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A study of certain aspects of the chemistry curricula in selected Massachusetts high schools.

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A STUDY OF CERTAIN ASPECTS OF THE CHEMISTRY CURRICULA IN SELECTED MASSACHUSETTS HIGH SCHOOLS

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A STUDY OF CERTAIN ASPECTS OF THE CHEMISTRY CURRICULA IN SELECTED MASSACHUSETTS HIGH SCHOOLS

by

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INTRODUCTION

Background of the Chemistry Curriculum in American High Schools -- Since the beginning of formal secondary education in 1635, when the Latin Grammar school was established, the school curriculum has changed many times to meet the needs of public education. These schools were established to prepare students for college entrance by means of a relatively narrow, formalized curriculum. They apparently did not reserve a place for science in their curriculum since no science offerings were recorded.

Science education began in the academies with the introduction of natural philosophy, a forerunner of physics, which was included in the curriculum of the first academy established by Benjamin Franklin in Philadelphia in 1751.

The curriculum of the first free public high school, English High School established in Boston in 1821, not only included natural philosophy, but chemistry as well. These inclusions were brought about by the success of the program in the academies. Although chemistry was offered as an elective in this school, it seems to have had a rather uncertain place in the curriculum of other high schools. Some schools presented it in their program and others did not. Heiss, Obourn, and Hoffman[1] state that by 1854, 26.6 per cent of all high school

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[1]Heiss, Elwood D. Obourn, Ellsworth S. Hoffman, Charles W. Modern Science Teaching. The MacMillon Company. New York 1950. pg. 5.

students in Ohio were enrolled in classes in chemistry. There was little or no laboratory work done by students prior to 1860 since many schools had difficulty in getting apparatus and chemicals.

An appraisal of science education in the first fifty years seems to indicate that these courses were taught primarily for their practical and informational value with little laboratory or demonstrational work. Great emphasis was placed on factual memorization. The courses enjoyed wide popularity even among students who were not preparing for college. While some of the textbooks of the period approached the subject inductively, most of the teaching was done by lecture and recitation.

Period of College Domination -- In 1872 Harvard College began the practice of accepting physics and other science courses for college entrance, and, within a few years, most of the colleges had followed suit. High school courses of study soon were being prepared by college teachers of science and many of the textbooks of the time were written by them. High school textbooks were nothing more than simplified and abridged college texts that had little value beyond that of preparing the student for meeting college entrance requirements. Colleges had already set standardizing documents and requirements, the most influential of which was the Harvard Descriptive List published in 1887. This was a listing of forty-six experiments in physics which were acceptable for college entrance. The rigid influence of the college domination of high school science offerings continued down into the early years of this century and the influence may very well be detected in some of the textbooks that are still used in high school science today.[2]

Reports given by the Committee of Ten of the National Education Association in 1893 and the committee on College Entrance Requirements of the same organization given in 1896 and in 1899 helped bring about the standardization of college entrance requirements. The College Entrance Board was formed in 1900 culminating the movement toward standardization.

The reports of these committees had far-reaching influence on the organization of the high school curricula of the times. The reports condemned the then common practice of presenting short term courses in physics, chemistry, astronomy, geology, botany, zoology, and physiology and recommended full year courses in fewer sciences. The first real science sequence came about as a result of these reports. The proposed sequence was: First year, physical geography; second year, biology; third year, physics; and fourth year, chemistry.

Contrast this sequence with one of the proposed sequences made by a group of today's educators during a recent conference held for the purpose of discussing mathematics and science education in U.S. public schools.[3]

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[2] Op. cit.

[3] American Association of School Administrators, Mathematics and Science Education in U.S. Public Schools, Circular No. 533, 1958, United States Office of Education. Washington, D.C., pg. 78.

Grade	Slow	Average and Science-shy	Science-prone
9	All took General Science in undifferentiated classes		
10	General Biology	Biology	Honors Biology
11	Physical Science or	Chemistry	Honors Chemistry
12	Earth Science	Physics	Honors Physics

The science-prone also had the free choice of additional independant (project type) laboratory research work for three years. The definition of the term 'science-prone' combines the concept of superior intelligence with the profound desire to do sustained and productive research.

Physical science and earth science for the 'slow' students embody the basic principles of physics and chemistry, but on a level designed to accommodate their understanding. Their attitudes and general understandings toward science are considered to be far more important than theories through which these attitudes are gained.

It would be well to note that this type of program was recommended by the committee for use in high schools that have a large enrollment. However, there was no mention in the recommendations as to the numerical enrollment of the specific groupings mentioned, i.e., large schools, medium schools, and small schools. Since there is no guideline, it may be worthwhile for the author to use two examples that are mentioned later in the chapter as guides to understanding the general designations set up by the committee. The working examples are Forest Hills High

(N.Y.) (3000 students) and Garden City High (N.Y.) (1100 students) which are large schools compared to the schools sampled in this study. For the purpose of this paper, it is assumed that a large high school should have an enrollment of at least 1000 students, a medium-sized high school from 500 to 999, and a small-sized high school up to 499. These categories will help the understanding of the various restrictions that this committee has placed on this program.

It is suggested by the proponents of the previously mentioned program that medium-sized schools (500 to 999 students) may find the diversity of offering of the program impractical. Two 'tracks', one designed for the 'slow' student and one for the combination of average and 'science-prone,' are recommended and that the especially talented be further encouraged through differentiated assignments, special tutorial sessions, and science club work.

In the small schools (10 to 499) the problem of diversity of offerings becomes acute since the slow, average, and the science-prone are generally assigned to the same classes. Even greater responsibily for diversification falls upon the individual teacher. Hence, in small schools, there is slight chance of such a program.

There is an other concept of the sequence of science courses in high schools that was mentioned at a 1958 conference on mathematics and science in U.S. high schools by Reuben G. Gustavson, President of Resources for the Future, Inc., that deserves much consideration and merits further study. Mr. Gustavson states:[4]

> "Let us look at biology, for example. What is the current method of approaching the biological problem, not only in our colleges, but in our high schools as well? Well, we have general science; and then we take biology. Biology is the most complex of the subjects; it has the largest number of variables, it is the field in which prejudice plays the largest part. This is where we take the young scientist and start him. Why not have chemistry in the tenth grade with its relatively simple mathematics? The sixth grade mathematics will serve exceedingly well. Nothing much beyond that. If you can tell how many oranges you can buy for one dollar if they are twenty cents per dozen, you can work most high school chemistry problems and most of the problems that you get in the freshman course in college as well. -- You could do that at the tenth grade level; the concepts are not difficult. Then in the junior year, let us suppose, you taught physics. By then you have had greater preparation in mathematics to deal with the problems. Then in the senior year, let us suppose that you taught biology, not only from the standpoint of classification of morphology, of hammering away at some of the concepts of evolution, which are perfectly fine concepts to hammer on. But because of the fact that the battle in evolution was fought something like a hundred years ago is no sign that you keep drumming on it forever, teaching comparative anatomy and all that sort of thing. The new day in biology -- and there is a tremendously important new day on the horizon --- is the use of tools of physics and chemistry and mathematics to understand the biological problem. There is no question in the minds of a great many very competent persons that the next great area of research will be in the biological field. Yet statistics will show that the kind of persons going into the field (I mean in terms of their training) are those who have avoided the very tools that the future will show are necessary if we are going to make any progress in solving the problem."

In chemistry problems, the most difficult mathematical process used is that of proportion which any ninth grade student in mathematics must surely have mastered by the end of the year. The most difficult of the concepts in chemistry lie in the

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[4]Gustavson, Reuben G., Science in Tommorrow's World. Mathematics and Science Education in U.S. Public Schools., Circular 533, U.S. Office of Education, Washington, D.C. 1958

theoretical material dealing with the actions of the various compounds and elements involved in the study itself. Biology is certainly not a necessary pre-requisite course upon which the concepts of chemistry can be based. There is every reason to assume the contrary because the complex body processes can be better understood, not only through firm, basic understanding of the chemical process involved, but also through knowing basic fundamentals that are taught in high school physics courses as well. Some examples of biological processes that can be better understood by understanding chemistry, are the processes of digestion, mastication, assimilation, respiration, circulation of the blood, cell manufacture and construction, the composition of certain foods, testing of foods for nutrients, and many other processes of the body. A study of physics could explain more clearly the process of osmosis, nerve actions, etc. There is sufficient reason for educators to take a thorough examination of the current sequence-of-study and to attempt to reorganize this sequence for the most efficient use of the student mind.

Course Content in High School Chemistry -- Whereas many educators have applied their efforts to an attempt to reorganize sequence of science study in the high school, others have given much attention to course content. At the Conference on Mathematics and Science Education in U.S. Public Schools held in 1958, Mr. Gustavson states:[5]

> "The high school chemistry course should be one which the college course can build upon and the college course should build upon. High school chemistry should emphasize basic principles and a fundamental body of knowledge. High school chemistry should not emphasize the practical. In both chemistry and physics we should help the student get the answers to his own questions. We should not merely document what he already knows."

In much the same trend of thought, Strong and Wilson[6] cite two comments recurring in recent writings concerning the effective relationship between college and high school chemistry courses:

> (1) care should be taken to avoid wasteful repetition between the two courses, and (2) performance in freshman college chemistry appears to be little influenced by whether or not the student has had high school chemistry. This latter statement seems to imply that the standard high school chemistry course is ineffective as a basis for more advanced work."

Reference was made about the inadequacy of textbooks in science by the 1958 conference in this manner:[7]

> "Over the past quarter of a century textbooks in science have become encyclopedic because of the accelerated pace at which new knowledge has been discovered and because of the rapid advances in technology. New topics and applications have been added with little thought of removing material that has become obselets. Some new concepts have been neglected."

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[5]Gustavson, Reuben G., Summary and Resolutions, op. cit. pp. 25-26

[6]Strong, Laurence E. and Wilson, M. Kent, "Chemical Bonds: A Central Theme for High School Chemistry" Journal of Chemical Education Vol. 35, February 1958 page 56

[7]Gustavson, Reuben G., Summary and Resolution op. cit. pp 25-26.

Mr. Bowen C. Dees also at the conference noted that:[8]

> " -- many high-school students learn nothing from the 'cookbook experiments required in science courses and that there is a real need, not to do away with science laboratories, but rather to re-examine the functions of such laboratories and the experiences they provide."

One example of a conference that took the discussion of course content as the main theme was the Reed College Conference[9] at which fifteen high school teachers and eighteen college teachers discussed the subject. This Conference did not arrive at any concrete answers to the problem of duplicity between college and high school chemistry courses, but did make one proposal that offers a way forward toward the achievement of clarity and simplicity in high school chemistry and at the same time provides a basic preparation for future courses:[10]

> "It was agreed that a good high school chemistry course ought to have a quality of intellectual integrity that can be communicated to the student and that this could be achieved by having a focus toward which most of the discussion could be directed. If a course for high school students could be devised with a central theme less broad than the whole of chemistry, but including the major paths by which a chemist proceeds in his dealings with chemical phenomena, then it ought to be possible to produce a reasoned argument for the topics to be included or excluded, the order of presentation, and the points at which individual variation might most readily be introduced."

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[8]Dees, Bowen C., Facilities and Useful Teaching Aids op, cit. pg. 17

[9]"The Reed College Conference on the Teaching of Chemistry.," Journal of Chemical Education (February 1958) 35: 54-55.

[10]Strong, Laurence E. and Wilson, "Chemical Bonds; A Central Theme for High School Chemistry.," op. cit. pp. 56-57.

> "A major differentiating aspect between chemistry and other branches of natural philosophy is the concept of chemical bonds. Indeed, the making and the breaking of these ties between atoms is chemistry. Our proposal is that "Chemical Bonds" is the logical central theme for a meaningful high school course."

Since there is limited space at this point it is sufficient to say that this entire course concept concentrates upon explaining the basic principles of chemistry through the action of chemical bonding.

Despite the proposal of the Reed College Conference that "Chemical Bonds" be adopted as the central theme of the high school chemistry course, the Conference made an effort to formulate the fundamental content of a high school course. The outline of content covers recommended Class Room Instruction, Laboratory Instruction, and Examples of Minimum Level of Treatment. At this point, it was felt that the objectives for a high school chemistry course formulated by this Conference should be mentioned as a guideline in comparing the findings of this study with that of current thought. These objectives are listed below:[11]

1. To present the basic principles of chemistry as an intellectual discipline and to achieve an appreciation of chemistry as a creative pursuit of human knowledge.
2. To develop facility in analytic, critical thinking -- especially thinking which involves logical and quantitative relationships.

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[11] op. cit.

3. To develop scientifically literate citizens through an understanding of (a) the methods of science and (b) the role of chemistry in society and everyday living.

4. To stimulate interest in chemistry, to identify promising students, and to provide adequate preparation for further scientific studies.

Report of the New England Association of Chemistry Teachers[12] On December 8, 1956, the Association revised the minimum syllabus that it had set up in 1939. The required section of the syllabus was divided into two parts: Part I, Descriptive Chemistry; and Part II, General Chemistry. Part III, Supplementary Topics includes subjects that are important but not essential. This part was presented for teachers who had additional time for gifted students.

The NEACT made certain recommendations:[13]

> "-- that individual laboratory work, including preparation of gases, quantitative exercises, and ionic reactions should be an essential part of the course. At least one double laboratory period each week should be assigned to laboratory work and four single periods to classroom discussions and demonstrations."

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[12] "A Minimum Syllabus for a College Preparatory Course in Chemistry" New England Association of Chemistry Teachers, Journal of Chemistry Education (June 1957) 34:307

[13] Report of the New England Association of Chemistry Teachers op. cit. pg. 307.

Laboratory Work With Non-Accelerated Students--In a study in which he attempted to learn the benefits gained from out enriched investigative experiences as contrasted with regular lecture, demonstration, and classical laboratory work, Lucow[14] divided accelerated pupils and non-accelerated pupils into two sections each. One accelerated and one non-accelerated section were given the enriched course which he named laboratory-centered groups; the other two (one accelerated and one non-accelerated) groups were given the regular course which he called the textbook-centered groups. He found that the accelerated groups did equally well with the textbook centered course as with the laboratory-centered on a 'criterion examination.' He found that the non-accelerated pupils did better according to the spread of scores of the examination with the laboratory-centered course than those having had the textbook centered course. The implication for this study being that all chemistry courses should have some laboratory work and that the non-accelerated classes benefit most by laboratory work.

Clubs and Extra-Curricular Science Activities -- In most schools administrators and supervisors utilize extra-curricular activities as a means of stimulating pupil participation and initiative in learning. The advantages of clubs over regular classroom procedures have been stated by McKown:[15]

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[14]Lucow, William H. "Learning of High School Chemistry," The Science Teacher. (November 1955) XXII pp. 283-285

[15]McKown, H.C., School Clubs, MacMillan Co., New York, 1929.

"The Club offers the pupil an opportunity for specialization which he does not have in the classroom. In the classroom his work is formal, in the club it is informal; in the classroom he is told what to do, in the club he does what he chooses; in the classroom his method of dealing with the topic is clearly outlined by teacher imposed restrictions, in the club program the method is of his own devising; in the classroom he tries to please the teacher, in the club he works for his own and his club's interests and for the joy of doing his work; in the classroom he conforms to a system, in the club he suits his own convenience. In short, the club represents freedom and expression where the classroom represents conformity and repression."

The science clubs in the public school serve a definite purpose in that they may be the means for the accelerated and science-prone pupil to enrich his knowledge of science and also do individual experimentation within his own interests. This is especially true of small-sized and middle-sized high schools where a diversity of course offerings is particularly difficult to achieve.

Webb[16] has compiled a list of clubs that seem to be most popular with students. The most popular of these are listed in the order of their popularity.

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[16] Webb, H.A., "Some First-Hand Information Concerning Science Clubs," School Science and Mathematics, XXIX: 273-276, 1929

Types of Science Clubs

1. General Science
2. Chemistry
3. Physics
4. Biology
5. Nature
6. Radio
7. Astronomy
8. Photography
9. Experiments
10. Aviation
11. Birds
12. Botany
13. Current Science
14. Meteorology

The investigation further stated that these clubs held meetings both during and after school. Out of two hundred clubs poled, fifty per-cent held meetings during school and fifty per-cent held meetings after school. It is the author's candid opinion that where vital and effective clubs are active there is activity both in and outside the framework of the school day.

Class Enrollment in Chemistry -- Brown and Obourn in a study conducted for the U.S. Department of Health, Education, and Welfare[17] reported that the average enrollment in chemistry classes was 22.6 pupils as a national average. In a further and more recent study these same authors found 46.2 percent or, the highest percent of schools reporting, stated that the average class length in minutes was in the 55-59 minute range.[18] The next most common reported durations were the 50-54 range and the 45-49 range with 24.0 percent and 19.0 percent, respectively. Less than 1 percent reported a length of period greater than 60 minutes

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[17]Brown, Kenneth E. and Obourn, Ellsworth S., "Offerings and Enrollments in Science and Mathematics in Public High Schools, 1956", U.S. Department of Health, Education, and Welfare, Office of Education., Washington, U.S. Government Printing Office, Reprinted 1958 pg. 20, (Pamphlet 120)

[18]Brown, Kenneth E. and Obourn, Ellsworth S., "Qualifications and Teaching Loads of Matics and Science Teachers in Maryland, New Jersey and Virginia," U.S. Department of Health, Education and Welfare, Office of Education, U.S. Government Printing Office, Washington, D.C., Circular 575, 1959, pg. 86.

and only 10.6 percent between 40 and 44. Class length then in most cases, was between 55 and 60 minutes.

Implications for this Study -- From the previous information given in these studies and citations, certain implications as to the form and content of a standard high school chemistry course peculiar to the needs of today's schools are quite clear. According to this particular set of information, a current chemistry program should:

1. Be presented in a proper sequence so that its basic fundamentals add to the pupil's growing understanding of science phenomena in his environment and not duplicate or confuse it.

2. Be presented as early as the tenth, but surely by the eleventh grade.

3. Be designed in levels of content so that the slow, average, and science-prone student may proceed at the level most suited to his ability to understand.

4. Be designed so that, whenever possible, pupils are homogeneously grouped according to their science ability.

5. Be designed so that the science-prone may have an extra enriched program of study.

6. Be basic and fundamental in course content and not practical in nature.

7. Be a course that college chemistry can build upon.

8. Be provided with texts that emphasize basic principles and theory without being encyclopedic in nature.

9. Be presented in such a manner as to provide proper sequence of learning in correlated subjects.

10. Be presented as a 'central theme' subject, e.g. chemical bonds.

11. Be provided with laboratory experiences for all classes, even the applied or general classes.

12. Have at least one double period laboratory per week in which the pupils perform experiments designed for student experiences in the scientific method of discovery, research and deduction.

13. Have more than one double laboratory period provided for the college preparatory classes and the science-prone.

14. Have periods of between fifty to sixty minutes in duration per single period.

15. Have enrollment of approximately 23 pupils per section.

16. Have ample club or extra-curricula activities for students with special science interests and ample opportunities for these students to exhibit or demonstrate their special talents or projects.

Whereas the suggestions listed above are based partially on actual study and, partially on the suggestions of outstanding educators, each of the foregoing suggestions points the way toward a more efficient science program. Obviously, there is still much to be done and it is the purpose of this thesis to compare the standing of certain schools in Massachusetts with the preceeding features.

CHAPTER II

OUTLINE OF PROCEDURE

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Statement of the Problem -- This thesis has a triple purpose: (1) to gather and set down in proper statistical form data concerning the chemistry curricula in operation in a selected group of Massachusetts high schools, (2) to compare each facet of their programs with criteria set forth by the author and substantiated by the suggestions of other contemporary writers on the subject, and (3) to make any summations or suggestions that seem to be an evident result of that comparison.

A check list type of questionnaire was sent to seventy-five high schools throughout Massachusetts. The questionnaire and letter of transmittal were sent to the Head of the Department of Chemistry in each of the respective schools. A sample questionnaire and letter of transmittal are included in Appendix 1 and 2. Little attention was paid to any special sampling except that, in order to get a complete cross-section, it was felt necessary to send the queries to approximately the same numbers of large, medium-and small-sized schools. The text of this study is based on the resulting replies made by the forty-eight schools out of the original seventy-five schools that were queried.

A list of the schools answering the questionnaire is included in Appendix 3.

How the Questionnaire was Constructed -- The purpose of this problem was that of collecting data concerning the current chemistry curricula in Massachusetts schools and the most promising way to do that was through the use of a check-list type of questionnaire. The questionnaire was so constructed as to obtain answers to specific questions with the least amount of literary effort on the part of the respondant. The wording was simple and sufficient choice of responses for complete coverage of all possible answers was provided. In one case in which there was a variety of answers dealing with three types of chemistry classes, a special block was constructed for more ease in furnishing answers. Attention was paid to sequence so that all allied material was grouped together. Finally, the questionnaire was not long enough to make its completion by the respondant a tedious task.

Much effort went into the construction of the final copy of the questionnaire. Not only did a list of questions have to be designed to give a pattern of responses that would present a complete educational picture of each school program, but, also, a list of practical experiments had to be compiled, assayed as to fitness for use, and then culled to fit the brevity of the questionnaire.

Numerous laboratory manuals were consulted until the list of laboratory experiments followed closely the general concept of the ideal high school chemistry course that correlated to the general criteria set up in the problem.

The questions were grouped according to a reasonable set of categories: general organization of the chemistry curriculum, equipment and facilities, extra-curricular activities based on the science program, new or advanced training programs, and the list of experiments performed.

Assumptions and Limitations -- In attempting a project such as this, the author must make certain assumptions: (1) that the data gained is a true sampling, (2) that errors in the reporting by each school are at a minimum, and (3) that the questions and responses give an accurate picture.

Since this project was designed very carefully in order to eliminate any or all of these errors, if possible, it is the author's staunch belief that the errors incurred through any of the above factors are negligible in their effect upon the accuracy of the final report.

There are, however, certain limitations that must be reported at this time. It was not the author's intention to obtain a voluminous amount of data since the quality of the reporting was of far greater import. Certain schools, in not reporting as completely as possible limited the usefulness of their reports.

There are also certain areas of exploration in the current program in chemistry that do not lend themselves to complete examination and evaluation. Complete information about such areas would have to be gathered by direct contact or by an extraordinarily long and tedious questionaire. Both of these methods would necessarily lead to few or devious reportings.

Such areas are: teacher qualifications, science library facilities, and the amount and type of chemical equipment.

This study was further limited in that it was based on an objective type of questionnaire which does not, fundamentally, lend itself to the obtaining of any complete picture of the various programs and innovations of the representative schools. Some schools that have introduced, or plan to introduce new chemistry programs were not able to give a complete enough description of them. In most cases, even though all were asked to send descriptive literature concerning these innovations, only two of the 48 responding sent any material. Hence, the value accruing from the study of these programs is lost to this report. At the least, it can be reported that such programs are in operation in some schools and various others are envisioning some future changes.

Thus, the results given here should be considered only as a contribution to whatever fund of knowledge there is about the current chemistry curricula in secondary schools in Massachusetts.

Lastly, the conclusions in the study are based on the assumption that the information given in the individual reports was substantially correct.

CHAPTER III

ANALYSIS OF THE QUESTIONNAIRE MATERIAL ON THE CHEMISTRY PROGRAM

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Number of Replies -- As shown in Table I, although an attempt was made to get equal representation from each of the large, medium and small-sized schools, the largest number of replies came from the large-sized schools (27) and next largest from the small-sized schools (10) while the least number was received from the medium-sized schools (9). One of the reasons for this may be that some of the smaller schools have become regional schools and therefore may have slipped into the larger classification. The classifications were made as follows: large schools, enrollment above 1000 pupils; medium schools, enrollment of 500 to 999; small schools, enrollment up to 499. Only two schools, of the forty-eight reporting, failed to report their total enrollment and, therefore, their responses were of limited use.

Number of Teachers Teaching at Least One Chemistry Class -- According to Table I, the number of teachers teaching at least 1 section of chemistry per day ranges from a high of seven at Springfield Technical High School to a low of one in the large high school range. In the medium range of high school, the high is four at Northampton High School and the low of one is shared by six other high schools. Out of the group of nine high schools in this range of size, only Walpole with two teachers and North Adams with three have more than one teacher of

TABLE I

List of Large-Sized Schools in Order of Size, Total Enrollment, Number of Teachers, Student-Teacher Ratio, Year Offered.

School	Total Enrollment	Number of Chemistry Teachers	Student-Teacher Ratio	Year Taken
Fall River	3000	4	26	11 or 12
Lowell	3000	5	25	11 or 12
Boston Latin	2400	3	29	11
New Bedford	2300	5	26	11
Somerville	2200	5	20	11
Springfield Tech.	2100	7*	25	11 or 12
Cambridge Latin	2000	3	24	11
Medford	1900	3	26	11
Pittsfield	1900	3	28	11 or 12
Malden	1800	3	25	11
Revere	1700	2	35	11
Framingham	1700	2	24	11 or 12
Taunton	1600	3	24	11
Haverhill	1590	2	25	11
Melrose	1475	1*	27	11 or 12
Gloucester	1400	2	25	11 or 12
Salem	1400	2	35	11
Natick	1400	2	24	11 or 12
Needham	1400	2	24	11 or 12
Fitchburg	1350	1*	24	11 or 12
Beverly	1250	4	25	11
Hyde Park	1200	2	30	11
Roslindale	1200	1	35	11
Winchester	1200	2	22	10, 11 or 12
Waltham	1150	3	25	11 or 12
Holyoke	1100	2	30	11 or 12
Wachusett Region.	1100	2	20	11

chemistry. In the small high school range only Tatasqua Regional has two teachers of chemistry and the rest have one. This is to be expected in the case of small high schools because of the relatively small enrollment in chemistry. The median number of teachers in the large school is two, the median number for the medium-sized schools is one, and that of the small schools is one. Perhaps a better way to compare the large, medium and small schools in this aspect is by dividing the number of teachers of chemistry in each school into the total enrollment. This would give a figure which would be common ground for easy comparison. This figure will be referred to as enrollment per teacher.

In the large schools, the median enrollment per teacher is one teacher for every 615 students in total enrollment, the median enrollment for the medium-sized schools is one teacher for every 510 students, while in the small schools the median drops to one teacher for every 360 students. The overall median for this figure is one teacher for every 550 students enrolled, i.e., taking a comparison of all schools disregarding size groupings. It would seem by comparison that the smaller-size schools have the advantage of a better teacher-pupil ratio. Taking the information given for student-teacher ratio in each of the Tables I, II, and III, this does seem to be the case. The median for the large school teacher-student ratio is 24.4 pupils per teacher; the median for the medium-sized school teacher-student ratio is 24.4; and the median for the small-sized school teacher-student ratio is 20.0. Whereas the median teacher-student ratio for the small school differs by 4.4 students the difference is not so great as the enrollment per teacher medians would tend to indicate. The overall student-teacher ratio for the forty-eight, 24.1, is 1.5 pupils more than the 1956 national average class size[1] which was given as 22.6. In a similar study done by Brown and Obourn involving a sampling taken in Virginia, Maryland and New Jersey,[2] the average class size was 23.7 or 0.4 of a pupil less than the class average found in this study. In taking the individual states in this study, however, Massachusetts ranks higher than Virginia (21.3 pupils) and New Jersey (22.7 pupils) but lower than Maryland (28.7 pupils). The authors of this study report that: "The average class size in small-and medium-sized high schools was well below the national class average but in the large-sized high schools it was well above."[3]

In the comparison of small-sized high schools with medium- and large-sized high schools, in this study made by the author, it was found that the small-sized high schools (20.0 pupils)

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[1]Brown, Kenneth E. and Obourn, Ellsworth S., "Offerings and Enrollments in Science and Mathematics in Public High Schools in 1956.," U.S. Department of <u>Health, Education, and Welfare</u>., U.S. Government Printing Office, Washington Pamphlet 120. 1958. pg. 20

[2]Brown, Kenneth E. and Obourn, Ellsworth S., "Qualifications and Teaching Loads of Mathematics and Science Teachers in Maryland, New Jersey and Virginia.," <u>U.S. Department of Health, Education, and Welfare, Office of Education., U.S.</u> Government Printing Office, Washington, D.C., Circular 575, 1959, pg. 90

[3]*op. cit.*, pg. 24

ranged below the national class average, while both medium- and large-sized high schools (24.4) ranged above. This would seem to make this study disagree with that of Brown and Obourn[4] but it actually does not because these authors designated small high schools at 10 to 199 pupil enrollment, the medium high schools at 200 to 499 pupil enrollment, and the large schools at 500 and beyond. This study places small schools at 10 to 499 which includes both the small and medium high schools of the Brown and Obourn study. The medium and large high schools in this study then would compare with the enrollment of the large schools in the study of Brown and Obourn. (medium-500 to 999, large schools 1000 and beyond). To sum up the findings of this study regarding average class enrollment, the large schools in Massachusetts have the larger average class enrollment in chemistry and the small schools have the smaller. This compares with the findings of Brown and Obourn in their study.

Year in Which Chemistry is Offered -- In the large schools in Table I, every one of the schools offered chemistry in the eleventh grade, 13 of the 27 offered chemistry in either the eleventh or tweleveth grades, and only one school (Winchester) reported that it is offered in the tenth as well as the eleventh or twelveth. The eleventh grade appears with the greatest frequency in the large schools.

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[4]*op. cit.*, pg. pg. 22

TABLE II

List of Medium-and Small-Sized Schools in Order of Size, Total Enrollment, Number of Teachers, Student-Teacher Ratio, Year Offered.

School	Total Enrollment	Number of Chemistry Teachers	Student-Teacher Ratio	Year Taken
		Medium-sized Schools		
North Adams	920	3	28	11
Northampton	800	4	25	11 or 12
Agawam	800	1	22	11 or 12
Westfield	700	1	26	12
Greenfield	630	1	20	11
Longmeadow	560	1	27	11 or 12
Walpole	540	2	26	11
Dennis-Yarmouth	520	1	25	12
Adams	500	1	22	12
		Small-sized Schools		
Turners Falls	490	1	24	11
Amherst Region	425	1	23	12
Great Barrington	400	1	20	11
Pioneer Valley	385	1	15	11 or 12
Duxbury	380	1	15	0
Williamstown	360	1	15	12
Tatasqua Region.	333	2	16	11
Frontier Region.	325	1	30	12
Narragansett	250	1	25	11
South Hadley	130	1	0	11 or 12
Foxborough	*	1	15	11
Gardner	*	1	22	11

* no figure given by respondant

In Table II, only three schools offer the course in the eleventh or twelfth, three offer the course only in the eleventh, and three offer the course only in the twelfth grade. Chemistry seems to be most frequently offered in the eleventh year in the medium-sized high schools.

In the smaller schools only two schools offer chemistry in the 11th or 12th grades while six of the schools out of twelve offer the course in the 11th grade and three out of the twelve offer chemistry in the 12th grade. It seems that the small schools favor the eleventh grade for chemistry.

Out of the forty-eight schools reporting, forty-six of the schools mention the 11th grade as a grade in which chemistry is offered. The two previously mentioned sequences of science courses (Forest Hills High (N.Y.) -- 11th grade and Garden City (N.Y.) -- 10th grade for the science-prone, 11th grade for the college preparatory, and 12th grade for the slow), it seems that there is a diversity of opinion. It is the studied opinion of the author that the most important and best grade to give chemistry is the tenth grade. The argument for this opinion has been previously given in Chapter I.

<u>Standardized Material Content for All Chemistry Classes</u> -- Fifteen of the large schools answered that the chemistry material content was standardized for all classes, while 12 out of the 27 answered that the content of the various classes differed. Out of the nine medium-sized schools reporting, eight reported having their material content of the course

standardized and one reported that the course content was different for the various courses.

Standardized Achievement Tests -- When queried about the use of a standardized achievement test, 15 of the 27 large schools replied that they did; 5 of the 9 medium-sized schools replied to the affirmative and 6 out of 12 of the small schools answered yes to the question. Slightly less than fifty per cent of the forty-eight schools polled on the question replied that they do not use standardized achievement tests.

Types of Science Clubs Reported -- Table III lists the various activities that the schools maintained. It would be well to note that upon examination of the contents of Table III that much of the variety of activities and the greater frequence of occurrence favor the larger high school offerings. It must also be noted that the clubs or activities having the greater popularity are the ones that are not specialized in nature of offering, e.g., Science Fair, Science Club, etc. It is only natural that these activities would attract pupils of diversified talents and also include other clubs of a specialized nature wherever there is a scarcity of sponsors or lack of sufficient membership to warrant forming a separate club. It is assumed that this is a condition existing particularly in the smaller-sized schools.

Only two of the large schools, three of the medium-sized schools and one of the smaller-sized schools failed to list any type of extra-curricular activities in science.

TABLE III

List of Activities in Large-, Medium-, and Small-sized Schools according to frequency of Occurrence.

Activity	Large Schools	Medium Schools	Small Schools
Science Fair	15	3	7
Science Club	15	2	7
Photography Club	8	4	2
Chemistry Club	0	0	4
Biology Club	2	1	0
Meteorology Club	2	0	0
Science Seminar	2	0	0
Radio Club	1	1	1
Engineering Club	1	0	0
Radiation Club	1	0	0
Rocket Club	1	0	0
Science-Math Club	1	0	0
Laboratory Club	1	0	0
No Clubs	2	3	1

<u>Types of Chemistry Courses</u> -- Tables IV, V, VI, and VII list the various schools and their course offerings and the information concerning them. College preparatory courses are listed in Tables IV and V, while the applied, general, or nurses are covered in Table VI and the accelerated course is displayed in Table VII. All the schools reported at least one section in college preparatory chemistry. Fifteen of the large-sized schools out of the total twenty-seven reporting were conducting programs in general, applied, or nurses' chemistry courses for a percentage of 50.5 per cent. Only two out of the nine medium-sized schools reported any type of general or

TABLE IV

College Preparatory Chemistry Classes in Large Schools, Number of Sections per Day, Duration of Lecture and Laboratory Periods in Minutes

School	Total Enrollment	Sections per Day	Average Size	Periods per week Lecture	Duration of Lecture Period	Laboratory Periods per Week	Duration of Laboratory Periods
Fall River	3000	6	26	5	55	2	120
Lowell	3000	4	25	5	55	5	55
Boston Latin	2400	4	29	4	50	1	100
New Bedford	2300	14	26	2	42	2	84
Somerville	2200	14	20	4	43	1	90
Springfield Tech.	2100	19	25	5	42	#	42
Cambridge Latin	2000	4	24	4	45	3	45
Medford	1900	10	26	4	40	1	80
Pittsfield	1900	10	28	4	50	1	50
Malden	1800	6	25	4	42	1	42
Revere	1700	4	35	5	*	@	@
Framingham	1700	8	24	*	53	#	53
Taunton	1600	6	24	4	45	1	90
Haverhill	1590	5	25	4	45	2	90
Melrose	1475	4	27	4	55	1	60
Gloucester	1400	4	25	3	50	2	90
Salem	1400	2	35	4	50	1	50
Natick	1400	7	24	4	40	1	80
Needham	1400	7	24	4	44	1	52
Fitchburg	1350	3	24	4	40	1	40
Beverly	1250	9	25	4	50	1	100
Hyde Park	1200	3	30	4	40	2	40
Roslindale	1200	5	35	*	*	1	45
Winchester	1200	8	22	3	50	2	50
Waltham	1150	8	25	4	44	2	100
Holyoke	1100	3	30	3	43	2	80
Wachusetts Reg.	1100	6	20	4	52	2	52

\# no scheduled laboratory, optionally scheduled by teacher.
@ no scheduled laboratory, scheduled after school for a selected few.
* not given by the respondant.

TABLE V

College Preparatory Chemistry Classes in Medium and Small Schools, Number of Sections per Day, Duration of Lecture and Laboratory Periods in Minutes and Average Class Size.

School	Total Enrollment	Average Class Size	Sections per Day	Lecture Periods per Week	Duration of Lecture Period	Laboratory Periods per Week	Duration of Laboratory Periods
	Medium-sized Schools						
North Adams (Drury)	920	26	4	6	45	1	90
Northampton	800	25	5	7	40	2	80
Agawam	800	22	3	5	42	2	84
Westfield	700	26	5	4	42	1	42
Greenfield	630	20	3	3	55	2	55
Longmeadow	560	27	2	3	55	1	85
Walpole	540	26	2	4	50	2	50
Dennis-Yarmouth	520	25	2	5	40	4	40
Adams	500	22	2	5	52	2	50
	Small-sized Schools						
Turners Falls	490	24	2	5	45	#	45
Amherst Region	425	23	3	4	50	1	100
Gr. Barrington	400	20	2	4	50	3	50
Pion. Valley Reg.	385	15	2	3	50	4	50
Duxbury	380	15	2	4	50	1	100
Williamstown	360	15	2	5	40	1	40
Tatasqua Reg.	333	16	3	3	60	1	120
Frontier Reg.	325	30	1	4	40	1	80
Narragansett	250	25	1	5	45	#	45
South Hadley	130	*	3	4	50	5	50
Foxborough	*	15	2	2	30	4-5	45
Gardner	*	22	3	4	45	2	45

optional scheduling done by individual teacher
* no figures given by respondant.

applied courses which is only 22.2 per cent of the schools reporting. Out of the 12 small schools reporting, five of them mentioned that they conducted general courses in chemistry. This was 24.0 per cent of the schools reporting. It would seem that the medium-sized schools, due to their greater variety of courses in chemistry for the needs of the average student than the small schools.

Ten of the twenty-seven large schools reported classes designed to take care of the interests of the science-prone student. This is 37.1 per cent of the number reporting. The majority of the schools reported only one such class as indicated in Table VII, column 3. The exceptions are Lowell (8 sections per day), Pittsfield and Framingham (each having listed three sections per day).

Of the medium-sized schools, only Longmeadow reported having any type of accelerated classes. This is only 11.1 per cent of the medium-sized schools that reported.

None of the small schools reported having any type of advanced work in chemistry. It is to be expected that the small schools would have few or no forms of accelerated work because of the small enrollment and also because of the heavy and varied teaching load of the small school science teacher. It is hoped that the small schools provide for the needs of the science-prone student through the various science extra-curricular activities, where his special talents may lead him into productive work.

TABLE VI

Applied, and General Chemistry Classes in all Schools, Number of Sections per Day, Duration of Lecture and Laboratory Periods in Minutes, and Average Class Size.

School	Total Enrollment	Average Class Size	Sections per Day	Lecture Periods per Week	Length of Lect. Per.	Lab. Per. per Week	Length of Lab. Per.
	Large-sized Schools						
Fall River	3000	30	8	5	55	0	0
Lowell	3000	25	6	4	55	1	55
Somerville	2200	20	2	3	43	1	90
Springfield Tech.	2100	25	8	5	42	#	42
Cambridge Latin	2000	25	5	5	45	#	45
Pittsfield	1900	28	1	4	50	1	50
Malden	1800	25	3	4	42	1	42
Revere	1700	35	1	5	*	@	@
Haverhill	1590	20	1	5	45	2	45
Gloucester	1400	25	2	4	50	0	0
Salem	1400	30	2	4	50	1	50
Hyde Park	1200	30	2	3	40	2	40
Waltham	1150	25	1	5	44	0	0
Holyoke	1100	30	2	5	43	0	0
Wachusetts Reg.	1100	16	1	5	52	0	0
	Medium-sized Schools						
North Adams	920	28	3	5	45	0	0
Walpole	540	20	2	5	50	0	0
	Small-sized Schools						
Turners Falls	490	30	1	5	45	0	0
Amherst Reg.	425	15	2	5	50	0	0
Narragansett	250	20	2	5	45	0	0
South Hadley	130	0	2	4	50	0	0
Gardner	0	16	1	4	45	2	45

n.b. # none assigned, optionally planned by teacher.
@ laboratory held after school for a selected few.
* no response to question.

TABLE VII

Accelerated Chemistry Classes in all Schools, Number of Sections per Day, Average Class Size, Duration of Lecture and Laboratory Periods in Minutes.

School	Total Enrollment	Average Class Size	Sections per Day	Lecture Periods per Week	Length of Lect. Per.	Lab. Per. per Week	Length of Lab. Per.
	Large-sized Schools						
Lowell	3000	25	8	3	55	2	55
Boston Latin	2400	22	1	4	50	1	100
New Bedford	2300	20	1	2	42	2	84
Medford	1900	26	3	4	40	1	80
Pittsfield	1900	14	3	4	50	3	50
Revere	1700	27	1	*	*	@	@
Framingham	1700	20	1	5	53	#	53
Salem	1400	25	1	4	50	2##	50
Needham	1400	12	1	3	44	2	42
Fitchburg	1350	18	1	4	40	1	80
	Medium-sized Schools						
Longmeadow	560	14	1	3	55	1	85
	Small-sized Schools						
None mentioned.							

n.b.
- * no response to question.
- @ Laboratory held after school for a selected few.
- # none assigned, optionally planned by teacher.
- ## scheduled after school.

Percent of Students Enrolled in Chemistry.--The enrollments in college preparatory, applied and accelerated classes in chemistry for each school is given in Tables VIII and IX. These tables also show the total enrollment for each school in addition to the percent of students enrolled in the chemistry course.

In the large-sized schools, Springfield tops the list with 32.1 per cent reported enrolled in chemistry courses. The next highest are: Waltham, 19.6 per cent; Pittsfield, 18.4 per cent; and Beverly, 18.0 per cent. The large per cent shown enrolled at Springfield Technical (32.1) is more than likely due to the fact that this school specializes in students that are interested in taking such subjects. It neccessarily follows that there would be a higher percentage of students taking a course in chemistry. Other schools such as Waltham (19.6 per cent), on the other hand, must necessarily deal with a greater variety of student needs. Therefore, the high percentage of pupils enrolled in chemistry courses in Springfield Technical will not be considered as a trend, only as a commendable example.

Perhaps the lowest figure of 5.8 per cent could be considered a case in the opposite extreme, i.e., that this school represents more of a liberal arts type of school. The median of the larger schools in percentage enrollment in chemistry is 12.5.

TABLE VIII

Per Cent of Total Enrollment of Large-sized High Schools Enrolled in Chemistry, Enrollment of College Preparatory, Applied, and Accelerated Classes.

School	Total Enrollment	College Preparatory Enrollment	Applied Enrollment	Accelerated Enrollment	Total Chemistry Enrollment	Per Cent
Fall River	3000	136	240	0	376	12.5
Lowell	3000	100	150	200	450	15.0
Boston Latin	2400	116	0	22	138	5.8
New Bedford	2300	364	0	20	384	16.7
Somerville	2200	280	40	0	310	14.1
Springfield Tech.	2100	475	200	0	675	32.1
Cambridge Latin	2000	96	125	0	221	11.0
Medford	1900	260	0	78	338	17.7
Pittsfield	1900	280	28	42	350	18.4
Malden	1800	150	75	0	225	12.5
Revere	1700	140	35	27	202	11.9
Framingham	1700	192	20	0	212	12.5
Taunton	1600	144	0	0	144	9.0
Haverhill	1590	125	20	0	145	9.2
Melrose	1475	108	0	0	108	7.3
Gloucester	1400	100	50	0	150	10.7
Salem	1400	70	60	25	155	11.1
Natick	1400	168	0	0	168	12.0
Needham	1400	168	0	12	180	12.9
Fitchburg	1350	72	0	18	90	6.8
Beverly	1250	225	0	0	225	18.0
Hyde Park	1200	90	60	0	150	12.5
Roslindale	1200	175	0	0	175	14.6
Winchester	1200	176	0	0	176	14.7
Waltham	1150	200	25	0	225	19.6
Holyoke	1100	90	60	0	150	13.6
Wachusetts Reg.	1100	120	16	0	136	12.6

TABLE IX

Percent of Total Enrollment of Medium-and Small-sized Schools Enrolled in Chemistry, Enrollment in College Preparatory, Applied and Accelerated Classes.

School	Total Enrollment	College Preparatory Enrollment	Applied Enrollment	Accelerated Enrollment	Total Chemistry Enrollment	Per-cent
Medium-sized Schools						
North Adams	920	94	56	0	150	16.3
Northampton	800	125	0	0	125	15.6
Agawam	800	66	0	0	66	8.3
Westfield	700	130	0	0	130	18.6
Greenfield	630	60	0	0	60	9.5
Longmeadow	560	54	0	14	68	12.2
Walpole	540	52	40	0	92	17.0
Dennis-Yarmouth	520	50	0	0	50	9.6
Adams	500	44	0	0	44	8.8
Small-sized Schools						
Turners Falls	490	48	30	0	78	15.9
Amherst Reg.	425	69	30	0	99	23.3
Gr. Barrington	400	40	0	0	40	10.0
Pion. Valley Reg.	385	30	0	0	30	7.8
Duxbury	380	30	0	0	30	7.9
Williamstown	360	30	0	0	30	8.3
Tatasqua Reg.	333	48	0	0	48	14.4
Frontier Reg.	325	30	0	0	30	9.3
Narragansett	250	25	40	0	65	26.0

For the medium-sized schools, Westfield with 18.6 percent enrolled in chemistry is the top percentage while the lowest is 8.3 percent. The median for the medium-sized schools is 12.5 per cent of the total enrollment enrolled in chemistry.

In the small-sized school group, Narragansett is high with 26.0 per cent enrolled in chemistry while the low is only 7.8 per cent enrolled in chemistry. The median percentage for the small-sized schools is 10.5.

The overall median for all the schools reporting is 12.4 per cent.

College Preparatory Lecture Periods per Week -- Of all the schools polled, the most common number of lecture periods per week in college preparatory chemistry regardless of size was four. Twenty-five schools reported four lecture periods per week, nine schools reported five lecture periods per week, seven reported three lecture periods per week, one reported having seven and one reported having six lecture periods per week.

The median duration of the lecture period in minutes was found to be 45 minutes for the entire sample. Five of the schools reported having 55 minute lecture periods and only one reported having 30 minute lecture periods. Twenty-six of the schools reported having lecture periods of 45 minutes or longer duration. One school reported three, 60-minute lecture periods per week which is quite unusual.

TABLE X

Comparison of Total Duration of College Preparatory Lectures and Laboratory in Minutes per Week.

School	Total Lecture	Total Lab	School	Total Lecture	Total Lab
		Large-sized Schools			
			Melrose	220	60¢
Fall River	275	240**	Gloucester	150	180**
Lowell	275	275	Salem	200	50
Boston Latin	200	100**	Natick	160	80**
New Bedford	84	168**	Needham	176	52
Somerville	172	90**	Fitchburg	160	40
Springfield Tech.	210	#	Beverly	200	100**
Cambridge Latin	180	135	Hyde Park	160	80**
Medford	160	80**	Roslindale	*	45
Pittsfield	200	50	Winchester	150	100**
Malden	168	42	Waltham	176	200**
Revere	*	@	Holyoke	129	160**
Framingham	*	#	Wachusetts Reg.	208	104**
Taunton	180	90**			
Haverhill	180	180**			
		Medium-sized Schools			
North Adams	270	90**	Longmeadow	165	85¢
Northampton	280	160**	Walpole	200	100
Agawam	210	168**	Dennis-Yarmouth	200	160
Westfield	168	42	Adams	260	100
Greenfield	165	110			
		Small-sized Schools			
Turners Falls	225	*	Williamstown	200	40
Amherst Reg.	200	100**	Tatasqua Reg.	180	120**
Gr. Barrington	200	150	Frontier Reg.	160	80**
Pion. Valley Reg.	150	200	Narragansett	225	#
Duxbury	200	100**	South Hadley	200	250

* not given by respondant
** double periods
\# optionally scheduled as needed.
@ Scheduled after school for a few
¢ not a double period, but extended.

The best method of comparing lecture time devoted to the study of chemistry is that of comparing the total time allotted during the week to this subject. Table X shows this total time given over to the lecture period per week and compares the total time in each of the responding schools according to their respective size.

Northampton reported the largest amount of time allotted to the lecture period (280 minutes), two other schools vie for next highest (275 minutes), Fall River and Lowell. The lowest reported number of lecture period minutes per week was 84 minutes. Three of the schools did not give this information and are not recorded. The median number of minutes allotted to lecture per week is 200 for this sampling.

College Preparatory Laboratory Periods -- In this phase of the course the number of laboratory periods were reported in Tables IV and V as the following: Three schools reported having up to five laboratory periods per week, one school reported as many as four per week, two reported three per week, fifteen reported two per week, twenty-one reported one per week, four schools reported that laboratories were not scheduled regularly but only at the teacher's discretion, and one school reported that the period or periods were scheduled after school for a selected few.

This information is not a good indication of the comparable laboratory activities of the various schools because it does not indicate the amount of time devoted to this very necessary phase of chemistry. Table X gives a much clearer picture of this phase by displaying the total number of minutes devoted to the laboratory per week. Twenty-two of the forty-six schools run double laboratory periods. Many of those schools reporting only one or two laboratory periods have this type of schedule which is considered more effective than the single laboratory period.

The highest number of minutes per week was reported by Lowell (275) and the lowest reported was 40 minutes per week. The median for the schools is 100 minutes per week devoted to laboratory work. The interquartile range includes the numbers from 80 to 168. Two schools, Longmeadow and Melrose submitted durations for the laboratory that were longer than their regular periods. Melrose extends the laboratory period from 55 to 60 minutes while Longmeadow extends the regular period by 30 minutes to 85.

In summation of this phase of the chemistry course, it is well to note that 48 per cent of the schools have double laboratory periods. Fifteen of those schools having the double laboratory period are in the large school group. It would also be interesting to note that in a comparison of time spent per week on lecture and the time spent per week on laboratory is revealed to be in the ratio of two to one in favor of the lecture period. The median for the total lecture time is 200 minutes and that of the laboratory is 100 minutes.

TABLE XI

Comparison of Total Duration of Applied Chemistry Lectures and Laboratory in Minutes per Week.

School	Total Lecture	Total Lab	School	Total Lecture	Total Lab
		Large-sized Schools			
Fall River	275	0	Haverhill	225	90
Lowell	220	55	Gloucester	200	0
Somerville	129	**90	Salem	200	50
Springfield Tech.	210	#	Hyde Park	120	80
Cambridge Latin	225	#	Waltham	220	0
Pittsfield	200	50	Holyoke	215	0
Malden	168	42	Wachusetts Reg.	260	0
Revere	*	@			
		Medium-sized Schools			
North Adams	225	0	Walpole	250	0
		Small-sized Schools			
Turners Falls	225	0	South Hadley	200	0
Amherst Reg.	250	0	Gardner	180	90
Narragansett	225	0			

** double laboratory period
# none assigned, optionally planned by teacher.
@ laboratory held after school for a selected few.
* no response to the question.

Applied or General Lecture Periods -- As shown in Table VI, thirteen schools reported four lecture periods per week, and two schools reported only three lecture periods per week. Out of 48 schools replying to the questionnaire, only 22 reported some kind of general course for the average student. This represents only 46.0 per cent of the schools in this survey. The most commonly occurring number of lecture periods per week is 5.

Two schools (Fall River and Lowell) reported the greatest duration of the lecture period of 55 minutes. The lowest duration of lecture was 40 minutes. Only one school in the table made no response to the question on the duration of the lecture period. The median for the entire group replying to the question was 45 minutes duration for the lecture period.

As with the college preparatory classes, perhaps the better way to make a proper comparison is through the comparing of total minutes devoted to lectures per week. The school that has the highest total of minutes of applied lecture is Fall River with a total of 275, while the lowest was 120 minutes per week. Only one school failed to furnish information concerning lecture period duration time. The median total time devoted to lectures in the applied courses per week is 220 minutes.

Applied Laboratory -- Only eleven of the twenty two schools that present applied chemistry, offer any type of laboratory. Twenty-two schools represent about 46.0 per cent of the total

TABLE XII

Comparison of Total Duration of Accelerated Chemistry Lectures and Laboratory in Minutes per Week

School	Total Lecture	Total Lab	School	Total Lecture	Total Lab
	Large-sized Schools				
Lowell	165	110	Revere	*	@
Boston Latin	200	100**	Framingham	265	#
New Bedford	84	168	Salem	200	100**
Medford	160	80	Needham	132	84
Pittsfield	200	150	Fitchburg	160	80**
	Medium-sized Schools				
Longmeadow	165	85¢			
	Small-sized Schools				
none mentioned					

n.b. ** double laboratory period
no laboratory assigned, optionally planned by teacher
@ laboratory held after school for a selected few.
* no response made to the question
¢ not a double period, but extended.

sample. Out of this group of 22 schools that offer applied chemistry only 50.0 per cent offer laboratory to accompany the lectures. Springfield Technical and Cambridge Latin are two of those that offer a laboratory class in the applied course, but the laboratory is only scheduled when considered necessary by the teacher. There is only one school in which the applied laboratory is held after regular school hours for a selected few. Somerville is the only school in this group that has a double period laboratory. The highest total laboratory working time of 90 minutes is scheduled at Somerville and Haverhill and the lowest is 42 minutes. The median for the total laboratory time is 55 minutes.

Accelerated Chemistry Lecture -- In Table VII, Framingham is the only school with five lecture periods per week which is high for this type of course. There are five schools that have four lecture periods per week. Three of the schools schedule three lecture periods per week for the accelerated group and only one schedules two periods per week. The median class period duration for the lecture period in the accelerated course is 50 minutes. The highest total time spent in lectures per week in accelerated courses is at Framingham which devotes 256 minutes per week to lectures for advanced work. The lowest total lecture minutes per week is only 84 minutes divided between two lectures. The median total time spent in lectures in advanced classes per week is 165 minutes. Revere mentioned having one section of accelerated students but made no response as to the number of lectures per week and the time allotted to that end.

Accelerated Chemistry Laboratory -- In Table VII the number of accelerated laboratory periods and durations of periods are shown. In Table XII the total lecture time per week and the total laboratory time per week are compared. Pittsfield has the highest number of laboratory periods per week with three. There are four schools that have two laboratory periods per week and four schools that have only one period per week. Framingham has no laboratory periods assigned in the accelerated group but they are held at the option of the teacher. Salem has two laboratory periods but these are reported scheduled after school. Revere reports that the laboratory is scheduled after school for a selected few.

New Bedford is the school reporting the highest total time allotted to laboratory work in the accelerated group with 168 minutes. The lowest total time reported was 80 total minutes. The overall median is 100 minutes. Three out of the ten schools reporting accelerated courses have double laboratory periods scheduled. One of the schools has its laboratory period extended 30 minutes. None of the small schools that responded to the questionnaire mentioned accelerated classes.

To sum up the facts concerning the accelerated course program, 11 schools out of 48 reported some type of honors or accelerated program for a percentage of 22.9. In these classes a total of 165 minutes per week is dedicated to lecture and demonstration or class work while 100 minutes per week is allotted to

TABLE XIII

Method of Pupil Experimentation in Large-, Medium- and Small-sized Schools According to Type of Class.

Method of Experimentation	Large Schools			Medium Schools			Small School			Total
	C.P.	Appl.	Acc.	C.P.	Appl.	Acc.	C.P.	Appl.	Acc.	
1. Pupils singly	13	2	6	2	0	0	3	1	0	27
2. Pupils by pairs	7	5	1	5	0	0	5	1	0	24
3. Pupil demonstration	3	1	1	1	0	0	0	0	0	6
4. Teacher demonstration.	3	5	2	3	0	0	2	2	0	17
5. Majority by pairs, few by pupil demonstration.	1	0	0	1	0	0	1	0	0	3
6. Majority by pairs, few by teacher demonstration	5	1	1	3	0	0	2	0	0	12
7. Majority singly, few by teacher demonstration	5	3	2	0	0	0	3	1	0	14
8. No formal experiments performed	0	1	0	0	2	0	0	0	0	2
9. By fours	0	0	0	0	0	0	1	1	0	2

laboratory work. Out of the 11 schools reporting accelerated programs, only three reported double period laboratory periods for a percentage of 27.2.

Method of Experimentation -- Table XIII shows the methods of student experimentation in the different types of classes in the various sized schools. The table indicates that in the college preparatory course in the large schools, the largest number of responses (13) indicates that most of the large schools attach great importance to the concept of solitary experimentation for college preparatory students. The last column on the table gives a comparison of the popularities of the various methods by totaling all responses assigned to each method. The method of experimentation most common to all schools and to all types of classes was the conduction of laboratory experiments by the single student. The next most often mentioned method, a close second, was the method of paired experimenters. Teacher demonstration ranked third. The method of letting students do most of the required experiments singly and having the most difficult or dangerous ones demonstrated by the teacher ranked fourth. A close fifth in number of responses was the method of allowing the students to work out most of the experiments in pairs and having the teacher demonstrate the most difficult or dangerous ones. Sixty-two responses showed complete student domination over the experiment while fourty-three responses showed some form of teacher domination or teacher control of the experimentation. Only three responses indicated no formal experimentation and this was only true in the applied or general type of course.

<u>Factors Governing Choice of Experiments</u> -- Table XIV shows the various responses to the question concerning the method of choosing the experiments that the students perform in the laboratory. The two most commonly mentioned choice of experiments performed by the college preparatory pupils were 'teacher's choice' and 'departmental choice.' Teacher's choice (29 responses) was almost favored two-to-one over 'departmental choice' (15 responses). 'Teacher choice based upon pupil interest' and 'text book choice' ranked a low third with only six responses in favor of these methods. 'Pupil choice' received only four favorable responses. One school reported that college preparatory students were given experiments chosen on the basis of college entrance requirements. Another school mentioned that their choice of experiments was based on the philosophy of the department and the course material coverage. It was the intention of this study to assume that experiments, despite the method of choosing, were chosen so as to represent in the laboratory the material covered in the lecture phase, and also in this particular case, college preparatory, to properly prepare the student to meet the requirements of college.

The method of choosing the experiments to be done by the pupil in the applied or general course in chemistry closely resembles the pattern of the college preparatory course. The most commonly used method is that of 'teacher choice' by almost the same ratio. The indication here, however, is that the teacher exercises a slight bit more control over the choice of experiments to be done. 'Departmental choice' ranks second with almost one-half as many responses. 'Teacher choice

TABLE XIV

Method of Choosing Pupil Experiments by Type of Course

Method of Choosing	College Preparatory	Applied	Accelerated	Total of All
1. Departmental Choice	15	4	3	22
2. Textbook Choice	6	1	0	7
3. Teacher Choice	29	9	5	43
4. Pupil Choice	4	0	2	6
5. Teacher Choice Based on Pupil Interest	6	3	4	13
6. Other (State)				
a. College Entrance Requirements	1	0	0	1
b. course content	1	0	0	1

based upon pupil interest' ranks third with one-third as many responses as many as complete teacher choice.

In the accelerated laboratory course there are almost twice as many responses for 'teacher choice' as for 'departmental choice.' There is a decided change in the ratio between 'teacher choice' and 'teacher choice based upon pupil interest' and also 'pupil choice.' According to ratios of the number of responses, pupils in the accelerated courses are given more control over the type of experiments that they do in the class than the students in the other types of classes.

Frequency of Individually Initiated and Executed Experiments -- In the college preparatory classes the responses of all schools grouped together report that 'few' experiments are student initiated and executed in the school year. The number of 'frequent' responses was nearly one-half the number of responses reported for 'few.' The number of responses for 'none' was slightly less than one-third the number of responses for 'few.'

In the applied courses, as it is to be expected, there were no responses in the 'frequent' column. The responses in the 'few' and 'none' columns are nearly equal in number, the advantage being in the 'none' column by one response.

In the accelerated classes 'frequent' student initiated and executed experiments was the most common response as was expected. There are twice the number of responses for 'frequent' as for 'none' and three times the number of responses for 'frequent' as for 'few.'

In summation, it is apparent that few experiments are initiated and executed by the college preparatory student, few or none are initiated and executed by the applied students, and in the accelerated classes most of the respondants indicated that students frequently initiated and executed their experiments.

Number of Experiments Performed During the Year -- Figure I shows the relationship between the number of schools and the number of experiments completed in college preparatory classes during the year. It shows that 12.5 per cent of the schools reported doing 50 experiments in a year. The next highest number of experiments done was 40 which 16.7 per cent of the schools reported. Twelve of the schools reported having done 30 experiments which was 25.0 per cent of the schools reporting.

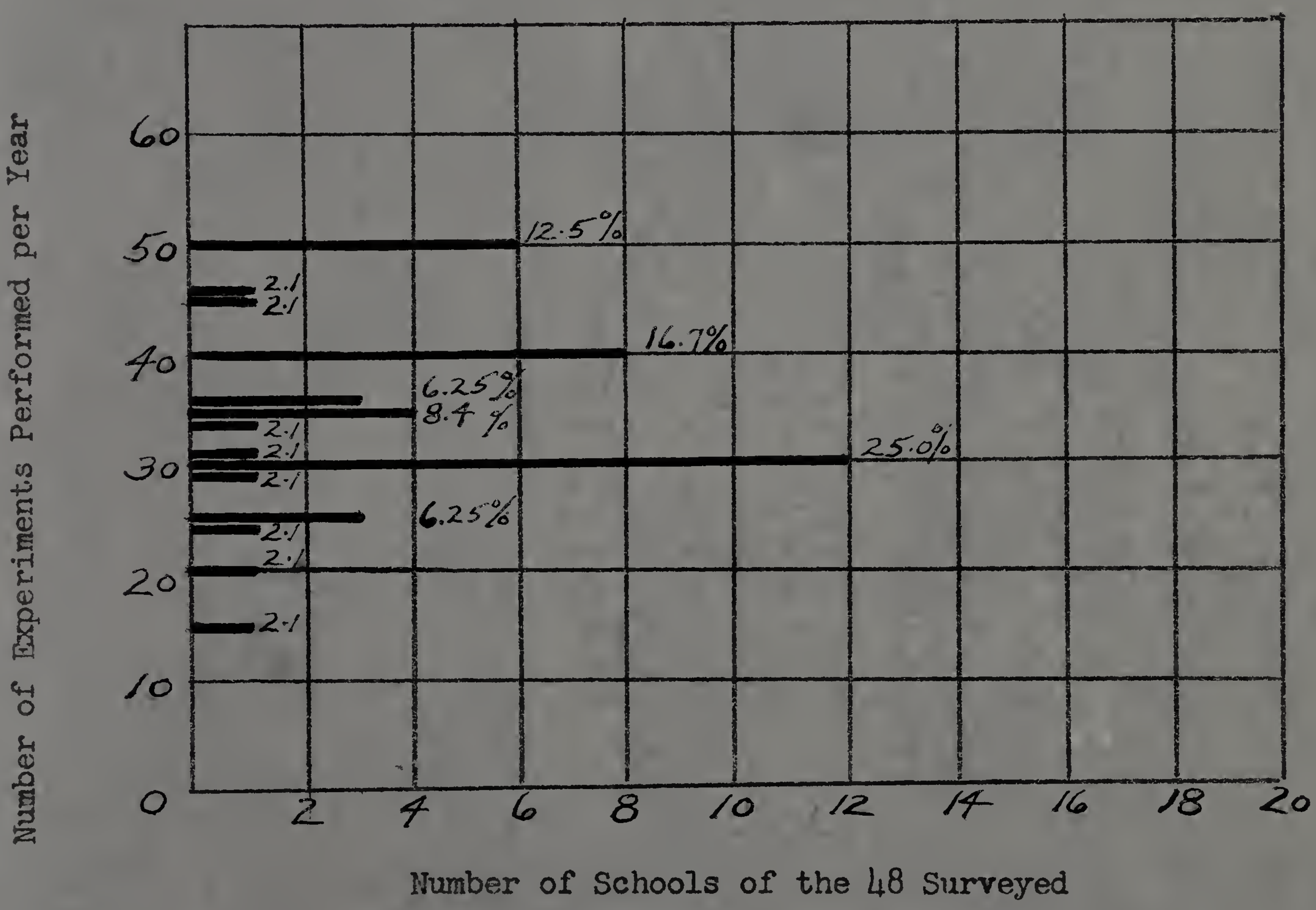

Figure 1. Number of Experiments Performed per Year in College Preparatory Chemistry in All Schools Scheduling This Course.

Over 80 per cent of the schools reporting stated that their college preparatory students completed 30 or more experiments during the year. No school reported scheduling less than 15 experiments per year. Less than 15 per cent of all the schools reported less than 30 experiments completed during their school year.

In Figure 2 the number of experiments done per year in applied courses in schools giving that type of course are shown. One school reported having performed 50 experiments during the year for a percentage of 7.2. Four schools out of the fourteen schools reporting on this course stated that only 15 ex-

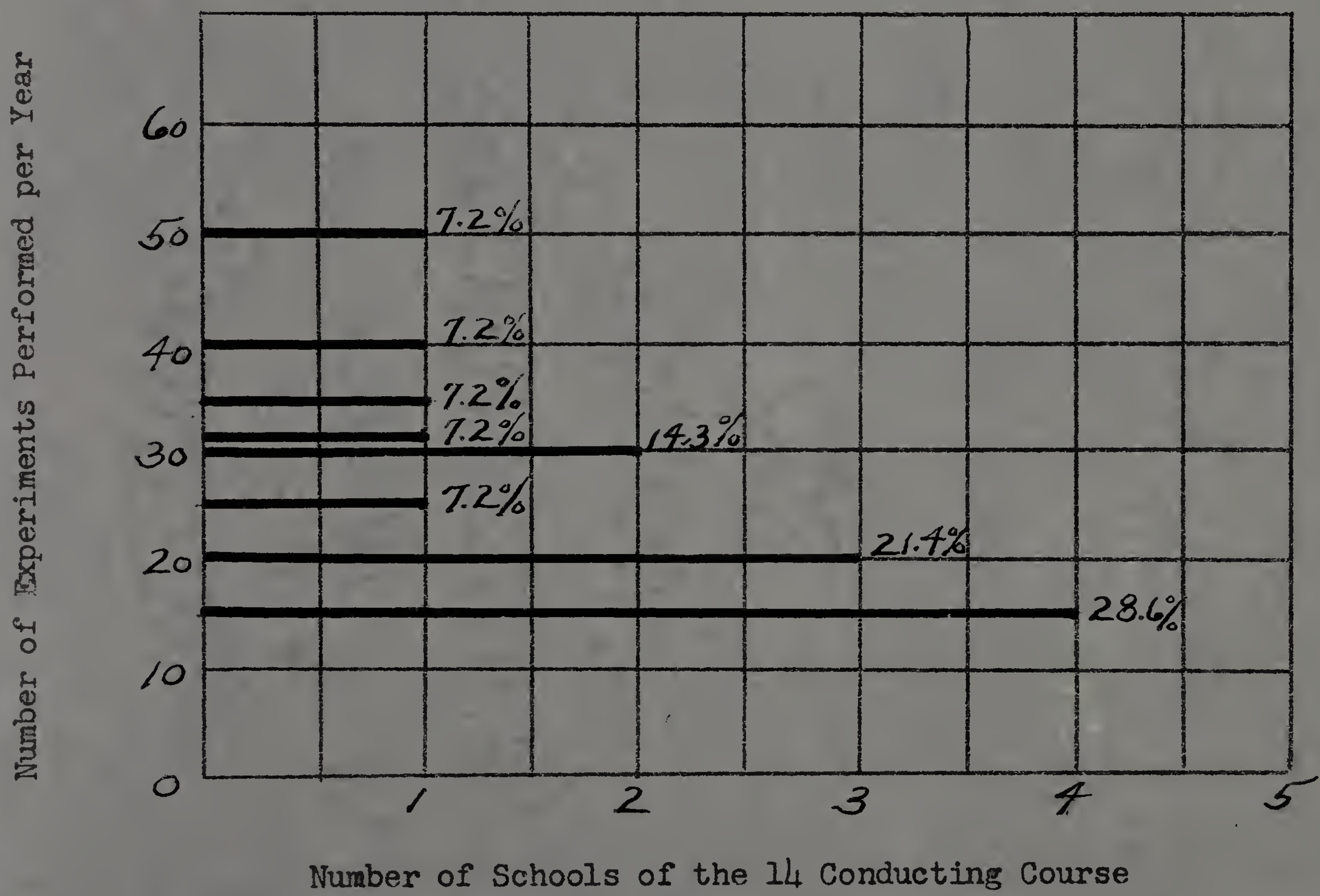

Figure 2. Number of Experiments Performed per Year in Applied Chemistry in 14 Schools Scheduling This Course.

periments were performed during the year. This was 28.6 per cent of the schools. Three schools (21.4 per cent) reported performing only 20 experiments. Approximately 57.2 per cent of the schools conducting applied courses reported that less than 30 experiments were performed per year. This is quite the opposite of the situation in the college preparatory chemistry courses.

In Figure 3. the number of experiments performed per year in accelerated courses is shown along with the number of schools reporting. As can be seen in this chart the majority

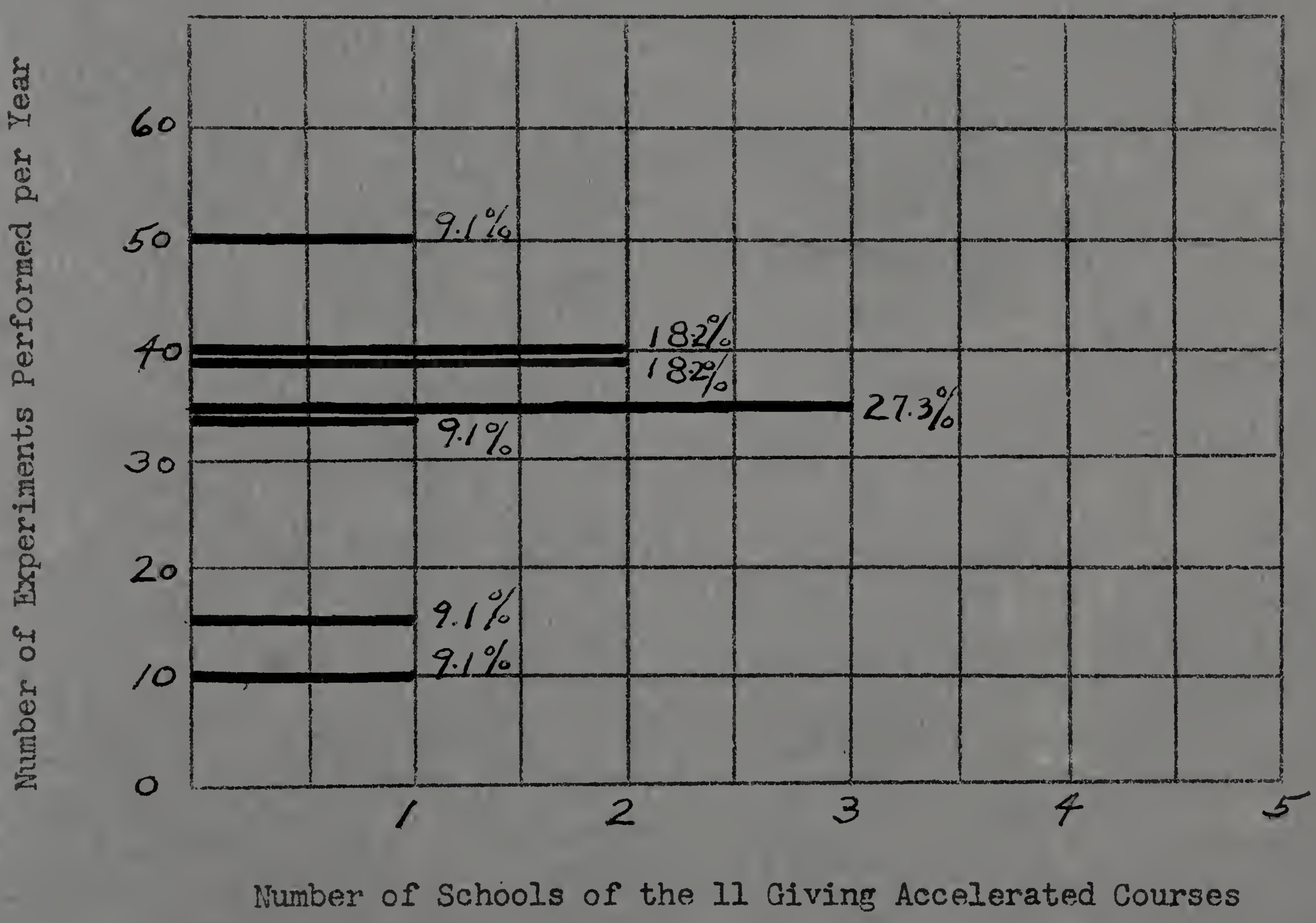

Figure 3. Number of Experiments Performed per Year in Accelerated Chemistry in 11 Schools Scheduling this Course.

of schools (approximately 82 per cent) reported that more than 30 experiments are performed during the year. One school reported only 15 experiments performed and one school reported only 10. The explanation here is that these were long-term experiments involving multiple phases. These were experiments that were student-initiated and student executed. The fact that these students performed even 10 experiments of this type is somewhat of an extraordinary feat. Most of the advanced or enriched courses for the science-talented students cover material that is comparable to the first-year college level.

It is to be observed in summing up this data that the college preparatory course and the accelerated course are, in most schools, given the benefit of larger numbers of experiments. The greater percentage of schools reported in these two courses that over 30 experiments performed per year was common practice. In many cases those schools reporting applied or general courses reported that laboratory was not even offered.

<u>Percent of Schools Doing Certain Experiments</u> -- Table XV shows the experiments listed by the responding schools as the ones most frequently done in their laboratories. The experiments are listed according to the percentage of schools completing them. This table shows that the most frequently used experiments are the classic experiments which cover the standard textbook material. The extraordinary and the more difficult and dangerous are reportedly used by the smallest percentage of the schools. Some of the schools reported that some of the experiments were used for demonstrational purposes. It is the opinion of the author that such demonstrations when

TABLE XV

Experiments Listed According to the Percentage of Schools Performing Them.

Percent of Schools Performing	No.	Name of Experiment
100	7.	Mixtures and Compounds - separations and changes in properties.
	10c.	Chemical Decomposition - electrolysis of water.
	11.	Preparation and Properties of Oxygen.
	12.	Preparation and Properties of Hydrogen.
	15.	Distillation of Water.
	24.	Single and Double Displacement Reactions.
	28.	Properties of Acids and Bases.
	51.	Sulfur and Sulfides.
98	4.	Preparing Glass Tubing for use in Actual Experiments.
	6.	Changes in Substances Heated in Air.
	8.	Use of Litmus and Indicators.
	25.	Conductivity of Solutions.
	32.	Neutralization of Acids by Bases.
96.0	9.	Use of the Bunsen Burner.
	10a.	Chemical Decomposition - heating of HgO, CuO, ZnO, and FeO.
	21.	Valence and the Writing of Formulas.
	22.	Writing and the Balancing of Equations.
	26.	Double Displacement Reactions That Go to Completion.
	42.	Test for the Chloride Ion.
	58.	Ammonia and Ammonium Hydroxide.
93.8	17.	Water of Crystallization in Crystals.
	27.	Hydrolysis of Salts.
	65.	Carbon Dioxide.
91.8	16.	Solution and Crystallization.
	10b.	Heating of $Pb(NO_3)_4$.
	18.	Percentage of Water of Hydration.
	23.	Synthesis and Analysis Reations.
	34.	Titrating an Acid by a Base.

(continued on next page)

TABLE XV (continued)

Percent of Schools Performing	No.	Name of Experiment
	36.	Replacement of Metals from Compounds by More Active Metals.
	55.	Test for the Sulfate Ion.
	3.	Measurements in the Metric System.
87.5	5.	Physical Properties of Common Substances - color, solubility, density, etc.
	44.	Preparation of Iodine.
	46.	Flame Tests.
85.5	14.	Chemical Properties of Water.
	20.	Structure of the Atom and Atomic Diagrams.
83.4	62.	Preparation of Nitric Acid.
	29.	Acid and Basic Anhydrides.
81.3	30.	Preparation and Properties of Hydrogen Chloride and Hydrochloric Acid.
	52.	Hydrogen Sulfide.
79.3	41.	Preparation of Chlorine.
	53.	Sulfur Dioxide and Sulfurous Acid.
77.1	64.	Carbon
	13.	Percent of Oxygen in Air.
75.0	31.	Preparation of Some of the Common Bases.
	43.	Preparation of Bromine.
73.0	38.	Ferric and Ferrous Compounds - tests for the ions, etc.
70.0	37.	A Laboratory Study of the Activity and Properties of Metals.
68.8	33.	Preparing Normal, Molar, and Percent Solutions.
66.6	59.	Ammonium Compounds.
	60.	Nitric Oxide and Nitrogen Peroxide.
64.6	45.	Borax Bead Tests and Cobalt Nitrate Tests.

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TABLE XV (continued)

Percent of Schools Performing	No.	Name of Experiment
	63.	Tests for the Acid Radicals.
62.6	72.	Preparation of Soap.
60.4	48.	Identifying Lead, Mercurous, and Silver Salts.
	19.	The Composition and Formula of a Compound by Synthesis of It.
	56.	Nitrogen.
56.3	57.	Composition of Air.
	66.	Baking Powders.
	71.	Preparation of Esters.
52.1	35.	Percentage of Acid in Vinegar Using Common Bases.
	47.	Sodium and Potassium Compounds.
43.8	39.	Extraction of Metals from their Ores.
	40.	Electroplating.
	70.	Preparation of Ethanol by Fermentation.
	54.	Preparation of Sulfuric Acid.
39.6	61.	Nitrous Oxide.
	67.	Chemical Fire Extinguisher.
37.5	2.	Measuring Relative Volumes of Standard Flasks.
	73.	Fats, Carbohydrates, and Proteins.
35.4	77.	Percentage of Acetic Acid in Vinegar.
33.4	68.	Carbon Monoxide.
29.2	69.	Carbon in Living Things.
	85.	Removal of Spots and Stains from Fabrics
25.0	49.	Identifying Textile Fibers.
	50.	Testing Foods for Nutrients.
20.8	84.	Dyeing Fabrics.

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TABLE XV (concluded)

Percent of Schools Performing	No.	Name of Experiment
18.8	83.	Comparing the Action of and Properties of Soaps and Detergents.
16.7	81.	Soil Analysis.
14.6	1.	Making a Graduated Test Tube.
12.5	76.	Preservatives and Bleaching Agents in Foods.
	78.	Adulterants in Foods.
10.4	80.	What Substances are Contained in Plant Tissue?
	82.	Mineral Content in Fertilizer.
8.3	79.	Extraction of Caffein in Coffee.
6.3	74.	Bacteria.
	75.	Testing Antiseptics.

conducted with entire class participation becomes an extremely effective instrument of learning. Since many experiments which are necessary to further student understanding are either quite complicated for normal laboratory periods or dangerous for inexperienced students, many of these lend themselves to teacher demonstration exercises.

Ability Grouping in Chemistry -- Table XVI shows the number of schools according to their size that group their students according to their scientific ability. The table shows that 11 of the large schools group their students according to their

TABLE XVI

Schools Grouping Their Students According to Ability

Response	Large Schools	Medium Schools	Small Schools
Grouped according to ability	11	3	4
No ability grouping	14	6	7
Accelerated classes only	2	0	0
At the beginning of the year, but not at the end.	1	0	0

ability while 14 large schools do not. Three of the medium schools group according to ability while six do not. In the small schools, only four use ability grouping and seven do not. One school (large) stated that it was a practice to group the classes according to ability, but during the year certain changes occurred in the scheduling and the grouping deteriorated by the end of the year. Two schools stated that only the accelerated classes were grouped according to ability other than that of normal curriculum grouping. The tendency, then, in Massachusetts high schools is slightly more in favor of not grouping their students according to ability other than normal curriculum grouping.

Methods of Selection in Ability Grouping or Accelerated Programming -- Table XVII shows the methods used in determining the students that are assigned to ability groups or accelerated classes in science. According to the table the

TABLE XVII

Methods of Selection for Ability or Accelerated Grouping

Method of Selection	Large Schools	Medium Schools	Small Schools	Total Schools
I.Q. scores	14	3	3	20
Past grades	10	2	4	16
Teacher' opinion	13	2	3	18
Achievement tests	5	2	3	10
All of the previous methods.	5	1	3	9
Parental demands	1	0	0	1
Guidance department at junior high level	1	0	0	1

most often used method of determining mental fitness of a student for ability or accelerated grouping is that of I.Q. scores. In the totals column of this table, the significant factor seems to be that I.Q. scores, past grades, and the teachers' opinion are the most frequently used methods for ability or accelerated grouping. Only five of the large schools, one of the medium schools, and three of the small schools used all of the first four methods of selection for this grouping. Most of the schools used some combinations of the three first methods. Few of the schools used only one of these methods. Only one large school mentioned that parental demands influenced the selection of students for this type of grouping. One school mentioned that a junior high school guidance department helped with the selection and arrangement of students according to ability.

Schools Taking Steps to Meet Increased Science Study Demands -- The following table shows the various responses to the question that asked whether or not the responding school was in the process of taking steps to meet the need for increased emphasis on science study. Table XVIII shows the number of responses 'yes' and 'no' according to the size of school. Twenty-one of the large schools replied that some form of program was being initiated to improve science education in their schools while only five reported that no action was going on in their schools. Only one of the large schools did not reply to the question. Of the medium schools five reported some new features and four reported none. Seven of the small schools reported some activity in the improvement of their science courses and only three reported none. More than two-thirds of the entire sampling of schools are involved in some planning

TABLE XVIII

Schools Taking Steps Toward Improvement of their Science Programs

Responses	Large Schools	Medium Schools	Small Schools	Total Schools
Course improvement	21	5	7	33
No course improvement	5	4	3	12
No response to question	1	0	0	1

to improve their science programs. Only about twenty-five per cent of the entire sampling of schools planned no form of improvement in their science offerings.

Examples of Enriched Science Study Programs

Fall River	Physical Science Study Committee Course in Physics Semi-Micro Qualitative Course in Chemistry
Lowell	Radiation Study and use of radiation equipment
Boston Latin	Student reports on recent discoveries in chemistry.
New Bedford	Enriched Physics and Chemistry classes for honor pupils
Somerville	Advanced second year chemistry for exceptional students in analytic chemistry, foods, carbon compounds, and biochemistry. (one discussion, four lab periods per week)
Springfield Tech.	Accelerated physics and biology classes, physical Science Study Committee Physics Course introduced, three years of physics given to all college preparatory, one year of biology and chemistry for college preparatory boys, all students must take one year of chemistry.
Medford	Science seminar.
Pittsfield	Honors program in grades 9, 10, and 11; advanced (college) chemistry course in grade 12.
Revere	Instituting science study in all elementary grades.
Framingham	Senior course of 1/3 year of biology, 1/3 year of chemistry and 1/3 year of physics.
Taunton	Biology on the college level (second course in biology)
Salem	Advance courses in chemistry and biology (two years); math and science-talented grouped in a special course in the first year.

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Examples of Enriched Science Study Programs (continued)

Natick	Group chemistry projects, i.e., building styrene models of atoms and ions to scale.
Needham	Introduction of an advanced placement program in chemistry.
Fitchburg	One accelerated group in chemistry with double laboratory periods and 'open-end' (continuous) experiments.
Beverly	Introduction of Physical Science Study Committee physics.
Hyde Park	Special instruction given to College Entrance Examination Board candidates; participation in Boston's Science Institute for Able Learners.
Winchester	Plans are ready to give freshman-college-level chemistry, physics, and biology; seniors do honors work projects after school on a voluntary basis.
Waltham	Honors groups have been established; advanced courses to start in the Fall of 1960.
Wachusetts Reg.	Accelerated science group started in grade 9 this year; simple qualitative analysis at the end of chemistry year.
Drury High	Double periods in all chemistry and physics (college preparatory courses; double periods possibly in biology next year (1960, Fall)
Westfield	Afternoon classes in math and science on a voluntary basis.
Longmeadow	Introduced accelerated course in chemistry.
Walpole	Accelerated Program for the 'academically talented, i.e., biology in grade 9 and an extra year of chemistry or physics.
Adams	Use of the Geiger counter and ionization chamber taught.
Amherst Reg.	Semi-Micro experiments with certain individuals.
Gr. Barrington	Considering instituting an advance chemistry course.

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Examples of Enriched Science Study Programs (concluded)

Duxbury	Next year's offerings: biology in grade 9, chemistry in grade 10, physics in grade 11, advanced science (research in grade 12).
Williamstown	Curriculum revision is in the planning stage; students are required to give class demonstrations and act as laboratory assistants.
Frontier Reg.	Added two sections of physical science and one section of general science to the offerings.
Narragansett	Re-evaluation of the science curriculum in progress.

As is shown by the preceding list of schools that are either planning innovations in their science offerings or have already made changes, it is clear to see that chemistry curriculum change is widespread and increasing among the schools of this sampling. Of the 48 schools in this sample 31 have recognized the need for some kind of revision or enrichment. Five schools are in the planning stage and 26 have already made some changes.

It is significant to note that eleven of these schools have instituted advanced chemistry courses for the science-talented student. There are various ways in which this was accomplished.

At least two schools in this group provide a senior year for science-talented students that includes advanced level physics, biology and chemistry. The year culminates with a completed project or assignment from one of these subjects. Schools using this type of enrichment work are large schools in which the 'three-track' system of science program is best maintained.

In ten other schools enrichment 'phases' are being carried on as an addition to whatever program of study is prevalent. This is a simplified version of the 'three-track' system, wherein all students generally take the same basic chemistry course while a selected few are allowed to carry on extra investigations of an advanced nature. Use of Geiger counters, radiation studies, semi-micro analysis, etc. are some examples of this type of program.

The previously listed examples show that the majority of schools in Massachusetts are either involved in one or the other of these types of programs or are in the process of inaugurating them.

CHAPTER IV

SUMMARY AND CONCLUSIONS

CHAPTER IV

SUMMARY AND CONCLUSIONS

This problem has presented data concerning the current chemistry program in a sampling of Massachusetts public high schools. The emphasis was placed upon their organizational features, functional operations, and their plans for future reorganization.

Forty-eight of the seventy-five schools that were sent the questionnaire completed it. Thirty-one of the forty-eight schools that replied to the questionnaire sent additional information concerning innovations or future reorganizational plans. All of this information has been included in the examination of the questionnaire data.

Summary and Conclusions--This study has shown that the large schools of this sampling tend to have two chemistry teachers, the medium-and small-sized schools generally have but one. The median number of chemistry teachers seems to be one chemistry teacher for every 550 pupils in total school enrollment.

The small-sized schools have the advantage in the teacher-pupil ratio. The small-sized schools having a median pupil-teacher ratio of 20.0 while the large- and medium-sized schools have a median teacher-pupil ratio of 24.4. In 1956 the national class average in chemistry was reported to be 22.6 pupils.[1] The average class size for the New England region was 23.0 pupils in this same study.

Most of the schools sampled reported that chemistry was offered in the eleventh grade and quite frequently in the twelfth. It has been previously suggested in this problem that chemistry might be offered in the tenth grade so as to become a preparation for the study of biology which the quoted author[2] stated was the most complex of the sciences. It would be well to consider this viewpoint in setting up future science sequences.

All of the schools of the sampling reported that they offered college preparatory chemistry. The national survey[3] by Brown and Obourn show that 4.8 percent of their sampling of schools offered no chemistry courses, New England had no schools that did not offer chemistry in high school.

Twenty-two of the schools of the forty-eight sampled in this problem offered courses to the non-college preparatory students and only eleven of this group of schools offered

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[1]Brown, Kenneth E. and Obourn, Ellsworth S., "Offerings and Enrollments in Science and Mathmatics in Public High Schools, 1956. U.S. Department of Health, Education, and Welfare. Washington., U.S. Government Printing Office. pp. 19 and 20. Pamphlet 120.

[2]Gustavson, Reuben G., Science in Tomorrow's World. Mathematics and Science Education in U.S. Public Schools., Circular 533, U.S. Office of Education., D.C. 1958.

[3]Brown, Kenneth E. and Obourn, Ellsworth S. op. cit.

any laboratory for the course. Lucow,[4] in his study reported that students of average ability (not science-talented) benefitted much more from laboratory work than those in the accelerated classes.

Eleven schools out of the forty-eight reported that accelerated courses in chemistry were offered in their schools for the science-talented students. All of these schools had a total enrollment of 500 students or more. It is the opinion of educators that have made a study of the needs of the science-talented student that many medium-sized schools and all the large schools could profitably institute a program for the science-talented student. It was deemed impractical for small-sized schools to attempt to institute such a program because of the extra work that this program entails.[5]

The median percent of students enrolled in chemistry for all the schools of this study is 12.4. This figure is based on the total school enrollment figures. Brown and Obourn[6] state that in 1956 only 7.5 percent of the students were enrolled in chemistry in a national survey. The schools in the sampling of this problem then exceed the national figure by 4.9 percent.

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[4]Lucow, William H. Learning of High School Chemistry.," The Science Teacher. (November 1955) XXII pp. 283-285

[5]Brandwein, Dr. Paul F., The Selection and Training of Future Scientists., Selected Science Teaching Ideas of 1952., National Science Teachers Association., Washington, D.C. 1953 pp 1-5.

[6]Brown, Kenneth E. and Obourn, Ellsworth S., op. cit. pp. 19-20

In the comparison of time spent on lecture and time spent in laboratory per week, twice as much time was spent on lecture as was spent on laboratory in college preparatory courses. Four times as much time was spent on lecture as spent on laboratory in the applied chemistry courses. Schools reporting having acelerated courses state that the time spent per week, on lecture is one and one-half as much as the time spent in laboratory. This seems to be out of phase with the findings of Lucow,[7] that the less able student profits more by laboratory work.

In this study, 22 schools reported that double periods were scheduled for laboratory work in college preparatory chemistry courses out of the 48 queried. Only one school out of the 22 having applied chemistry or a similar course reported having double periods for the laboratory. Of the eleven schools offering acelerated chemistry courses only four reported that double periods are scheduled for the laboratory work. It was suggested by the New England Association of Chemistry Teachers[8] in a report in June 1957 that double laboratory periods be instituted in courses for the gifted

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[7]Lucow, William H., op. cit. pp 283-285.

[8]"A Minimum Syllabus for College Preparatory Course in Chemistry"., New England Association of Chemistry Teachers, Journal of Chemistry Education. (June 1957) 34:307.

student. It seems only logical to this author that this be extended to include the college preparatory and applied laboratories as well, for the simple reason that experience will prove that an ordinary single period of 55 to 60 minutes duration will not provide nearly enough time for the student to prepare for his experiment, conduct it, make his deductions and conclusions, and still be able to make a reasonably accurate report of his findings. A single period makes laboratory work a discontinuous learning situation. To many students this is a frustrating experience.

The majority of the respondants to this questionnaire replied that the choice of experiments completed by the students was made by the teacher for the most part in all three types of chemistry courses. Departmental choice of experiments was the next most used method of choosing experiments.

Eighty percent of the schools in the sample reported that their college preparatory classes performed over 30 experiments per year.

Fifty-seven percent of the schools having applied chemistry courses and offering laboratory reported that less than 30 experiments were performed by these classes per year. Twenty-one percent of these schools reported that these classes performed only 20 experiments per year and 28.6 percent reported that these classes performed only 15 experiments per year.

In the accelerated courses, approximately 82 percent of the schools offering this course reported performance of over 30 experiments, 72.8 percent of these schools reported doing between 30 and 40 experiments per year.

Most of the schools sampled concurred that the most frequently performed experiments were the classic experiments, according to Table XV, which were closely related to current standard textbook coverage.

The schools were about evenly divided in their responses concerning ability grouping in their chemistry classes. Twenty-seven schools reported that they did not group their classes according to ability other than the normal curriculum grouping. Eighteen schools reported that their students were grouped according to ability in science subjects.

The methods most commonly used to determine grouping according to the student's ability were reported to be I.Q. scores, past grades, teacher's opinions, and achievement tests rated in this order.

More than two-thirds of the schools in the sampling reported that their school was planning to make or was in the process of making some course improvements or innovations in chemistry or in science. A list of these innovations has been made available in the previous chapter.

<u>Inferences</u>-- From the factual data that has been pre-

sented previously and the conclusions that have been drawn from the study of this data, it can be stated that some attempt is being made in Massachusetts to meet the demand for improvement in high school science courses,

The fact that 31 out of the 48 schools questioned are attempting to provide enrichment for their superior students is highly commendable. Another fact brought out in this study is that all the schools in this sampling have some type of chemistry course. This is not true of all sections of the United States. All of the schools in this study have at least one college preparatory course in chemistry.

It is also worthy to note that about 50 percent of the large schools have classes in non-college chemistry and about 37 percent have accelerated chemistry courses. The fact that the percentage of medium and large schools having both types of chemistry courses is not higher points out the necessity for administrative changes to correct this situation.

Twenty-two of the 48 schools in the sample reported that their laboratory periods were double periods. This is a definite improvement over the single period laboratory. It is the opinion of a few prominent educators that double period laboratories should be made available to all chemistry classes in all schools, large or small, to allow for more complete and efficient experimentation.

Most of the schools of the sampling devoted little or no time to laboratory for non-college chemistry classes. In the light of the fact that these students need more concrete application than theory, it would seem that these students, more than any others, would have to have many and frequent laboratory exercises. It is assumed, however, that the main reason for schools not providing ample laboratory experiences for the applied chemistry students is that, where there is a scarcity of schedule time and laboratory facilities, the greatest emphasis must be placed upon laboratory for college preparatory students rather than on laboratory forthe terminal students. It remains an important fact, however, that a properly conducted course in chemistry necessarily includes ample time for laboratory experiences.

BIBLIOGRAPHY

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Books

Ahner, Walter L., Amsco Laboratory Manual in Chemistry. Amsco School Publications, Inc., New York. 1952.

Auerbach and Tedesco., Laboratory Experiments in Chemistry. Republic Book Company, Inc., New York. 1947.

Brownlee, Fuller, et al., Laboratory Experiments in Chemistry. Allyn and Bacon, Inc. New York. 1957.

Dull and Brooks., Chemistry Workbook. Henry Holt and Company. New York. 1954.

Dull, Metcalf, and Williams., Chemistry Workbook. Henry Holt and Company. New York. 1958.

Eckert, Lyons, and Strevell., Discovery Problems in Chemistry. College Entrance Book Company. New York. 1950.

Heiss, Obourn, and Hoffman., Modern Science Teaching. The Macmillan Company. New York. 1950.

McGill and Bradbury., New Chemistry Guide and Laboratory Exercises. Lyons and Carnahan. New York. 1944.

McKown, H. C., School Clubs. Macmillan Company. New York. 1929.

Tuleen, Muehl, and Porter., Test It Yourself. Scott, Foresman and Company. New York. 1941.

Weaver, Elbert C., Laboratory Introduction to Chemistry. McGraw Hill Book Company. New York. 1952.

Articles

American Association of School Administrators, Mathematics and Science Education in U.S. Public Schools., Circular No. 533. 1958. United States Office of Education. Washington, D.C. pg. 78.

Brown, Kenneth E. and Obourn, Ellsworth S., "Qualifications and Teaching Loads of Mathematics and Science Teachers." U.S. Department of Health, Education and Welfare., Office of Education. U.S. Government Printing Office. Washington, D.C., 1959. Circular 575.

Brown, Kenneth E. and Obourn, Ellsworth S., "Offerings and Enrollments in Science and Mathematics in U.S. Public High Schools". U.S. Department of Health, Education and Welfare, Office of Education. U.S. Government Printing Office. Reprinted 1958. Pamphlet 120. pg. 20.

Burnett, R. Will (Ed.), Selected Science Teaching Ideas of 1952. National Science Teachers Association. Washihgton, D.C. 1953.

Lucow, William H., "A Research Study in the Learning of High School Chemistry." The Science Teacher. XXII (November 1955) pp. 283-285.

National Science Teachers Association, Science for the Academically Talented Student. National Education Association. Washington, D.C. 1959.

Strong and Wilson., "Chemical Bonds: A Central Theme for High School Chemistry." Journal of Chemical Education. (February 1958) 35:56-57.

Reed College Conference on the Teaching of Chemistry. Journal of Chemistry Education. (February 1958) 35:54-55

New England Association of Chemistry Teachers., "A Minimum Syllabus for a College Preparatory Course in Chemistry" Journal of Chemistry Education. (June 1955) 34:307- 308.

Webb, H.A., "Some First-Hand Information Concerning Science Clubs". School Science and Mathematics. XXIX: 273-276. 1929.

APPENDICES

1. Questionnaire on the Chemistry Curricula in Massachusetts High Schools.

2. Letter of Transmittal.

3. List of Cities to which the Questionnaire was Sent.

APPENDIX 1

This questionnaire is designed for the purpose of determining the type and quality of courses in chemistry that are offered to high school students in grades 11 and 12 in high schools in Massachusetts.

Please place a check (x) in the box for the most appropriate answer to the statements below as they apply to your particular program. Please disregard the instructions above whenever a number or direct answer is preferred.

1. State the approximate total student enrollment in your high school. (   ) students.

2. State the number of teachers that are teaching one or more classes in chemistry. (   ) teachers.

Does one of these teachers act as department head?

( ) yes ( ) no

3. Is your chemistry curricula standardized so that all chemistry classes in the same curriculum grouping cover the same material content? ( ) yes ( ) no

4. Is it a department policy to give standardized achievement tests? ( ) yes ( ) no

If yes, state name of test.

If yes, during what months are these given?

(   ) month (s)

5. Check the science clubs or activities that your high school sponsors. ( ) chemistry club ( ) photography club ( ) science club ( ) science fair ( ) other, please state.

6. Do local industries give aid to or show interest in any of these clubs or science activities? ( ) yes ( ) no

If given, how is it given? ( ) gifts of money ( ) gifts of equipment ( ) use of their equipment or facilities ( ) loan of professional advisors or instructors ( ) field trips.

7. Does the school furnish all the equipment and facilities needed to run these activities successfully? ( ) yes ( ) no ( ) part school, part student ( ) part school, part industry.

8. For each of the types of chemistry curricula listed, state the information necessary to complete the following table.

* Place the number of the proper response in the following table.

(1) singly, (2) by pairs, (3) pupil demonstration, (4) teacher demonstration, (5) majority by pairs, few by pupil demonstration, (6) majority by pairs, few by teacher demonstration, (7) majority by singles, few by teacher demonstration, (8) no formal experiments performed.

** Place the number of the proper response in the table below. (1) departmental choice, (2) textbook choice (3) teacher choice, (4) pupil choice, (5) teacher choice based on pupil interest, (6) state any other.

	College Prep.	Applied	Accel-erated	Other (state)
Number of sections or classes per day				
Average number of pupils in each class per teacher (pupil-teacher ratio)				
Semesters of chemistry required.				
Number of lecture periods per week.				
Average duration of of each lecture in minutes per period				
Number of lab periods per week.				
Duration of each lab period in minutes.				
Year chemistry offered? 11, 12, or other.				
Name textbooks used. Give title, author, and publisher.				
Name lab manual used, author, and publisher.				
* Method of performing experiments.				
Frequency of individually initiated and executed experiments.	( ) freq ( ) few ( ) none	( ) freq ( ) few ( ) none	( ) freq ( ) few ( ) none	( ) freq ( ) few ( ) none
** Factor governing choice of experiments done by pupils.				
Average number of experiments performed per year.				

9. Are your students grouped according to ability other than the grouping in the table above?

( ) yes ( ) no

10. If you have ability grouping or an accelerated program check the criteria used for selecting the individual members of these groupings.

( ) I.Q. scores ( ) past grades ( ) opinion of teachers
( ) Standardized achievement tests.

11. Has your high school taken any specific steps to meet the current demand for increased emphasis upon advanced science study at the high school level? ( ) yes ( ) no

If yes, please elaborate.

Any pamphlet which has been published by your school pertaining to programs of modernization of your science program would be very welcome if returned along with this questionnaire.

12. Please check the experiments that the students in your classes are required to do.

( ) 1. Making a graduated test tube.
( ) 2. Measuring relative volumes of standard flasks.
( ) 3. Measurements in the metric system.
( ) 4. Preparing glass tubings for use in actual experiments.
( ) 5. Physical properties of common substances (color, solubility, density, etc.).
( ) 6. Changes in substances heated in air.
( ) 7. Mixtures and compounds- separations and changes in properties.
( ) 8. Use of litmus and indicators.
( ) 9. Use of the Bunsen burner.
( )10. Chemical decomposition.
  a. Heating of HgO, CuO, ZnO, FeO.
  b. Heating of $Pb(NO_3)_4$
  c. Electrolysis of water.
( )11. Preparation and properties of oxygen.
( )12. Preparation and properties of hydrogen.
( )13. Percent of oxygen in air.
( )14. Chemical properties of water.
( )15. Distillation of water.
( )16. Solution and crystallization.

12. Check list of experiments (continued)

( )17. Water of hydration in crystals.
( )18. Percentage of water of hydration.
( )19. The composition and formula of a compound by the synthesis of it.
( )20. Structure of the atom and atomic diagrams.
( )21. Valence and the writing of chemical formulas.
( )22. Writing and balancing of equations.
( )23. Synthesis and analysis reactions.
( )24. Single and double replacement reactions.
( )25. Conductivity of solutions.
( )26. Double displacement reactions that go to completion.
( )27. Hydrolysis of salts.
( )28. Properties of acids and bases.
( )29. Acid and basic anhydrides.
( )30. Preparation and properties of hydrogen chloride and hydrochloric acid.
( )31. Preparation of some of the common bases.
( )32. Neutralization of acids by bases.
( )33. Preparing normal, molar, and percent solutions.
( )34. Titrating an acid by a base.
( )35. Percentage of acetic acid in vinegar using a common base.
( )36. Replacement of metals from their compounds by more active metals.
( )37. A laboratory study of the activity and properties of metals.
( )38. Ferric and ferrous compounds - tests for the ions, etc.
( )39. Extraction of metals from their ores.
( )40. Electroplating.
( )41. Preparation of chlorine.
( )42. Test for the chloride ion.
( )43. Preparation of bromine.
( )44. Preparation of iodine.
( )45. Borax bead tests and cobalt nitrate tests.
( )46. Flame tests.
( )47. Sodium and potassium compounds.
( )48. Identifying lead, mercurous, and silver salts.
( )49. Identifying textile fibers.
( )50. Testing foods for nutrients.
( )51. Sulfur and sulfides.
( )52. Hydrogen sulfide.
( )53. Sulfur dioxide and sulfurous acid.
( )54. Preparation of sulfuric acid.
( )55. Test for a sulfate ion.
( )56. Nitrogen.

12. Checklist of experiments (concluded)

( )57. Composition of air.
( )58. Ammonia and ammonium hydroxide.
( )59. Ammonium compounds.
( )60. Nitric oxide and nitrogen peroxide.
( )61. Nitrous oxide.
( )62. Preparation of nitric acid.
( )63. Tests for the acid radicals.
( )64. Carbon.
( )65. Carbon dioxide.
( )66. Baking powders.
( )67. Chemical fire extinguisher.
( )68. Carbon monoxide.
( )69. Carbon in living things.
( )70. Preparation of ethanol by fermentation.
( )71. Preparation of esters.
( )72. Preparation of soap.
( )73. Fats, carbohydrates, and proteins.
( )74. Bacteria.
( )75. Testing antiseptics.
( )76. Preservatives and bleaching agents in foods.
( )77. Adulterants in foods.
( )79. Extraction of caffeine in coffee.
( )80. What substances are contained in plant tissue?
( )81. Soil analysis.
( )82. Mineral content of a fertilizer.
( )83. Comparing properties and action of soap and detergents.
( )84. Dyeing fabrics.
( )85. Removal of spots and stains from fabrics.

13. Please list or describe any unique program of study in your chemistry curriculum not covered in this questionnaire.

The Commonwealth of Massachusetts
University of Massachusetts
Amherst

SCHOOL OF EDUCATION

May 15, 1959

Head of Chemistry Department

Dear Sir:

A graduate student in our School, Mr. Lewis M. Whitcomb, is conducting a survey study for the purpose of examining the current chemistry curricula of secondary schools in Massachusetts.

The enclosed questionnaire is his instrument for gathering material for this study. We would appreciate it very much if you would fill out this questionnaire and return it in the enclosed envelope so that a complete and representative evaluation can be made.

Thank you for your kind cooperation in this matter.

Yours truly,

Dr. Albert W. Purvis, Dean
School of Education

APPENDIX 3

List of High Schools in Massachusetts to Which the Questionnaire was Sent.

Schools Answering Questionnaire	Schools Answering Questionnaire
1. Adams	35. Salem
2. Agawam	36. Somerville
3. Amherst Regional	37. South Hadley
4. Beverly	38. Springfield Technical
5. Boston Latin	39. Tatasqua Regional
6. Cambridge High	40. Taunton
7. Dennis-Yarmouth Regional	41. Turners Falls
8. Duxbury	42. Wachusetts Regional
9. Fall River	43. Waltham
10. Fitchburg	44. Walpole
11. Foxborough	45. Westfield
12. Framingham	46. Williamstown
13. Frontier Regional	47. Winchester
14. Gardner	48. Drury (North Adams)
15. Gloucester	49. Attleboro
16. Great Barrington	
17. Greenfield	
18. Haverhill	
19. Holyoke	
20. Hyde Park	
21. Longmeadow	
22. Lowell	
23. Malden	
24. Medford	
25. Melrose	
26. Narragansett	
27. Natick	
28. Needham	
29. New Bedford	
30. Northampton	
31. Pioneer Valley Regional	
32. Pittsfield	
33. Revere	
34. Roslindale	

List of High Schools in Massachusetts to Which the Questionnaire was Sent. (concluded)

Schools Not Answering Questionnaire	Schools Not Answering Questionnaire
1. Acton-Boxborough Regional	14. Mount Everett Regional
2. Chelsea	15. Palmer
3. Chicopee	16. Peabody
4. Concord	17. Quincy Senior
5. Easthampton	18. Scituate
6. Everett	19. Shrewsbury
7. Groton	20. South Boston
8. Jamaica Plains	21. Springfield Classical
9. King Phillip Regional	22. Watertown
10. Lawrence	23. Wellesley
11. Lee	24. West Springfield
12. Leominster	25. Winthrop
13. Lynn Classical	26. Worcester Classical

Approved by:

William G. [illegible]

Albert S. Anthony

Date: May 31, 1960