creamery.

It is probable that in some cases reference was made to plants in other communities, but at such distances that it could be visited by the chemistry class. If a list of industries had been included in the questionnaire instead of asking the teacher to name them undoubtedly the list would have been larger as some of the teachers must have overlooked industries that they would be likely to visit, or that their students would visit. Of the 13 schools reporting no chemical industry 8 are found in third class districts (only 11 schools responded).

In summary it may be said that there is an appreciable number of industries that might be visited, some of them of greatest interest to the student of chemistry.

Number of Field Trips Made. Do the schools that have industries that they can visit go to visit them? The extent to which they do is shown in Table XLIX.

Table XLIX. Field Trips Made by Classes.

The number of schools in communities that have industries of a chemical nature	27
The number of schools making field trips	14
The number of schools not making field trips	13
The number of schools in communities that do not have industries of a chemical nature	13
The number of schools making field trips	6
The number of schools not making field trips	7

The number of field trips made is shown in Table L.

Table L. Number of Field Trips Made.

Schools where there are three industries	
Number of schools making no visits	2
Number of schools making one visit	3
Number of schools making indefinite visits	1
Schools where there are two industries	
Number of schools making no visits	2
Number of schools making one visit	2
Number of schools making two visits	3
Number of schools making three visits	0
Schools where there is one industry	
Number of schools making no visits	9
Number of schools making one visit	2
Number of schools making two visits	2
Number of schools making three visits	3
Schools where there are no industries	
Number of schools making no visits	7
Number of schools making one visit	4
Number of schools making three visits	2

In summary of the Tables XLIX and L the following points should be noted:

1. That only one-half of the schools that have industries of a chemical nature go to visit them.

2. In communities where there are no industries of a chemical nature half of the schools make field trips.

3. Only one-half, or 50 percent, of the schools responding made field trips.

4. The number of industries present that the class might visit in no way indicates the number of visits that will be made.

Here is another case where the teachers in Montana are not taking advantage of the opportunities that are presented to vitalize and make functioning their teaching.

Additional Efforts Made to Make the Course More Interesting. The teachers were asked if they had a science club

in their schools and to what extent their students took part in the American Chemical Essay Contest. The responses are shown in Tables LI and LII.

Table LI. Schools Having Science Clubs.

Schools having science clubs	8
Schools not having science clubs	32

Table LII. Schools Participating in the American Chemical Society Contest.

	1st Class Dist.	2nd Class Dist.	3rd Class Dist.	Co. High Schls.	Totals
Schools participating	5	6	2	4	17
Schools not particlpat.	0	10	9	4	23
Number of students	44	113	3	67	227
Largest number	30	47	2	39	---

Here, once more, are tabulations that show lost opportunities, especially for the third class district schools. Not a single one of these schools had a science club, and only two schools had students entered in the essay contest. Five of the larger schools in the state require all of their students to write essays. Two of the teachers made notations that their students had won in the state contest. To the knowledge of the writer, one student in a school not responding won in the National Contest.

About 23 percent of the students enrolled in the schools responding wrote essays for the contest.

Library Facilities. Three questions were directed to the teachers asking for information regarding the library.

More detailed information is desirable than that obtained thru the questionnaire; however, it was not practical to ask more questions in the present study on this phase. In response to the question of how many reference books were available thru the school library the number varied from a few to 40 for the first class district schools; from 0 to 100 in county high schools; 0 to 25 in second class district schools, and 0 to 20 in third class district schools. Only 4 schools did not have reference books and three did not answer. The median number of books was 10. The number most frequently mentioned was 10.

Thirty-five of the schools had some of the American Chemical Society books. Thirty-three had Creative Chemistry, 21 had "Chemistry in Medicine," 29 had "Chemistry in Industry, Volume I," 24 had "Chemistry in Industry, Volume II," and 27 had "The Life of Pasteur." Three of the schools did not have any of these books.

Of the periodicals listed in the questionnaire it was found that the schools subscribed to the extent shown in Table LIII.

Table LIII. Periodicals in Chemistry to Which the Schools Subscribe.

	1st cl. dist.	2nd cl. dist.	3rd cl. dist.	Co. H.S.	Totals
Journ. of Chem. Ed.	5	7	4	3	19
Sci. Sci. & Math.	1	2	0	1	4
Popular Science	3	11	9	8	31
Scientific American	4	13	5	4	26
Popular Mechanics	2	7	6	6	21

All of the schools responded and all of the schools had

at least one of these. Other periodicals mentioned were: "Chemistry Leaflet" four times and "Science News Letter" two times. From the totals column it will be seen that four of the five periodicals were quite generally subscribed to with "Popular Science" in the lead. Less than half of the schools subscribed to the Journal of Chemical Education. This magazine is meant primarily for the teacher, and much of the material is somewhat too difficult for high school students. However, it is a source of inspiration to the teacher, and provides excellent material designed not only to "keep the teacher up on chemistry" but discusses and provides solutions for many of his difficulties. Every teacher should have this journal on his desk.

To one acquainted with conditions in Montana the number of reference books and journals available is gratifying. As might be expected the third class district schools and second class district schools are the most poorly provided. When compared to what they should have the comparison is not any too favorable. B. Clifford Hendricks writing in the Journal of Chemical Education[81] has listed twenty books on chemistry that should be in every high school library. He lists the names of fourteen magazines that are desirable. In the article he offers many helpful hints on what can be done to increase reading on the part of high school chemistry students.

81. B. Clifford Hendricks, The High School Library a Neglected Teaching Tool. Journal of Chemical Education, 5:863, (July 1928).

Efforts Made by the Teachers to Meet Recognized Standards. Three questions were directed to the teachers to determine what effort was made to meet recognized standards. In 1923 a well worked out course of study[82] in science was distributed to the teachers of Montana. In the questionnaire the teachers were asked how closely they followed this course. The responses are shown in Table LIV.

Table LIV. How Closely the Teachers Follow the Course of Study.

Teachers that follow very closely	2
Teachers that follow closely	15
Teachers that do not follow closely	17
Teachers that do not follow at all	7

In the course of study the material has been divided into two groups, that which is required and that which is optional. The manual has the following to say about those groups:

> "As one becomes acquainted with the syllabus which follows it will become apparent that the material given under required topics is very much restricted. Attempt has been made here to include the most essential topics in the most important fields. It is not intended that the time of the whole year should be given over to these required topics, but that much work with optional topics will be introduced. It will be noted further that many of the optional topics are nothing more than elaborations of required topics; in these cases a more detailed study of the required topic is made optional." [83]

It is to be regretted that the course of study does not

82. Course of Study in Science, op. cit.
83. Ibid p. 53.

take up for discussion in more detail the desirable outcomes and methods of procedure in teaching chemistry. It is stated[84] that,

> "Teaching of these courses (chemistry and physics) is seldom undertaken by an instructor unless he has had considerable training in them. Furthermore, despite the new developments which are continually taking place, much of the material to be taught in these sciences remains fairly well standardized due to their long tenure of position in the high school program and the rather general disposition of educators to regard them as pure sciences."

Certainly this survey does not bear out the contention that the teachers are sufficiently well prepared so that they do not need the extended treatment of subject matter. A great deal could be done for the teachers of third class districts.

The teachers were asked if, in their opinion, they met the minimum requirements as proposed by the committee on chemical education of the American Chemical Society.[85] The question was not a good one as it was not first determined how many of the teachers were acquainted with these standards. Inasmuch as these minimum essentials have not been widely distributed the responses may be questioned. At least the answers indicated pronounced optimism or great confidence on the part of the teachers that they are doing a good job of teaching. Thirty-five teachers answered that they do meet this standards. One answered "no" and two answered "not completely." Three do not answer. If this al-

84. Course of Study in Science, op. cit.
85. Committee on Chemical Education of A.C.S. Correlation of High School and College Chemistry, Jr. of Chem. Educ. 4:640.56 (May 1927)

most unanimous opinion that a good job is done can be corroborated by facts then there is much to be well pleased about in the teaching of chemistry in Montana, because many teachers well acquainted with these minimum essentials are of the opinion that they are really maximum essentials. The minimum course as proposed by the committee on Chemical Education does not recommend the study of the chapters on gold, silver, copper, magnesium, mercury, zinc, lead, tin, strontium, barium, silicon, aluminum, baron, potassium, and the periodic system, but places these topics for supplementary study. If the Montana teachers meet the recommendations of the committee on study of gases, theories and applications of chemistry as well as the study of the above elements as required by their course of study, then the course must be very comprehensive and complete.

Twenty-seven of the teachers indicate that they will give standardized tests of some form at the end of the year. Two answer "perhaps" and twelve answered "no." This attitude of the teachers to know how their students compare to accepted standards is to be commended.

Summary and Conclusions

1. The most widely used textbook in high school chemistry in this state (the same is true of other states) is the Brownlee and Others "First Principles of Chemistry." This book is advertised to meet as nearly as it is possible the objectives and aims of teaching chemistry as outlined by the committee on the Reorganization of Science in Secondary Schools.

2. In general the number of students per class in Montana is small. The median number for all schools is 13.0, which is smaller than the maximum opitimum number that can be handled by a well qualified teacher.

3. The class recitation period of from 40 to 45 minutes meeting three times per week is the arrangement found in 67 percent of the schools. For the state as a whole a fair picture can be had of the method of conducting the class if 5 minutes is given to the assignment of the lesson, 6 to 8 minutes to discussing student difficulties, 23 minutes to questioning and drill work, and 5 to 8 minutes to demonstrations. Supervised study is little used by the teachers. It is to be understood that the class procedure varies widely from that indicated by the above approximate times for the various teachers. The recitation is the characteristic and important activity of the class period.

4. Very small use is made of review books, drill materials

and prepared testing materials. In other words, the agencies that made possible the individualized mode of conducting the class are not used.

5. Motivating agencies such as the use of student reports, the working out of projects, making field trips, making use of visual education such as motion pictures, slides, exhibits, and taking part in American Chemical Society contests, are not widely used. It is these activities that make possible the achievement of the aims and objectives of instruction in chemistry as outlined in Chapter II.

6. Industries of a chemical nature are present in the communities to greater extent than might be supposed. The teaching possibilities of these industries are not utilized to the extent that they should be.

7. Library facilities are, for the most part, such that the schools can get along. They fall considerably short of the minimum desired as cited by one writer.

8. The State Course of Study is not followed closely in its recommendations. If the course of study had been more detailed in its statements of what constituted a satisfactory course in chemistry and how to develop such a course, it would have been much more useful. As at present constituted, too much space is taken up with writing in the table of contents of the ordinary high school text and reproducing a list of laboratory apparatus provided by a chemical supply house that

lists some apparatus not at all necessary for the ordinary course in chemistry.

9. The data of the chapter as a whole presents rather substantial proof that many of the desirable outcomes do not result from instruction in chemistry in Montana, but that chemistry is just the ordinary course taken with the purpose, primarily, of getting required credits in science.

CHAPTER VI

LABORATORY EQUIPMENT AND PRACTICE

When speaking of the laboratory sciences among school people in Montana, the comment is often heard that funds are not available for properly equipping the laboratories, and hence effective laboratory work cannot be done. Especially will this be heard when speaking of the smaller schools. In order to determine how much foundation there was for these comments, a question was directed to the teachers requesting the information whether or not the equipment they had available for chemistry was adequate to the work they wished to do. The responses to the question were tabulated and are shown in Table LV.

Table LV. Adequacy of Equipment

First Class Districts			2nd Class Districts			3rd Class Districts			County High Schools			All Schools		
V.C. A.	G.A.	E.O.	V.C. A.	G.A.	E.O.	V.C. A.	G.A.	E.O.	V.C. A.	G.A.	E.O.	V.C. A.	G.A.	E.O.
2 1	2	0	3 7	6	1	0 7	2	2	2 4	3	0	7 19	13	3

V.C. = Very Complete A = Adequate G.A. = Such as can get along E.O. = Important Experiments omitted.

The seven schools reporting very complete equipment have 26.8 percent of the students taking chemistry enrolled; the nineteen reporting adequate equipment have 31.8 percent of the students enrolled. The thirteen schools having equipment such that they can just get along have 38.5 percent of the students enrolled, and 2.9 percent of the students are found in the schools where important experiments

must be omitted. A summary of the data given above is included in Table LVI with the corresponding data obtained for Nevada.

Table LVI Summary of Data

	Schools having very complete equipment			Schools Adequate Equipment			Schools Equipment such just get along			Schools Equipment such must omit important exp.		
	No	%	% of Chem. Enrol	No	%	% of Chem Enrol	No	%	% of Chem Enrol	No	%	% of Chem Enrol
Montana	7	10.7	20.8	19	45.2	31.6	13	31.0	38.5	3	0.7	2.9
Nevada	0	0.0	0.0	9	82.0	96.0	2	18.0	4.0	0	0.0	0.0

It would seem permissible to consider that only those schools having "very complete" or "adequate" equipment as satisfactorily equipped. Equipment "such that you can just get along" would indicate that some laboratory work must be omitted or curtailed; likely the optional experiments, demonstrations, projects, etc., would be few in number. In this report these schools will be considered as having unsatisfactory equipment. On the basis as described above 61.0 percent of the schools, representing 58.6 percent of the students enrolled in chemistry, may be considered to have satisfactory equipment. Perhaps this is a somewhat better showing than might be expected from what is heard about the equipment of Montana schools, but certainly it

leaves much to be desired. Comparative data was found in the S.R. Powers Survey.[86] From this source it was learned that 71.7 percent of the schools have well-equipped laboratories, 22 percent have fair equipment and 6.8 percent poor. This is a better showing than that made by Montana. Nevada has much better equipment than Montana.

Extent to Which Certain Equipment Representative of a Well-Equipped Laboratory is Found. In every well-equipped laboratory there is certain equipment found. Question 47 of the questionnaire was asked in an effort to determine to what extent representative items of this equipment were found in Montana schools. This is shown in Table LVII.

Table LVII Representative Equipment in Montana Schools

	A	B	C	D	E	F	G
First Class District Schools	4	5	4	4	4	2	3
County High Schools	6	7	8	9	6	3	1
Second Class District Schools	5	7	12	10	6	2	5
Third " " "	0	6	4	5	4	0	0

A-gas C-running water at desks E-analytical balance
B-distilled water D-mercurial barometer F-spectroscope
G-effective hoods

	Percent of Schools Having This Equipment						
	A	B	C	D	E	F	G
Montana	55.7%	59.5%	66.7%	66.7%	48%	19.0%	21.4%
Nevada	45%	72.7%	100%	72.7%	63.6%	18.0%	54.5%

A short explanation of why this particular equipment was specified is given. The specteoscope was chosen because it was felt that only the especially well-equipped schools would have this piece of apparatus. Examination of the -

86. S.R. Powers op.cit. p. 815

master tabulation will show that only two schools classing their equipment as just enough to get along have spectroscopes. All chemistry and physics textbooks of recent editions devote from two to five pages to the study of spectrum analysis. It is difficult to understand how a student can get a very clear idea of spectrum analysis without actual demonstrations. Some knowledge of the spectroscope is desirable for those students going to college who will continue in the study of the physical sciences. Even for those who do not go on to college, an appreciation of the great aid that the spectroscope has been in the recent progress of chemistry, physics and astronomy will repay the cost of this piece of equipment.

In the case of the analytical balance an instrument sensitive to .002 grams was specified because the instruments usually listed in supply catalogues designed for high school use are of this sensitivity. It is difficult to understand how quantitative work worthy of the name can be done without such an instrument. The responses made by the teachers (Table LVII) indicate that not more than one-half of the schools of the state are equipped to do experiments of this kind.

Effective hoods, running water at the tables, and gas may be considered as essential requirements of a well equipped laboratory. It is possible to conduct a fairly satisfactory course without them, but efficiency in laboratory

work will not be high. Distilled water and a mercurial barometer are not at all essential bat desirable.

It should be noted in Table LVII that:

(1) One of every five schools have effective hoods.
(2) One of every three have gas.
(3) Two of every three have running water at the desks.
(4) A surprisingly large number have distilled water and mercurial barometers, 60 and 67 percent respectively.

When compared to Nevada it is found that Montana ranks considerably lower in the matter of laboratory equipment.

Laboratory Manuals in Use. Three laboratory manuals are used almost to the exclusion of others. These are Brownlee and Others with 16 adaptions, McPherson and Henderson with 9 adaptions, and N.Henry Black with 6. Ten schools use 10 other manuals. Thirty-six of the schools are using manuals written by the same authors as the textbooks, and designed to accompany the text. In using a laboratory manual written by the author of the textbook Montana conforms to the general practice of the United States.

Experiments Done by the Students and by the Teachers as Demonstrations. It is the common practice for the teacher to do certain quantitative experiments, and experiments where toxic or corrosive gases are formed, and then requiring the student to report the experiment. For this reason, in order to get a proper conception of the extent of laboratory work done, both that by the student and by the teacher as demonstrations, must be taken into consideration. In the

questionnaire the teachers were asked to approximate the number of experiments completed. This was done for three reasons.

1. The questionnaire was circulated about three weeks before the close of the schools, hence, the teachers could not be certain how many would be completed.
2. Few teachers know exactly how many experiments are completed even at the close of the year.
3. The number of optional experiments done by the members of the class will vary, so it is impossible to answer accurately for the entire class.

Because of the nature of the question asked considerable allowance must be made for error. Even in considering the average number of experiments done by all of the schools using any one manual, the figure cannot be considered more than a mere approximation. The data is accurate enough however to give some idea of what part of the laboratory manual was completed, and that is all that is desired in this report. The tabulation of responses is shown in Table LVIII.

Table LVIII Extent to Which Students Do Laboratory Experiments

Laboratory Manual	Exp. in man.[87]	Median No. by student	Med. No. by teach.	Combined	% of Total
Brownlee	74	62	8	70	95
McPherson & Henderson	100	78	13	91	91
M. Henry Black	80	57	9	66	82

87. The number of experiments in the different editions of the manuals varies. The number given here is the number int the last edition.

Table LVIII shows that practically all of the experiments n the laboratory manual are completed. How well they are done he writer is not able to say.

The Number of Laboratory Periods Per Week and Length in inutes. Twenty eight (70 percent) of the schools providing ata for this question have two 90 minute laboratory periods er week. Two other arrangements are found. Five schools have 60 minute period twice per week, and five schools have an 80 inute period twice per week. The pronounced tendency in Mont - na is for two periods per week of 90 minutes duration. Mont- na is in agreement with the large majority of schools over the ountry in this respect. Not all teachers are in agreement hat this is the best practice. One respondent writes: "My laboratory period is one hour long. This length in my opinion is ideal, contrary to many reports....The one hour period keeps them (students) busy for every experiment, and never necessi- tates the wasting of time. Occasionally - very seldom - an experiment runs over."

Sequence of Laboratory Period and Recitation: This is one phase of laboratory practice upon which considerable ex- perimental evidence is available, altho more experimental work must be done before a definite answer can be made as to what is the best procedure. Since the discussion of this experimental evidence does not fall within the purposes of

this report, reference will be given to the studies made, but no evaluation will be made of the results. Actual practices in Montana are given with such comparative data as are available in Table LIX.

Table LIX. Sequence of Recitations and Laboratory.

	Lab. Precedes		Lab. Follows		Vary	
	No.	%	No.	%	No.	%
Montana	5	12	17	26	27	62
Nevada	1	9	4	36	6	55
Powers Survey[88]	49	33	61	41	39	26
Committee Report A.C.S.1928 [89]	35	55	22	35	7	10
Committee Report A.C.S.[90]	30	66	19	32	1	2

It is found that laboratory practice in Montana and Nevada differs markedly from that found in Eastern and Middle-western states. Very few schools in Montana and Nevada precede class discussion with laboratory work. In the schools represented in the Powers and American Chemical Society reports a much larger percentage of schools follow this procedure, with two-thirds of the teachers recommending that this is the correct procedure. The tendency in Montana and Nevada is to vary the procedure, while in the other studies reported the tendency is decidedly the opposite to this, with only 2 percent of the teachers represented in the

88. Powers, op. cit.
89. Committee on Chemical Education ACS (actual practice as determined by survey) Journal of Chemical Education 5:1302, Oct. 1928.
90. Ibid., p. 1303. (This is based on the opinions of the teachers of what actual practice should be.)

important American Chemical Society report giving as their opinions that this is the desirable practice. This opinion of the experienced teachers represented in the American Chemical Society survey is all the more surprising in view of the rather pronounced views in high school chemistry that there should be close integration between laboratory work and class discussion.

Methods of Reporting Laboratory Work. The notebook practices as employed by the teachers vary thru wide extremes. The ultimate system used by the teacher results frequently from years of trial and error modified by the system in use where their college chemistry was studied, preconceived ideas, and prejudices. A great deal of work of an experimental nature should be done on this phase of instruction in chemistry. The goal should be the formulation of some device by which the drudgery and routine of correcting notebooks could be reduced materially.

The practices in Montana and Nevada of reporting laboratory exercises are shown in Table LX.

Table IX Methods of Reporting Laboratory Work

	Outside (formal) notebook		Interlinear		Outline Notebook (91)	
	No	%	No	%	No	%
Montana	19	46	17	40	5	14
Nevada	5	50	3	30	2	20
Graham Study (92)	200	61	127	39	--	--

It will be seen that there is no decided tendency, altho the use of a formal outside notebook shows a slightly wider use. This is somewhat in enntrast to the rather pronounced tendency of Eastern and Middlewestern schools. In tabulating the data it was noticed that all but one of the first class district schools used the formal method of reporting experiments.

There are some features in favor of the formal notebook. It is desirable that students be able to make a formal report of a laboratory exercise done, and especially is this desirable for those who will continue with science work. On the other hand, the method is time consuming where time is not always available. Without doubt many students lose interest intthe subject of chemistry and learn to dislike it because of what appears to them to be of little value. An important factor in making chemistry a "stiff" subject and accounting for many failures is this practice. As a general rule the teachers

91. This is a bound notebook where the outline of writing up the experiment such as (1) Title; (2) Materials and apparatus; (3) method of procedure; (4) results; (5) discussion; (6) conclusion; (have been printed in the book.
92. Hoyt C. Graham Notebook Methods in High School Chemistry Journal of Chemical Education. 7:1125 1930

themselves pay little attention to the mechanics of writing up the report after the first few weeks.

Where the Experiments Are Written Up. The data as collected is reported in Table LXI.

Table LXI. Where the Experiments Are Written Up.

	Written up in Laboratory		Written up outside of Laboratory	
Case	No	%	No	%
Montana	22	55.0	18	45.0
Nevada	5	45.0	6	55.0
Graham Study (93)	190	58.7	119	35.5

Once more there is no significant trend in the practices of the teachers. The question arises of why teachers of high school chemistry should insist that the students write up experiments in the laboratory or class room. The answer is to prevent copying. Of course there will be copying if laboratory exercises are written up outside of the class room or laboratory, but will there be more than there is in the case of other school work of a similar nature not done in the classroom? There shouldn't be and probably there isn't. The teacher should be able to detect copying of laboratory exercises as well as he can detect copying in other subjects. Precautionary measures can be taken. The time is so limited in high school chemistry that to require writing the exper-

93. Hoyt C. Graham, op. cit. p.

iments in the laboratory greatly retards the progress of the class. The laboratory period should be a work period, a period during which the work is vitalized.

In the absence of definite experimental proof just what the writing up of formal laboratory reports in the laboratory has to contribute towards gaining the aims and objectives of teaching chemistry cannot be stated objectively. The writer is firmly of the belief that much of this procedure is hereditary from college practice and is not warranted from the results obtained.

Preparation in Advance of Doing Experiment. The data for this question is presented in Table LXIII.

Table LXII. Extent to Which Previous Preparation is Required Before Doing Laboratory Experiment.

	Prep. No.	Req. %	Prep. No.	Req. %
Montana	16	39.0	25	61.0
Nevada	5	45.5	6	54.5
Committee Report A.C.S. (1928) (94)	24	37.0	41	63.0

It is found that about the same percentage of teachers require advance preparation previous to laboratory work as is found in Eastern and Middlewestern States.

Without previous preparation students waste much time getting started. A few minutes preparation may arouse the interest and anticipation of the pupil, and gives a chance to connect the topic under consideration, thus correlating the text. If the student studies the direction for the procedure in davance and has formulated an outline for his report

94. Committee Report of Amer. Chem. Society for 1928 op. cit. p.1302

so far as possible he is ready to begin without loss of time and is practically certain to complete the exercise within the limits of the laboratory period. However, this requires more supervision on the part of the teachers and rather than make the effort some teachers lose a splendid teaching opportunity. Systematic preparation before the laboratory period contributes directly to the formation of desirable habits which is an objective in teaching Chemistry. (See item A question 46 of questionnaire.)

Size of Laboratory Sections. That there is an optimum number of students that a teacher can handle in the laboratory is recognized by everyone who teaches the sciences. What that number is no one can say. The number will vary so much with different teachers that a number separated from a teacher would have no significance. Many teachers consider twenty a large class, and certainly it takes an efficient teacher to give the individual guidance and attention, which is the essence of good laboratory teaching, to this number of students. A quotation is taken from "Principles of Science Teaching,"(95) that gives the opinion of an authority on science teaching.

"There is a very general agreement among leading science teachers that for the best work there should not be more than 20 pupils in a laboratory division. Exceptionally able teachers handle as many as thirty, but the latter number is considered upper limit."

95. George R. Twiss Principles of Science Teaching p. 137 MacMillan 1917

The size of laboratory sections as found in Montana is found in Table LXIII.

Table LXIII. To Show Size of Laboratory Sections

	1-5	6-8	9-11	12-14	15-17	18-20	21-25	26-30
First Class Districts				2	1			12
Second Class Districts	1	2	2	3	3	3	6	2
Third Class Districts	3	3	1	4	1			
County High Schools		2		2	3	5	3	
All Montana Schools	4	7	3	11	8	8	9	14
Percentages of each group	6.3	10.9	4.7	17.2	12.5	12.5	14.0	21.8
Comparative data								
Nevada	7.7	23.0	7.7	7.7		38.0		23.0
Silverman study 96)	3.0	14.1	11.9	14.0	14.7	14.7	17.7	10.4

It should be noted in Table LXIII that

(1) In Montana 21.8 percent of the laboratory sections have between 26 and 20 students
(2) Fourteen percent have between 21 and 25.

According to the standard cited above about 76 percent of the laboratory sections are such that only a very capable teacher can teach with desirable efficiency. In these classes are found 700 students or about 63 percent of the students enrolled in chemistry. When viewed from this angle, large laboratory classes become a rather serious factor and one having a tendency to decrease the efficiency of instruction. In the matter of optimum size of laboratory classes, Montana is not as fortunately situated as Pennsylvania as shown by the Silverman study. The marked tendency in Montana is to have single classes up to the number of thirty which number, when exceeded, results in dividing the class into smaller divisions

96. Alexander Silverman A Survey of High School Chem. in Penn. Science 48: (1918)

of equal size.

Practice in Correcting Notebooks. Responses to this question were not satisfactory for tabulation. Answers were too short and sketchy to convey any definite meaning. The tenor of most responses was that it involved a great deal of hard work, and that their methods were so complex as to not permit a simple answer. To get this information a questionnaire would have to be circulated with a number of questions permitting short and objective answers.

Method of Laboratory Grouping. The data shown in Table LXIV should be of interest to the teachers of chemistry in Montana. The writer was surprised at the very marked tendency of having two students work together. This marked tendency of grouping may be explained by reason of the very limited laboratory facilities available.

Table LXIV. Grouping of Students in Laboratory

	Individual	Group of two
First Class District Schools	2	3
County High Schools	1	8
Second Class District Schools	1	15
Third Class District Schools	2	10
Totals	6--14.3%	36--85.7%
Nevada	4--37%	7--63%

Comparative data is not available for high schools on this question. The summary of a study made by W.G. Bowers (97) will be given. The study was made with normal and college

97. W.G. Bowers Grouping Students for Work in the Chemistry Laboratory. Education XLV p. 434 (1924-25)

students, but it is believed by the writer that, in general, the results would be the same for high school students. The conclusions reached by Bowers are:

1. That the average strong students are neither benefited nor injured by working in pairs.

2. That weak students are benefited by working in pairs, especially if paired with strong students.

3. That strong students are not injured by working in pairs with weak students, although a mechanical genius is handicapped by being required to work with another student whether the latter be weak or strong.

The evidence indicates that the better way, that is, the least expensive way, is to have students work in pairs. Upon the basis of this evidence Montana is quite in line with the best procedure. More corroborative evidence, however, is desirable on this point and it is suggested that this would make an exceedingly interesting experiment that could be placed on a strictly experimental basis.

Teacher Opinion of the Probable Success of Recitation-Demonstration Method. In the light of the rather extensive experimentation carried out in the past few years on this method, and the likelihood of considerable discussion and reading on the part of the teachers, the writer thought it might be of value to get a tentative opinion from the teachers as to its possible value in Montana, where the problem of providing proper laboratory equipment is a serious one. It is recognized by all teachers familiar with the literature that no case has been conclusively proven for or

against the recitation-demonstration method. Such studies as have been carried out seem to be in favor of the class-demonstration method. When recommendations are discussed in Chapter VII more will be said as to the possibilities of adapting more exclusively the lecture-demonstration method to instruction in Montana.

The responses of the teachers to questions 60 and 61 of the questionnaire have been tabulated and are presented in Table LXV.

Table LXV. Teachers' Opinions as to Success of Recitation-Demonstration Method and Extent to which they would recommend using it in their Schools.

	Rec.-Dem. method could be made to take place of Rec.-Lab. method				Number and percent that would advise placing Rec-Dem. method in their school.			
	Yes	%	No	%	Yes	%	No	%
Montana	8(a)	21	22	58	5	14.2	31	85.8
Nevada	3(b)	30	6	60	1	11.1	8	88.9

(a) Eight gave qualifying answers such as possibly, not entirely, not very well, etc.
(b) One gave a qualifying answer.

Apparently about a fifth of the teachers of chemistry are of a pioneering turn of mind whose attitude might be that of "I'd try anything once." Of those teachers who gave provisional answers of whether they thought the method would be successful not a single one answered that they would recommend putting it in their schools.

In a questionnaire circulated to the teachers of the New England Association of Chemistry Teachers, Wilhelm

Segerblom asked the question "Do you think that a satisfactory first year course in chemistry can be given without accompanying laboratory work?" Of the 95 answers 93 said No. This discussion will be left for the time being with the suggestion that teachers of chemistry in Montana are really of a more pioneer type.

Summary and Conclusions:

1. According to the judgment of the teachers only 62 percent of the schools have satisfactory equipment when measured by the standard that they are able to do what they wish to do. This equipment is found in schools having 58 percent of the chemistry enrollment. When measured by the comparative data available, Montana ranks poorly. This was corroborated when it was found that the number of schools having certain equipment found in every well-equipped school was about half of the number teaching.

2. The laboratory manuals used were in almost every case written by the same authors as the text-book used, and designed to accompany the text. Practically all of the experiments in the laboratory manuals were done by the students or by the teachers as demonstrations.

3. The most commonly found laboratory period arrangement is that of 90 minute length meeting twice a week. This is the general practice over the country.

4. The marked tendency in Montana is to vary the sequence of laboratory and recitation according to the nature of the topic; Montana does not conform in this respect to the practice in Eastern and Middlewestern states.

5. No distinct tendency is found in Montana with respect to the method of reporting laboratory work or of requiring laboratory exercises to be written in the laboratory or classrooms. Probably these procedures are matters of minor importance that are stressed because of preconceived ideas or inheritance from college methods.

6. Preparation of the laboratory exercise before the exercise is done in the laboratory is not the common practice in Montana. Such a practice has much in its favor.

7. As a whole, laboratory sections are large in Montana, with 63 percent of the students in sections larger than that considered of correct size by authorities on laboratory work.

8. The decided tendency in Montana is to group two students together for laboratory work. There is experimental evidence that this arrangement is as good as any that can be made. However, more experimental work is desirable to confirm this.

9. In the opinions of the teachers of Montana the recitation-demonstration method of conducting a chemistry course would not be satisfactory. Very few would recommend adoption of this system in their schools.

CHAPTER VII

GENERAL CONCLUSIONS -- RECOMMENDATIONS

Conclusions.

1. When measured by the chemistry test circulated by the Kansas State Teachers College in its "Every Pupil Scholarship Contest" high school students in Montana rank higher than those of the two neighboring states of Missouri and Nebraska. A total of 427 students of chemistry took the test in Montana. Of the 62 schools representing Montana only two first class district schools and five county high schools are found. It is not likely that the showing made by Montana was due to a preponderance of selected schools. The test was based upon the factual matter of the textbook and was entirely objective.

2. Few schools of Montana make chemistry a required subject. In spite of this, in the school year 1928-29, eight and five-tenths percent of the total high school enrollment was taking chemistry. Twenty-nine and four-tenths percent of the juniors and seniors in those schools teaching chemistry were enrolled in the subject. Chemistry is decidedly a boys' subject in Montana; almost twice as many boys as girls are enrolled.

Forty-one percent of the high schools having chemistry in their curriculum are small, third class district schools. Only eighteen and six tenths percent of the students taking

chemistry, however, are found in these schools. This is fortunate, as this survey has shown conclusively that instruction in these schools is inferior to that in the other administrative units.

3. It is the conclusion of the writer that instruction in second class district schools is considerably better than that in third class district schools; that in first class district schools and county high schools is, in turn, better than that in second class districts. Perhaps the best instruction, as a whole, is that in county high schools. The reasons for coming to this conclusion are:

(a) The county high school teachers have the best preparation in the kindred subjects of chemistry, altho the first class district teachers have more credits in chemistry. In other words, the latter teachers are more the specialists in chemistry.

(b) A slightly larger percent of teachers in county high schools have had a course in the teaching of chemistry.

(c) The median sized class in county high schools is about nineteen, that in first class district schools is almost twenty-nine.

(d) Better equipment is provided in county high schools than in the other schools when measured by the standard that the teachers are able to do what they wish to do in the course.

4. About the only administrative restriction placed upon registration is that the student must be a junior or senior. In forty-seven and five-tenths percent of the schools, general science is prerequisite to enrolling in chemistry. Only one of these schools, however, was a first class district school,

and two were county high schools. It can be seen that the percent of the chemistry enrollment in those schools requiring general science would be relatively small. Very little conscious effort is made to guide students in registering in chemistry. In spite of this lack of guidance only twelve and four-tenths percent of the students fail, calculated on enrollment two weeks after the beginning of schools.

5. An attempt was made to get a measure of the outcomes of the teaching of chemistry. Two sets of objectives were set up. On set attempted to measure achievement of the social values and the other of the laboratory values. The social objectives are open to severe criticism on the grounds that at least four of the nine are truisms in the sense that they could apply equally well to any subject. Hence, they have small validity. The laboratory values are somewhat more valid, but are subjective in as much as they ask for a teacher rating.

The teachers feel, as a whole, that they achieve success ranging from moderate in amount to considerable.

The acquirement of laboratory technique is not an important factor in laboratory work as done in Montana. This value ranked highest in the opinions of a large number of chemistry teachers in Eastern and Middlewestern states. Teachers of chemistry in Montana and Nevada gave as their opinion that this value was obtained in small amount in their

teaching. In the case of seven other values the teachers of Montana and those of the Eastern and Middlewestern states were in close agreement. A correlation of 0.77 ± .097 was obtained with these values.

Teachers, to be efficient, must have more than mastery of the subject matter they are to teach. The teacher must be prepared in the methods of teaching the subject, in the general field of education, and in related subjects to that he will teach. This preparation must be received in colleges and universities of recognized merit.

About fifty-three percent of the teachers of chemistry in Montana are graduates of Middlewestern institutions. Twenty-nine percent are from Montana schools. When compared to some other states, the proportion of teachers not having a degree is not excessive (6.2 percent). In the opinion of the writer, the lowest qualification acceptable for teaching in Montana should be the Bachelor of Arts or the Bachelor of Science degree.

6. By a conservative estimation, it was determined from the data collected that not more than forty-nine percent of the teachers of chemistry have chemistry for a major or minor. If the convention is accepted that a major signifies mastery of the subject, it becomes clear that a large part of the teachers are teaching without mastery. Teachers in Montana are deficient in majors to a much greater extent than those

of other states where comparative data were available. A marked amount of this deficiency can be traced to graduates of institutions of this state. Twelve of the thirty-seven teachers answering question 12 of the questionnaire had less than twenty-five quarter hours of credit. Six of the third class district teachers did not have twenty-five quarter hours. On the other hand five of the teachers had over seventy-five quarter hours of credit. This explains in part the fact that the median number of hours credit in chemistry was 38.

7. Preparation was good in the related subjects of education, physics, and mathematics, when compared to other states. Preparation was especially satisfactory in education. In this subject only four teachers had fewer than twenty-five quarter hours. This, of course, is due to the standards of certification in this state. Why could not equal preparation be required in knowledge of the subject matter the teacher is to teach?

8. It is gratifying to know that only one teacher in the state is doing so without having had a course in general (college) chemistry. Seventy-five and six-tenths percent of the teachers have had high school chemistry. It is difficult to say just what advantage this would be to the teacher. Twenty-five percent of the teachers have had courses in physical chemistry. This indicates strong majors as this course is

only taken by those who specialize in the field of chemistry.

9. Few of the teachers have had a course in the teaching of chemistry. This is not a happy condition. For the teacher this course is next in importance to the course in general chemistry. Much inefficient and misdirected effort must result if the teachers are without specific training in the subject they are to teach. This must be expected in Montana. A course in the teaching of chemistry or of science is not taught in any of the institutions of higher learning in this state.

10. Teachers make little effort to improve their preparation by taking more courses in chemistry. For those teachers who are not well prepared, and should take more work in chemistry, another method must be devised than that of summer school.

11. Fifty-seven percent of the teachers have not had more than two years experience teaching chemistry. This is a limited experience when compared with that of teachers in other states. Tenure of teachers is also very short . This is not a desirable condition, but it seems unlikely that it can be changed unless larger salaries are paid, the teaching load is reduced, and more adequate equipment is provided.

12. Twelve and one-half percent of the teachers are teaching chemistry against their choice, and with the knowledge that they are not prepared to teach it. In the belief

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The subject matter of four very widely used texts in chemistry has been analyzed by the author. It is somewhat out of date, however, as the editions used have been replaced by later ones.

Bishop, Elizabeth L., Status of Science in California High School Programs of Studies.

Master's thesis, unpublished.

Black, N. Henry, and Conant, James Bryant, Practical Chemistry. New York 1929.

This textbook is used extensively all over the United States.

Bobbit, Franklin, The Curriculum, New York 1918.

This book was consulted by the writer when formulating the objectives for the teaching of chemistry which were used in the questionnaire. It does not contain a specific list of objectives. It may be characterized as thought provoking. It has a good discussion on the project method of teaching.

Bowers, W. C., Grouping Students For Work in the Laboratory, Education XLV:434 (1924-25)

In this the author presents experimental evidence that two students working together in the laboratory do as effective work as one working alone. There is need for more experimental evidence on this subject.

Brownlee, Raymond Bedell, and Others, First Principles of Chemistry, New York 1926.

This high school text in chemistry is used in more schools in the United States than any other. This fact

vouches for the merit of the book.

Brown, E. A. and Bowers, W. C.,"Psychology Underlying Instruction in Chemistry", School Science and Mathematics, 23:715-19 (1923)

The authors give a very good discussion of their subject.

Charters, Werrett,Wallace, Curriculum Construction, New York (1923)

This deals primarily with the construction of the curriculum in elementary schools. However, the discussion may be applied in determining the objectives of any course. The material on motivating agencies, such as the project, is very helpful.

Cook, Charles C., New Type of Questions in Chemistry, New York 1927.

This book should be very useful to the teacher. It contains testing and drill questions to cover the entire course in chemistry. Most of these questions are of the short answer, objective type. This book should be on every chemistry teacher's desk. It is designed for student use as well as teacher's.

Cornog, J., and Colbert J. C., "A Quantitative Analysis of Aims in Teaching High School Chemistry", School Science and Mathematics, 24:163-173 (1924)

This book contains one of the very best analyses of subject matter of high school chemistry texts in the literature. Even though the editions analyzed are old the material presented is very worth while.

"Correlation of High School and College Chemistry", Revision Committee on Committee of Chemical Education, Journal of Chemical Education 4:640-656 (1927)

Recommends different courses in chemistry depending upon whether or not the student plans on attending

college. It provides topics for a standard minimum high school course in chemistry with suggestions for supplementary work. It also recommends a standard minimum first-year course in chemistry for colleges. These standards should be widely accepted, although they have been critized as being maximum rather than minimum.

Course of Study in General Science, Biology, Chemistry, and Physics for Montana High Schools, prepared and issued under the direction of the State Dept. of Public Instruction, Helena, 1923.

Many of the recommendations made in this course of study were put in the form of questions and included in the questionnaire. It is to be regretted that the course of study for chemistry is not worked out in more detail, and does not offer more helpful suggestions to the beginning teacher. It is suggested that the course could have followed more closely the recommendations made by the Committee on Revision of the Committee on Chemical Education of the American Chemical Society.

Davis, C. O., Our Secondary Schools, published by the North Central Association of Colleges and Secondary Schools. 1925.

This pamphlet is referred to in the body of the report as the "Quinquennial Study of the North Central Association". It provided comparative data on degrees held by teachers, and percent of juniors and seniors enrolled in chemistry. This pamphlet contains a great deal of information pertaining to the high schools that are members of the association.

Dewey, John, Democracy and Education, New York (1922)

His works are accepted as authoritative in education.

Dinsmore, Ernest L., Chemical Calculations, New York (1922)

This provides a wealth of practice and drill material in chemical problems. Every chemistry teacher should have this book on his desk. It is also adapted for use by the student.

Englehart, Max D., "A Psychological Basis for Objectives",

Journal of Chemical Education, 4:364:69 (1927)

This is a short article which was based upon a longer report. It suggests the possibilities of defining the objectives or outcomes of chemistry upon a psychological basis. The teacher of chemistry could learn much from this article.

"Every Pupil Scholarship Contest", conducted by Kansas State Teachers' College, Emporia, Kan. (1930)

The results of this test provided material for comparison of achievement between chemistry students of Montana, Nebraska and Missouri. Every person interested in education in Montana should be acquainted with these texts.

Gordan, Neil, "Application of Psychology to Chemical Education", School Science and Mathematics, 21:862-868 (1921)

Many suggestions may be had from this article when read with the article by Max D. Englehart referred to before.

Graham, Hoyt C., "Notebook Methods in High School Chemistry", Journal of Chemical Education, 7:1122-24 (1930)

This is a questionnaire study sent to the ten largest schools in each state. There were 351 returns or 74 percent. This is as accurate as questionnaires of this type can be. It afforded excellent comparative data, although somewhat selective in nature.

Hendricks, B. Clifford, "The High School Chemistry Library", Journal of Chemical Education, 5:861-867 (1928)

The suggestions offered in the article on how to induce high school students to read are excellent. It contains a list of twenty books on chemistry that should be in every high school library.

Hendricks, B. Clifford and Chambers, John S., "Chemistry Teaching in Nebraska", School Science and Mathematics, 29:138-141 (1929)

Very good comparative data was provided in this article. It is based on a questionnaire sent to all schools of Nebraska and gives data directly comparable to small schools of Montana.

Horton, Ralph E., "Measurable Outcomes of Individual Laboratory Work in High School Chemistry", Contributions to Education, Columbia Univ. 303 (1928)

The most thorough and convincing evidence that the recitation--demonstration method of instruction has much in its favor and as far as learning of subject matter of chemistry is concerned is as effective as the recitation--laboratory plan.

McPherson, William, and Henderson, William Edwards, Chemistry and Its Uses, New York, 1927.

This is a widely used textbook.

Montana Educational Directories, 1927-28 and 1928-29, published by State Superintendent of Public Instruction, Helena, Montana.

This source provided much of the data on enrollment, the schools teaching chemistry, teacher load and teacher salary. This source was almost indispensible.

Oppe, Gretta, "The Status of Chemistry in Texas High Schools Affiliated with the Southern Association of Secondary Schools", Journal of Chemical Education, 6:1748-1758 (1929)

This was a questionnaire study. The response was good. For diagnostic purposes the schools were divided into four groups according to enrollment. Much comparative data was available from the study which was reliable. A number of the questions in it were based upon teachers' opinions.

"Order of Precedence of Laboratory Work and Recitation in High School Chemistry", Journal of Chemical Education, 5:1300-06 (1928)

This is an excellent report. In it were provided the laboratory values listed in question 62 of the questionnaire, and other good comparative data. The above report was a questionnaire study with replies received from the larger schools of 15 states. It may be criticized on the basis that the data was selected.

Phelan, Earl W., "The Status of Chemistry and Chemistry Teacher in Ohio", Journal of Chemical Education, 6:2196-2202 (1929)

The same questionnaire was used to make this survey as was used by A. Swartz referred to below. Since schools of all sizes were surveyed, this source provided much good reference material.

Powers, Samuel R., "Diagnostic Study of the Subject Matter of High School Chemistry", Columbia University Contributions to Educations, 149 (1924)

This was an epoch making study in chemistry. It proved through a carefully controlled testing program that the factual subject matter of chemistry is soon forgotten. It is subject to criticism on the basis that the choice of testing items could have been improved.

"Report of Chemistry Survey", School Science and Mathematics, 15: 810-19 (1915)

This was one of the first surveys made in chemistry. A large number of questions were asked, many of them requiring answers of subjective nature. Seven hundred and sixty blanks were distributed to all schools belonging to territory covered by Central Association of Science and Mathematics Teachers. Three hundred were sent to all parts of the United States except New England. Only a fifteen percent response was received. It provides much comparative material although the data maybe unreliable because of small response.

The Questionnaire--Research Bulletin of the N. E. A. No. 1, Vol. VIII (1930)

This bulletin provided the criteria by which the reliability of the questionnaire circulated by the writer was tested. This is the best article that has been written on the questionnaire. No one should undertake

a questionnaire study before consulting this pamphlet.

"Reorganization of Science in Secondary Education", A Report of the Commission on the Reorganization of Secondary Education, Appointed by the National Education Association, Bureau of Education Bulletin 26 (1920)

This is one of the best statements that has yet been made on the teaching of science. It formed the foundation for a number of questions in the questionnaire. The social objectives of question 45 were taken from this source.

Reports of Principals and Superintendents to High School Supervisor, Part B. On file at the office of Superintendent of Public Instruction, Helena, Montana.

This contains much valuable information concerning teachers' degrees, majors, teaching load, salary, etc.

Rogers, T. A., "A Survey of Chemistry Teaching in Wisconsin High Schools", Journal of Chemical Education, 5:1415-24 (1928)

This questionnaire study was sent to all schools having five or more high school teachers. The data is selected. The attitude of the author was very critical in interpreting the data. However, this would not effect its reliability. A fair response was received to the questionnaire.

Sampey, John R., "An Outline on Pandemic Chemistry", Journal of Chemical Education, 5:1243-1254 (1928)

This is an excellent discussion of cultural chemistry. Many helpful suggestions are made on how values other than the factual matter of the textbook may be obtained. A suggested outline for a laboratory course is given. It is written primarily from the point-of-view of the college professor, but applies equally well to high school.

Silverman, A., "A Survey in High School Chemistry in Penn.",

Science 43:179-182 (1918)

This is one of the older surveys. Questions are asked concerning methods of conducting classes, subject matter covered, and teacher preparation in an effort to establish closer correlation between high school and college chemistry. The eighteen questions asked provide considerable comparative data. There is no way of determining to what extent the questionnaire was answered.

Stannard, E. A., Chemical Review Book, New York 1924.

This is one of the series of "Oxford Review Books", and is without doubt the very best in the field. This book should be placed in the hands of every student of chemistry. It will save the teacher much drudgery and drill work.

Stoddard, George D., "Iowa's Placement Examinations"; Chemistry Aptitude, CA-1, Revised, Forms A & B. University of Iowa, Studies in Education, Vol. III, No. 2 (1925)

This test will be used more by teachers when they learn of its possibilities in predicting success in chemistry. Simpler directions are needed for administering the text. Its reliability is 0.88 with P. E.--score 4.0.

Swartz, A., " A Survey of the Chemistry Course of Oregon High Schools", Journal of Chemical Education, 3:817-823 (1926)

This survey was made by means of a questionnaire. The author claims to have received close to a 100 percent response. It contains excellent material for comparison in Montana. This was one of the best sources for comparative data available to the writer.

Twiss, George R., Principles of Science Teaching, New York, (1917)

This is one of the older books on science teaching, but is still one of the very best. Many teachers have used this book and improved their teaching thereby. It is suggested that this book should be in every high school library.

Weber, James J., "Is the Term Visual Educative Scientific?" The Phi Delta Kappan 11:78-9,83 (1918)

Woodhull, John Francis, The Teaching of Science, New York (1918)

This book has been widely used by teachers of science as a form of manual. The discussion on general science is especially good. It was used by the writer in formulating the aims and objectives (first list) and in suggesting questions on means of motivating the course and laboratory procedure.

APPENDIX B--QUESTIONNAIRE

FOR THE PRINCIPAL OF THE HIGH SCHOOL

During the past three years the Committee on Education of the American Chemical Society has been attempting to determine thru surveys and other means the status of instruction in high school chemistry. Several such surveys have been made for the Eastern states and some of the Middle Western states, but, as far as I know, this has not been done for any of the Rocky Mountain states. I propose to make such a survey of two representative Rocky Mountain states - Montana and Nevada - by means of a questionnaire, one of which I have enclosed.

In this questionnaire I have attempted to cover ten of the possible twelve or fifteen phases presented by this problem. They are:

(1) Administrative restrictions placed upon registration
(2) Teacher qualifications thru education and experience
(3) The extent to which students enroll in chemistry
(4) General method of carrying on class work
(5) Efforts made to make chemistry more interesting (and valuable) thru other means than the study of textbooks.
(6) The local interests there are that would aid in motivation of the subject.
(7) Efforts the teachers make to meet recognized standards
(8) The objectives of the course
(9) Laboratory equipment and practices
(X) The values to be derived from laboratory work.

The data collected will be analyzed, organized and summarized and then sent to the Superintendents of Public Instruction in the states where data was obtained; also, this data will be sent to the school journals of the above listed states and to the Journal of Chemical Education to be used by them as they may desire. Personally, I propose to use the data obtained as the basis for thesis as part requirement for my masters degree in education.

The more responses I receive to the questionnaire of course, the more reliable the conclusions that I may draw will be. I am very anxious to do just as good a piece of work as I possibly can Hence, will you co-operate with me by answering the question on the sheet "For the Principal" and then passing the questionnaire on to your teacher of chemistry?

I wish to thank you very kindly for any time you may be able to give to this matter.

Sincerely yours,

P.S. If chemistry is taught in alternate years and this happens to be the odd year, will you ask your teacher who would teach chemistry to answer such questions as apply this year?

G.L.T.

FOR THE PRINCIPAL OR HEAD OF DEPARTMENT

1. Name of high school:

2. Of the number attending how many are of (a) sophomore standing_____, (b) junior standing_____, (c) Senior standing_____?

3. Is chemistry offered (a) every year, or (b) alternate years

4. Is general science prerequisite to taking chemistry?

5. Do you have a rule that chemistry must precede physics?____ That physics must precede chemistry? _____

6. Under what conditions are sophomores permitted to take chemistry?

7. In registering students for chemistry what effort is made to include only those students who have in the past done good work in other subjects?

8. Indicate if chemistry is required (R) or elective (E), for graduation from the following courses: (a) scientific ( ), (b) classical ( ), (c) English ( ), (d) commercial ( ), (e) any other _____.
(Note) If you have a different classification of courses would you place it on the back of this sheet with the information asked for?

FOR THE TEACHER OF CHEMISTRY

Below I have listed fifty-four (54) questions on the methods, objectives, and results of instruction in chemistry. These questions I am sending to the teachers of chemistry in the states of Montana and Nevada. I wish to determine what the sta status of instruction is in these states as compared to that in Eastern and Middle Western States. I believe that it will be a favorable comparison.

For the most part answers can be made by marking with a check, underscoring or writing "yes" or "no". If you think that you cannot state just the response you wish to make by these marks feel free to write in more complete statements. Criticism or comment on any question or group of questions is asked for. I recognize that a few of the questions asked are general in nature and may be difficult to answer. However, when I consider that the school year is almost finished I know that you have answered most of these questions for yourself, and that the answers will come readily. Your best judgment in cases of doubt is all I ask for.

I have found it necessary to include questions for both the large and small school. If you find questions that do not apply to your school, leave them blank.

In a letter to your principal my purpose for sending out the questionnaire is given in more detail than is given here. This letter will probably be passed on to you.

I wish to thank you for any time you may give to this matter.

Sincerely yours,

FOR THE TEACHER OF CHEMISTRY

9. Your name (you may omit if you wish)

10. From what schools have you graduated?

11. Major subjects (a) (b) Minors(a) (b)

12. How many hours credit (state if quarter or semester) do you have in (a) education_____(b) chemistry_____(c) physics_____ (d) mathematics_____.

13. In the list which follows underscore the courses you have taken: (a) High School chemistry, (b) general (college) chemistry, (c) qualitative analysis, (d) quantitative analysis, (e) organic chemistry or carbon compounds, (f) physical, (g) industrial (h) physiological (i) course in the teaching of chemistry, (j) any others

14. How many weeks of summer school work have you had in the past five years or since graduation?_____

15. What courses in chemistry have you takenduring this time?_____

16. How many months of teaching experience have you had in chemis try?

17. How many months of high school teaching experience have you had?

18. What experience have you had in industries such as you would study about in high school chemistry?

19. What industries (other than stores) do you have in your community that would be of interest for a class in chemistry to visit?

20. Do you live in an agricultural community?____. Do you try to make direct application of your teaching of chemistry to the problems to be met in such a community?

21. Do you make chemistry a first choice subject, a second choice subject, or a third choice subject in making application for positions?

22. How many years have you been in your present school?

23. What is your salary per year (omit if you wish)?

24. How many students did you have enrolled in chemistry at the end of the first two weeks this year?___How many were (a) so phomores_____(b) Juniors_____(c) seniors?_____.

25. Of this number how many dropped the first semester (a) because of unsatisfactory work_____(b) for other reasons?____

26. About what number will do satisfactory work for the entire year?_____

27. Do you attempt to section students according to ability as shown by I.Q.'s or previous work?____

28. What textbook are you using?_____What edition?_____

29. How many recitation periods do you have per week?_____Length of period in minutes?_____How many sections?_____Number in each section (a)_____(b)_____(c)_____.

30. About how many mimutes of the recitation period do you give to (a) assignment of the lesson____; (b) for discussion of student difficulties_____; (c) for questioning_____; (d) for drill work_____; (e) supervised study_____; (f) demonstrations_____.

31. Do you use, for class purposes, a review book such as the "Oxford"?_____A question book such as Cook's "New Type Questions in Chemistry?"_____Practice material in problems such as Dinsmore's "Chemical Calculations?

32. Do you make student reports, either oral or written, on outside readings a regular feature o f your class work?

33. Do make use of projects in your teaching ?_____If so, about how many will you work out this year?_____

34. What use do myou make of visual education such as motion pictures, slides, etc.?_____

35. About how many field trips will each class make this year?

36. How many students will you have take part in the American Chemical Society Essay Contest this year?

37. Do you have a science club?

38. Do you follow your present State Course of Study (a) very closely (b) closely (c) not closely (d) not at all?

39. Will you give standardized tests in chemistry at the end of the years work?

40. Do you feel that your students meet the minimum standards as proposed by the Committee of Chemical Education of the American Chemical Society?

41. Which of the following characterizes your method in teaching chemistry: (a) textbook - supervised study - laboratory plan; (b) textbook - class recitation - laboratory plan; (c) the contract plan; (d) any other plan_____.

42. Underscore the periodicals which follow that are available for student use; (a) Journal of Chemical Education(b) School Science and Mathematics (c) Popular Science (d) Scientific American (e) Popular Mechanics (f) others.

43. About how many reference works on chemistry, other than high school textbooks, do you have in your school library?

44. Which of the following are included among these: (a) Creative Chemistry (b) Chemistry in Medicine? (c) Chemistry in Industry Vol. I (d) Chemistry in Industry Vol. II (e) Life of pasteur

45. Below is listed some of the values to be derived from a course in chemistry. Indicate to what extent you think you have achieved these for your class as a whole this year. (1) would indicate to a marked amount (2) inconsiderable amount; (3) moderate amount; (4) small amount; (5) negligable.
( ) The development of interests, habits and abilities.
( ) The development of direct and effective methods of solving problems that might arise in real situations.
( ) Development of a higher appreciation by the student of the pleasure and profit to be obtained by the exercise of his own abilities.
( ) Control of an appreciable body of facts and principles of significance in the home and community.
( ) The building up of an intelligent understanding of the conditions, institutions, demands and opportunities of modern life.
( ) Development of clearly defined points of view, intensified powers of insight, and points of departure for new attempts for future study.
( ) Appreciation of the contributions of chemistry to health, and in the control and elimination of disease.
( ) Appreciation of the privileges, duties and responsibilities that living in this age of science involves.
( ) Aesthetic appreciation to the degree that the eyes are open to the perception of new beauty, and power to understand and enjoy.

LABORATORY EQUIPMENT AND PRACTICE

46. Do you find that your laboratory equipment is (a) very complete (b) adequate (c) such that you can just get along (d) such that some important experiments must be omitted?

47. Underscore the facilities that follow that are available in

your laboratory; (a)gas (b) distilled water (c) running water at desks (d) mercurial barometer (e) analytical balance accurate to .002 gram (f) spectroscope (g) effective hoods.

48. What laboratory manual do you use?

49. Approximate the number of laboratory experiments done by each pupil.

50. The number of optional experiments.

51. The number of laboratory experiments done by you as demonstrations.

52. How many laboratory periods do you have scheduled per week?_____ Length of laboratory periods.

53. Does laboratory work (a) precede (b) follow or (c) vary according to the nature of the topic, the class discussion of the topic?

54. Are students required to write up experiments in (a) outside notebooks (b) write observations and answer questions in laboratory manuals (c) use an outlined notebook such as the Troquois.

55. Are students permitted to write up observations and results outside of laboratory or classroom?

56. Do you require preparation in advance of performing laboratory exercises?

57. How many students do you have in your laboratory sections?

58. What is your practice in correcting notebooks?

59. What method of laboratory work is followed: (a) the individual method (b) two students working together (c) any other method.

60. Do you think that the recitation - demonstration plan may be made to take the place of the recitation - laboratory plan?

61. Would you recommend doing this in your school?

62. Following are eight educational values that may be derived from laboratory work. List them as you think they are of importance in your teaching, marking the most important (1) the second in importance (2) etc.

( ) Acquirement of manipulative skill (laboratory technic)
( ) Training in habits of accurate observation
( ) Appreciation of the scientific method of thinking
( ) Development of initiative and resourcefulness
( ) Increased interest
( ) Concrete, or first hand, knowledge through direct contact with the material studied.
( ) Training in habits of accuracy and neatness
( ) Cultivation of ability to reason and draw conclusions.

Appendix C

Table I. To Show Percentage of Failures in Chemistry

Number of School	Enrolled in chem. end 2 weeks	Dropping for other reasons than failure	Net	Failing 1st Semester	% of net failing	Finishing year	Number failing for year	% failing for year
		First Class Districts						
1	62	1	61	2	3.3	56	5	8.2
2	165	5	160	4	2.5	130	30	18.8
3	112	2	110	4	3.6	85	25	22.7
4	42	6	36	4	11.1	28	8	22.2
5	36	1	35	5	14.3	30	5	14.3
Totals	417	15	402	19	4.7	329	73	18.1
		County High Schools						
6	30	0	30	2	6.7	25	5	16.7
7	16	1	15	0	0.0	13	2	13.3
8	37	0	37	1	2.7	35	2	5.4
9	48	2	46	0	0.0	46	0	0.0
10	26	3	23	1	4.3	22	1	4.3
11	16	0	16	0	0.0	16	0	0.0
12	—	—	—	—	—	80%	—	20.0
13	38	1	37	7	19.0	26	11	29.8
14	42	0	42	0	0.0	39	3	7.1
Totals	253	7	246	11	4.5	222	24	9.7
		Second Class Districts						
15	28	2	26	2	7.7	24	2	7.7
16	16	0	16	0	0.0	15	1	6.7
17	—	—	—	—		—	—	
18	15	1	14	1	7.1	13	1	7.1
19	41	4	37	0	00	30	7	18.9
20	26	0	26	2	7.7	21	5	19.2
21	22	0	22	0	0	20	2	9.1
22	42	4	38	0	0	90%		10.0
23	18	1	17	0	0	18	+1	0.0
24	19	0	19	0	0	18	1	5.2
25	10	1	9	0	0	9	0	0.0
26	25	2	23	1	4.4	20	3	13.0
27	13	0	13	0	0.0	?	?	?
28	25	1	24	1	4.2	22	2	8.3
29	44	7	37	0	0.0	35	2	5.4
30	12	0	12	0	0.0	10	2	16.7
31	28	2	26	0	0.0	26	0	0.0
Totals	384	25	359	7	1.9	281	27	7.5
		Third Class Districts						
32	5	0	5	0	0.0	5	0	0.0
33	5	0	5	0	0.0	4	1	20.0
34	5	0	5	0	0.0	5	0	0.0
35	8	0	8	0	0.0	8	0	0.0
36	13	1	12	0	0.0	12	0	0.0
37	12	0	12	0	0.0	10	2	16.7
38	6	1	5	0	0.0	4	1	20.0
39	9	2	7	0	0.0	6	1	14.3
40	12	1	11	0	0.0	10	1	9.1
41	24	0	24	1	4.2	18	6	25.0
42	15	0	15	0	0.0	13	2	13.3
Totals	75	5	109	1	0.9	95	14	12.8
Totals of all schools	1129	52	1116	38	3.4	927	138	12.4

TABLE II. Schools from Which Teachers Received B.A. or B.S. Degree.

First and Second Class Districts and County High Schools

State University of Montana	4
Montana State College	4
Intermountain Union	3
University of Minnesota	3
University of Wisconsin	2
University of Dubuque	2
Washington State College	2

One teacher from each of the following: Purdue, Lafayette, Ind.; St. Olaf, Minnesota; Nebraska State Teacher's College; Bethany, Kansas; North Dakota State College; Waterloo, Iowa; Business College, ; College of St. Catherine, St. Paul, Minn.; University of Iowa; Lynchburg College, Va.; Knox College, Ill.; Whitman; Kansas State Teachers; Tarkio College, Mo.; Pittsburg Kansas Normal; Oregon Agricultural College; Albion, Michigan; State Teachers College, Superior, Wis.; Hillsdale College, Mich.; University of North Dakota; University of South Dakota; University of Nebraska.

Third Class Districts

State University of Montana	6
Montana State College	4
Intermountain Union	5
University of Idaho	2
St. Olaf College	2

One teacher from each of the following: University of Utah, Salt Lake; Nebraska State Normal; Aberdeen South Dakota Normal; Kansas State Normal; Gustavus Adolphus; Calsm-Newman College, Tenn.; Iowa State Teacher's College; University of

of Iowa; Columbus College, South Dakota; Montana State Normal; Luther College, Iowa; Bethany; University of Illinois; Kansas State Teachers College; Central Wesleyan , Missouri; Franklin College, Ind.; Pacific College, Ore.; Iowa Wesleyan; Union Theological Seminary, N.Y.

TABLE III. APPENDIX C.

Majors Held by Second and Third Class District Teachers in Education and Other Subjects.

Second Class Districts

Education alone	3
Home Economics	2
Biology	2
Pharmacy	1
Agriculture	1
Animal Husbandry	1
Sociology	1
History	1
Latin	1

Third Class Districts

Education alone	3
Education & Biology	1
Education & Psychology	1
Education & Greek & Sociology	1
Education & English	1
Education & Agriculture	1
Education & Biology & Psychology & Business Administration	1
Education & History	1

All Others

English	4
Mathematics	3
History & Political Science	1
Zoology	1
Business Administration	1
Sociology	1
Language	1
Physical Education	1
Latin	1
Spanish	1
Physics	1
Agriculture	1
Economics	1
Geology	1