INSTRUCTION IN SCIENCE

BULLETIN, 1932, No. 17

MONOGRAPH No. 22

UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF EDUCATION

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UNITED STATES DEPARTMENT OF THE INTERIOR
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OFFICE OF EDUCATION : WILLIAM JOHN COOPER
COMMISSIONER

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BY

WILBUR L. BEAUCHAMP

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UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1933

For sale by the Superintendent of Documents, Washington, D.C. - - - Price 10 cents

NOTE

Wilbur L. Beauchamp, the author of this monograph, is assistant professor of education at the University of Chicago and specialist in secondary school science of the NATIONAL SURVEY OF SECONDARY EDUCATION. *William John Cooper, United States Commissioner of Education, is director of the Survey; Leonard V. Koos, professor of secondary education at the University of Chicago, is associate director; and Carl A. Jessen, specialist in secondary education of the Office of Education, is coordinator.*

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LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF EDUCATION,
Washington, D. C., October, 1932.

SIR: Within a period of 30 years the high-school enrollment has increased from a little over 10 per cent of the population of high-school age to more than 50 per cent of that population. This enrollment is so unusual for a secondary school that it has attracted the attention of Europe, where only 8 to 10 per cent attend secondary schools. Many European educators have said that we are educating too many people. I believe, however, that the people of the United States are now getting a new conception of education. They are coming to look upon education as a preparation for citizenship and for daily life rather than for the money return which comes from it. They are looking upon the high school as a place for their boys and girls to profit at a period when they are not yet acceptable to industry.

In order that we may know where we stand in secondary education, the membership of the North Central Association of Colleges and Secondary Schools four years ago took the lead in urging a study. It seemed to them that it was wise for such a study to be made by the Government of the United States rather than by a private foundation; for if such an agency studied secondary education it might be accused either rightly or wrongly of a bias toward a special interest. When the members of a committee of this association appeared before the Bureau of the Budget in 1928 they received a very courteous hearing. It was impossible, so the chief of the Budget Bureau thought, to obtain all the money which the commission felt desirable; with the money which was obtained, $225,000, to be expended over a 3-year period, it was found impossible to do all the things that the committee had in mind. It was possible, however, to study those things which pertained strictly to secondary education, that is, its organization; its curriculum, including some of the more fundamental subjects, and particularly those subjects on which a comparison could be made between the present and earlier periods; its extracurriculum, which is almost entirely new in the past 30 years; the pupil population; and administrative and supervisory problems, personnel, and activities.

The handling of this survey was entrusted to Dr. Leonard V. Koos of the University of Chicago. With great skill he has, working on a full-time basis during his off-quarters from the University of Chicago, and part-time the other quarters, brought it to a conclusion.

This manuscript reports a study in one of the fields of the curriculum. It gives the survey of instruction in science, which, as might be expected, shows a remarkable increase in the number of pupils enrolled. Following careful analysis of available course of study materials the surveyor visited a considerable number of schools to acquaint himself more in detail with the practices and procedures in schools judged to be outstanding in their science work.

Those who are acquainted with the science instruction of 30 years ago will find that courses in general science and in the life sciences have risen since that time. Courses in physiography and certain short courses in the life sciences have nearly disappeared. Chemistry instruction has been altered in accordance with the changes in theories and in an attempt to bring the subject nearer to actual life conditions. Courses in physics are placing a much larger emphasis on work in electricity and rather generally follow the application of physics to common everyday appliances such as the automobile. The important position of science as a subject of study in our schools justifies the extended treatment of its aims, content, and teaching procedures found in this monograph.

Respectfully submitted.

Wm. John Cooper,
Commissioner.

The Secretary of the Interior.

INSTRUCTION IN SCIENCE

CHAPTER I : SOURCES OF DATA

Courses of study.—This investigation of the teaching of science in secondary schools is based upon the analysis of 58 courses in general science, 45 courses in biology, 27 courses in physics, and 30 courses in chemistry. The courses were obtained from schools in response to a request from the Office of Education for courses which had been revised since 1925. Some courses were also secured from the Division of Research of the National Education Association. Twenty-six States are represented by one or more courses of study.[1]

When one considers the large number of secondary schools in the United States, the response seems meager. Assuming that at least the majority of school administrators were sufficiently interested in the survey to send courses of study if they were available, the results probably indicate that a very large majority of schools do not have recently revised courses of study for science instruction at the secondary level. It is, of course, possible that many schools follow, more or less closely, a State course of study. It is highly probable, however, that the majority of courses are dictated by the outlines of individual teachers or by the particular textbook used by the instructor. The influence of the textbook is disclosed by an analysis of the courses of study. A considerable number of courses were merely outlines of particular books, or a series of page assignments to the required textbook. Classroom observation also indicated the great importance of the textbook in determining what is taught. Assuming that prepared courses of study represent a break with tradition and are in general the product of the more advanced thought on the teaching of science, the present analysis should be indicative

[1] Arizona, 4; Arkansas, 4; California, 25; Colorado, 5; Delaware, 3; Illinois, 10; Indiana, 5; Iowa, 4; Kansas, 1; Maryland, 4; Massachusetts, 1; Michigan, 6; Minnesota, 1; Missouri, 6; Montana, 2; New Jersey, 14; New York, 4; Ohio, 16; Oklahoma, 1; Oregon, 3; Pennsylvania, 8; Rhode Island, 4; Tennessee, 1; Texas, 8; Virginia, 1; Washington, 4; West Virginia, 5; Wisconsin, 10.

of the progress which is being made. Because of the small number of courses analyzed, it can not be construed to be a picture of general practice; it presents practice in school systems where recent revisions have been made and where the situation in science instruction is probably more dynamic than in the general run of secondary schools.

Classroom visiting.—In addition to the data obtained from the courses of study, visits were made to schools in 14 cities in various parts of the United States. Fifty-five classes were visited. The purpose of the classroom visiting was twofold: (1) To discover the extent to which the courses of study actually functioned in dictating the subject matter presented and the technique of instruction employed; and (2) to discover promising innovations in classroom technique. Most of the visits were made to cities in which revised course outlines had been prepared.

CHAPTER II : PREPARATION OF COURSES OF STUDY

Examination of the courses of study indicates that the majority of courses were formulated by committees representing each of the different fields of science; that is, the courses in general science were made by teachers of general science, courses in biology were made by teachers of biology, and so on. No reference was found which might indicate that the course was formulated by a single committee representing the whole field of science. Administrators apparently regard each of these subjects as a special field, rather than a sequence of subjects having a common core, with overlapping aims, methods, and psychology of learning. Conversation with teachers of science leaves a like impression. Teachers usually refer to themselves as teachers of physics or teachers of botany, and rarely as teachers of science. This tendency to regard each subject as an independent unit rather than as a part of a sequence of courses, as will be pointed out later, has an important bearing on the courses of study in science.

The committees operate under a variety of conditions, which are reflected in the courses of study produced. Four general types of situations will be described in this report: (1) committees operating under a director of curriculum; (2) committees operating under a supervisor of science; (3) committees operating under the direction of outside talent; and (4) committees operating without supervision.

Committees operating under a director of curriculum.—Many of our large cities have what is commonly called a department of curriculum. In some cities the department is small, consisting only of the director; in others the director may be assisted by a large staff. In the schools visited, the activity of the department of curriculum varied greatly with respect to its relations with the curriculum committees. Occasionally it offered only a perfunctory supervision of committee activity; in other systems it practically dictated the entire curriculum policy. Departments of curriculum assist in the construction of courses of study by assembling various materials, such as courses of study from other school systems, science textbooks, and professional literature on the teaching of science. In addition, they frequently formulate general aims, principles of organization, and a general scheme for the presentation of the materials in a printed course of study. In some schools, the members of the committees were relieved of class work during a portion of the school year and reported to the curriculum department offices where all available materials were placed at their disposal. This plan made possible frequent consultations with the director. In other schools, the teachers assisting were obliged to carry on their regular school work to which was added the burden of formulating a course of study. Under this plan, the majority of the committees met in some conveniently located high school after the regular work of the day was over. Little, if any, opportunity was possible for consulting the director or for studying the materials collected by the department.

A considerable difference appears in the courses of study produced by the two plans just discussed. The committees working during regular school hours under the supervision of the director produced courses of study, which, in the majority of cases, indicate a thorough understanding of the general principles of organization and the nature of the task which they were to perform. Committees working after school hours, with little or no contact with the director, produced a heterogeneous mass of material with few, if any, principles of organization apparent. In the situations where the form of organization was given to them by the director, many of the courses show that the form is conceived as a purely mechanical scheme to be followed arbitrarily. Examination of these courses indicates that the organization is entirely consistent. A more careful scrutiny shows that although the organization may be consistent in terms of its major divisions, these divisions may be purely artificial so far as the detailed material is concerned. No fault can be found with the committees who proceeded in this manner. They did the best that they could with the time and resources which they had at their disposal. The fault lies rather with the administration and organization which did not provide the opportunity for a good piece of work. The data in support of the point just made are presented in Chapter IV, The Organization of Courses in Science.

Committees operating under a supervisor of science.—In some of the larger cities a supervisor of science who is a specialist in the field of science teaching is employed. In such school systems the formulation of a course of study or the revision of existing courses is usually carried on directly under his supervision. The influence, however, of the supervisor of science in determining the content of the course of study varies greatly. In one school system observed, the course of study was formulated entirely by the supervisor and his assistant. The material showed clearly that they had first set up certain principles of organization and criteria for the selection of the content. The result was a unified series of courses in the different fields. The courses were placed in the hands of the teachers who were asked to suggest changes for their improvement. The personality of the supervisor was such that suggestions for improvement were readily given. The original course is in a constant process of revision and is used enthusiastically by the teachers in the system. This method of procedure, however, is an unusual one and would certainly be opposed by teachers in many cities. As a rule, the courses are formulated by committees who are appointed by the superintendent or the supervisor of science.

A comparison of the courses of study prepared by committees under the direct active control of the supervisor with those courses in which the control of the supervisor was limited, indicates the superiority of those courses over which the supervisor had the greatest amount of control. This superiority is evidenced most clearly by a comparison of the junior high school courses with the senior high school courses. In the junior high school, teachers as a rule are accustomed to supervision. Many have had little specific training in the various sciences, and as a result they are eager for suggestions; they regard the supervisor as an expert in the field. Senior high school teachers have no such regard for the supervisor; in fact, their attitude is often antagonistic. The majority of the senior high school teachers are specialists in some field of science. If the supervisor's training and experience in teaching has been in the field of chemistry, his opinion has weight with the chemistry committee. The other subject specialists do not regard him as competent in their fields. In other words, the majority of senior high school teachers are not prone to recognize expertness in the field of science *teaching;* they recognize only expertness in the subject matter of a certain division of the field of science. This attitude operates as a distinct disadvantage in the construction of courses of study. The lack of a general viewpoint toward the teaching of science is usually exhibited in courses formulated by subject-matter specialists; the content of the course is dictated solely by the logical divisions of the subject. Neither the contributions of the subject to the general aims of education nor the psychological and pedagogical considerations are taken into account in determining the organization or the subject matter selected.

It must not be concluded from the foregoing statements that this lack of cooperation between the senior high school teachers and the science supervisor exists in all systems. Observation by the writer, however, leads him to believe that it is often the case. Examination of courses of study and observation of classroom teaching leads the investigator to believe that the majority of senior high school teachers would profit by more contact with the science supervisor.

Committees operating under outside talent.—Experts brought in from outside the system have also left their impress on courses of study. In some cases these experts have been specialists in the curriculum and in other cases they have been specialists in science education. In the judgment of the investigator (as determined by an examination of the courses), each of these types of specialist has contributed to the development of the courses of study in such a way as to produce in the courses of the respective cities a uniformity of viewpoint and organization which are notably lacking in courses prepared without supervision.

Committees operating without supervision.—In some school systems the course of study is prepared by committees appointed for each special subject. These committees usually work independently of each other and are left entirely on their own resources, the only condition being that by a certain date a course of study for the subject must be forthcoming. A committee of that kind was observed in operation. Since the method of constructing a course of study aids in interpreting the final product, a description of the work of this committee is included. It is probably typical of the operation of many committees. The first meeting was very short. Each member was asked to present his outline of the course at the next meeting. No mention was made of the general aims of education toward the attainment of which the course should be focused. No specific objectives of the course were decided upon. No principles of organization nor criteria for the selection of subject matter were formulated. At the next meeting, one member was called upon by the chairman to present his outline. This was promptly criticized by those members whose outlines differed from the first in some respects. The criticisms consisted of—"I think that this should go first"; "That isn't a unit"; "This topic is too large"; "We will never have time to cover all that," and other remarks of a similar nature. The whole discussion was based upon personal opinions, likes, dislikes, and prejudices of the various members of the committee. After seven meetings the committee, through the process of compromise, arrived at a series of topics which were duly printed and distributed to the other teachers in the system. Two of the teachers of this committee were visited some time later and they were not following the course of study they themselves had cooperated in preparing. Lack of expert direction such as may be supplied by a director of curriculum or by a supervisor of science frequently produces the type of situation just described.

Another common type of committee procedure is to meet and decide upon the topics or units which are to be included. Each teacher is then assigned to develop a particular unit. Many courses of study disclose evidence of this type of procedure by an entire lack of uniformity in the organization of the different units. One unit will present a statement outline of the important ideas, another a topical outline, and another a series of problems. Analysis of the units reveals that the individual teachers must have had entirely different conceptions of the nature of the learning products to be attained and of the nature of the learning process. One unit may be focused upon the accumulation by pupils of details relating to the topic under discussion. Another unit may consist of problems to be solved, in which the details are used functionally to supply data for their solution. Still another unit may consist of a "hit-or-miss" collection of projects with apparently no other idea than "whole-hearted purposeful activity" on the part of pupils. And there may be one or more units in which the important generalizations of science and their applications in life situations are stressed. It is even possible to find all these types of materials mixed within a single unit.

The influence of other courses of study is indicated by the widespread use of certain objectives, specific aims, and topics phrased in identical words. As a rule, no credit is given for quotations made and it is only through a comparison of the years in which the courses appeared that the sources of these materials can be determined. A common procedure of course-of-study makers is to assemble all courses of study they can obtain and then make a composite of the whole. The assumption underlying this procedure is apparently that by this method they may be reasonably sure that nothing has been omitted.

Possibly more space has been devoted to a consideration of the preparation of courses of study than is necessary. The methods which have been described are more or less a matter of common knowledge. This section constitutes, however, a background for the analysis and interpretation to follow.

CHAPTER III : EDUCATIONAL OBJECTIVES LISTED IN THE COURSES

The frequency of mention of objectives.—Each of the courses of study was checked to discover the educational objectives of the course. Some of the courses did not include statements of objectives. This is shown by the totals for each subject.

TABLE 1.—*Number of courses stating objectives*

Objectives	General science (58)	Biology (45)	Chemistry (30)	Physics (27)
1	2	3	4	5
Objectives of secondary education	14	2		
Objectives of science in general	15	3	2	2
Objectives of specific courses	40	21	17	18
Reference to other committees	2		6	1
Total	71	26	25	21

NOTE.—The numbers in parentheses indicate number of courses analyzed.

The table indicates that the relationship of the specific course to the objectives of secondary education and to the objectives of science in general is considered by approximately one-third of the courses in general science and by very few other courses. It is, of course, impossible to determine whether or not the committees responsible for the courses in biology, chemistry, and physics, considered the relationship of their courses to the general educational objectives. A marked contrast appears between the courses in general science and the specialized courses in regard to the material on objectives presented in the courses. Courses in general science contain many references to applications of science in the home and community. With few exceptions, the specialized courses contain a presentation of the subject matter organized in terms of the logical divisions of the particular field of knowledge with which they deal. This difference in the courses of study may be due to the difference in the subject matter of the courses or it may be due to a lack of a general viewpoint of the objectives of secondary education or of the objectives of science on the part of the teachers of the special subjects. It is significant that the committees in the special field did not deem it necessary to include statements of the objectives of secondary education. Practically all courses in the special fields included statements of specific objectives. For example, in the biology courses a large number of the objectives referred to specific phases of biology; such as: To give the pupils an understanding of the life processes of plants and animals; to observe and explain the close relationship between plants and animals; to learn about the human body; and to learn how to care for plants and animals. This attention to specific contributions of the subject matter of the course was also evident in the other special courses. The objectives of the courses in general science on the other hand were more general and would apply to any field of science. This difference in objectives between the courses in general science and in the special sciences courses is probably explained by the fact that a special science teacher is especially trained in the subject matter of his course and thus tends to think of his courses in terms of content rather than in terms of general outcomes.

The classification of objectives.—A more detailed analysis of the objectives is presented in Table 2. In this table the objectives are classified under six major headings, namely, knowledge, exploration, abilities, attitudes, ideals and habits, and interests. These headings overlap in some degree. It is practically impossible to set up distinct categories for the classification of objectives because these categories are necessarily determined after the objectives have been formulated. For example, the exploratory objective might be considered as a knowledge objective. It was placed under a separate division because this objective is often mentioned specifically by writers in the field.

An examination of Table 2 indicates a very wide range of general objectives. The frequency of mention of the various objectives shows that there is far from an overwhelming consensus as to what the objectives should be. The frequency of mention is interesting, but is not, in the investigator's judgment, a valid criterion for determining what the objectives should be. It should be of value to course makers since it reveals what others consider to be the objectives of science teaching.

TABLE 2.—*An analysis of the objectives listed in courses of study in science*

Types of objectives	General science (51)	Biology (22)	Chemistry (19)	Physics (20)
1	2	3	4	5
A. Knowledge				
1. To acquire information about science	18			
2. To acquire knowledge which will produce a better understanding of our environment	40	12	7	14
3. To acquire the knowledge necessary to correct superstition and erroneous beliefs	4	4	1	2
4. To acquire a scientific vocabulary	6			
5. To acquaint the student with the source of scientific knowledge	3			
6. To acquire information concerning the lives of the great men of science	4			
7. To acquire a body of facts which will enable one to read scientific literature	2	5	5	
8. To acquire a knowledge of the fundamental principles of the subject	2	9	6	10
9. To acquire a knowledge of the application of principles in industry	3		5	5
10. To acquire the knowledge necessary for future courses in science or to prepare for college	6	1	7	6
11. To acquire knowledge to increase the general culture of an individual			3	1
12. To meet the demands of the State departments				1
13. To acquire knowledge which will function to secure the objectives stated in the bulletin on Cardinal Principles of Secondary Education—				
(a) Health	25	13	5	7
(b) Command of fundamental processes				1
(c) Citizenship	19	6	3	9
(d) Worthy home membership	18	8	5	5
(e) Vocation	12		3	5
(f) Worthy use of leisure time	14	10		
(g) Development of ethical character	11		1	
B. Exploration (or orientation)				
1. To give the pupil a view of the field of science so that he may explore his interests, capacities, and abilities	9	3	6	5
(a) As a basis for the election of further courses in science	8		1	3
(b) As a basis for the selection of a vocation	9	2	6	2
(c) To acquire new fields of interest	4	2	2	4
C. Abilities				
1. To develop the ability to think scientifically	44	5	9	9
(a) To develop reliance on facts	5			
(b) To develop the power of interpretation	10			2
(c) To develop the power of observation	19	4	3	9
(d) To develop the ability to form independent judgments	12			
(e) To develop the ability to evaluate	3			2

NOTE.—The numbers in parentheses refer to the number of courses listing objectives.

TABLE 2.—*An analysis of the objectives listed in courses of study in science*—Continued

Types of objectives	General science (51)	Biology (32)	Chemistry (19)	Physics (20)
1	2	3	4	5
C. Abilities—Continued				
1. To develop the ability to think scientifically—Continued.				
(*f*) To develop the ability to generalize	1			
(*g*) To develop the ability to locate problems	1			
(*h*) To develop the ability to plan prior to execution	1			
(*i*) To develop the ability to gather data systematically	2			4
(*j*) To develop the ability to recognize defects and errors in conditions and processes	1			
(*k*) To develop the ability to do quantitative thinking				4
(*l*) To develop the ability to express ideas in clear and coherent English			1	2
2. To develop the ability to use the scientific instruments common in the laboratory	4	2	2	4
D. Attitudes				
1. To develop a scientific attitude as shown by ability—				
(*a*) To view facts objectively	2			
(*b*) To be free from dogma and superstition	2			1
(*c*) To hold one's conclusion as tentative and to suspend judgment until facts are secured	3			2
(*d*) To revise one's opinions if the evidence warrants	1			1
(*e*) To have a spirit of inquiry	11			
(*f*) To be open-minded	12	1		5
(*g*) To have a conviction of the universality of the cause and effect relationship	3			
2. To develop attitudes of appreciation of—				
(*a*) The contributions of scientific method	7	2	1	
(*b*) The contributions of science to mankind	20	1	7	6
(*c*) The great men of science	8	6	1	1
(*d*) Expert judgment	5	1		
(*e*) Nature	12	14	1	1
(*f*) One's responsibility in the world	5	10		
(*g*) Natural laws	4	8		
(*h*) The importance of quantitative thinking				1
(*i*) The importance of original research				1
E. Ideals and habits				
1. To acquire ideals or habits of accuracy, persistence, honesty, self-control, truth, etc	16	2	4	6
2. To inculcate a safe, sane, reverent attitude toward science			1	
3. To evolve high standards of conduct in personal and group life			1	
F. Interests				
1. To acquire an appetite for investigations in science	8			
2. To acquire an appetite for scientific reading	9		3	1
3. To acquire an interest in taking more science	10			2
4. To acquire an interest in nature	10	6	1	
5. To acquire interests in vocational fields	2			
6. To acquire wholesome interests which may be used to enjoy spare time	14	3	2	7

The evaluation of objectives.—So far as the writer knows there is at the present time no conclusive method of evaluating the objectives as set forth. It is, of course, possible to compare the objectives with the recommendations of various authoritative committees such as those working with the National Education Association, the National Society for the Study of Education, and the North Central Association. These committee recommendations represent the consensus as to what the objectives should be. They are significant in that they indicate what objectives are entertained but they are not necessarily the objectives which should be attained in the study of science. For example, of the 160 courses examined only 11 courses stated the objective, "To acquire the knowledge necessary to correct superstition and erroneous beliefs." According to the consensus this is only a minor objective in the teaching of science. The writer is of the opinion that this is an important objective. This is an opinion only and we have no present means of validating it. The most recent authoritative formulation of the objectives of science teaching is presented in the Thirty-first Yearbook, Part I, of the National Society for the Study of Education, 1932, in a volume entitled "A Program for Teaching Science." The stand taken by this committee is shown in the following quotation:

> This committee, then, recognizes the aim of science teaching to be contributory to the aim of education; viz, life enrichment. It recognizes the objectives of science teaching to be the functional understanding of the major generalizations of science and the development of associated scientific attitudes.

This statement is based on the opinion of the members of the committee. As such it probably represents the best composite thinking which we have on this subject. However, one of the problems which must be solved before we can get far in formulating a truly scientific curriculum is that of discovering a method for determining and evaluating the objectives of science teaching.

It has already been stated that little importance should be attached to the frequency of objectives. The reason for this will be apparent if one will examine a dozen or more courses of study. Every degree of specificity in objectives will be found. It is not uncommon to find a general objective, such as securing the scientific attitude of mind, contained in the same list and coordinate in importance with the ability to read a weather map or the ability to raise a family of mice. Specific objectives began to make their appearance in science courses after the publication of the Los Angeles course of study in 1923. Hundreds of specific objectives were listed for each subject. These specific objectives were added to the general objectives in many courses and the result is a curious mixture which is neither "flesh, fish, nor fowl." This indiscriminate borrowing of material from other courses without an understanding of the viewpoint on which it was based is responsible in many cases for the heterogeneous courses which we now have.

CHAPTER IV : ORGANIZATION OF COURSES IN SCIENCE

The principles of organization.—After the objectives of a course have been formulated, the next step is probably that of determining the general principles which shall function in the selection and organization of the materials of instruction. The courses represented in this investigation were, therefore, examined to discover the nature of these principles. Only three courses presented any statement of principles, and with the exception of a single course, these were implied, rather than stated explicitly. The absence of a statement of principles indicates either (1) that a set of principles was not formulated, or (2) that the committees did not consider it necessary to include them in the courses of study as reproduced. Teachers must understand the principles of organization underlying the curricular materials if they are to use the courses intelligently. Perhaps the widespread distrust of printed courses of study is due in some measure to a lack of understanding by teachers of the basic principles of organization represented. Only two courses of study included references to the studies which have been made in the field of the science curriculum. Several references presenting the results of research and the formulation of courses by committees are available.[1]

Methods of organization.—Three general types of organization are common: (1) The topical organization, (2) the specific-objective organization, and (3) the unit method of

[1] Caldwell, O. W., *and Committee*. Reorganization of Science in Secondary Schools. United States Bureau of Education Bulletin, 1920, No. 26.

Report of the Committee on Standards for Use in the Reorganization of Secondary School Curricula. North Central Association Quarterly, 1:505–515, March, 1927. 3:589–614, March, 1929.

Curtis, Francis D. Investigations in the Teaching of Science. Philadelphia, Blakiston, 1926.

—— Second Digest of Investigations in the Teaching of Science. Philadelphia, Blakiston, 1931.

Fifth Yearbook of the Department of Superintendence, 1927. Pp. 147–186.

Sixth Yearbook of the Department of Superintendence, 1928. Pp. 344–360.

Twenty-sixth Yearbook, National Society for the Study of Education, 1926. Part II.

Thirty-first Yearbook, National Society for the Study of Education, 1932. Part I.

organization. The topical method of organization is the traditional method. The publication of the Los Angeles courses of study in 1923 ushered in a period of organization around specific objectives. This method was taken over by several cities and was modified to some extent by other cities. Since 1926, the unit plan of organization has been widely adopted. Sixty-two of the courses examined refer to the divisions of the course as units. Of the 26 courses appearing during 1930–31, 20 are presumably organized on the unit basis.

Topical method of organization.—Ninety-three of the 160 courses present simply a topical outline of subject matter such as the following:

Hydrogen and its compounds

A. Comparison of hydrogen with other elements in weight.
B. Uses of hydrogen.
C. Preparation of hydrogen.
D. Testing for properties of hydrogen.
E. Comparison with properties of oxygen.
F. Product formed when hydrogen burns.
G. Examples to show contrast between compounds and the elements which compose them, etc.

This is, of course, the traditional method of organizing courses of study and is based on the traditional conception of learning and of the subject matter of the curriculum. To quote the Twenty-sixth Yearbook of the National Society for the Study of Education, Part II, page 17:

> In times past, and too largely in present school practice, the curriculum has been conceived primarily as formal subject matter (facts, processes, principles), set out to be learned without adequate relation to life. The pupil has too frequently been required to repeat words, express ideas which he does not understand, and to accept, adopt, and use materials which have been furnished him ready-made and completely organized by the teacher. Learning was thought of as the ability to give back upon demand certain phrases and formulas which have been acquired without adequate understanding of their meaning and content.

While employment of the typical method of organization does not necessarily indicate that the memorization of subject matter is the most important aim of the course, the material included in the outline places the emphasis upon the accumulation of details and facts rather than upon understanding. In the foregoing example the pupil might emerge with a fund of details concerning the occurrence, preparation, compounds, and the physical and chemical properties of hydrogen, and probably could pass a good test upon them, but the question might be raised, Is chemistry simply the sum of the known facts about the chemicals with which the chemist deals, or is it an understanding of the principles of chemistry through the mastery of which one secures a basis for the interpretation of the world in which he lives? The topical organization in the past has been an outcome of a type of education in which the accumulation of facts is set up as the end product to be attained. While it is possible to arrive at an understanding of the important generalizations in science by this method, the emphasis on the accumulation of facts as the major goal would often secure these generalizations only as by-products of the course. This conception is in marked contrast to the viewpoint in which the facts are regarded as the raw materials with which one thinks, and are, therefore, means, and not ends. The fact that 60 per cent of the courses are organized on the topical basis should not be considered evidence for believing that this is the best method of organizing courses. The best method will be that method which educational science eventually determines to be the best method for attaining the objectives.

Organization in terms of specific objectives.—Organization of courses in terms of specific objectives is included as a separate mode of organization because it is markedly different from other types of organization. In one sense, it is not a distinct type of organization in that the courses may be divided into units or topics. The point of view taken by the committees who have organized courses on this basis is probably best expressed in the Los Angeles courses of study. These courses are commonly organized under headings such as the following: "Specific Objectives," "Suggested Activities," "Suggested Procedure," and "Desirable Outcomes." An examination of the specific objectives shows that they commonly begin with an infinitive and are usually expressed in somewhat the following form: "To learn that metals increase in weight when heated." An analysis of one of these courses of study showed 53 different ways of expressing a knowledge objective like the one stated. Some of the methods of stating the objectives are "to comprehend," "to understand," "to become familiar with," "to learn," "to become sensible to," "to obtain a knowledge of," "to become acquainted with," "to find out," "to realize the significance of," "to become aware of," "to gain information concerning," "to study that," "to ascertain how," "to acquire a working concept of," "to consider," "to know," "to augment knowledge of," "to advance further in the study of," "to introduce the pupils to," "to begin to understand," "to give specific facts concerning." If the infinitives are written on one side of the page and the subject matter on the other, we have on one side a series of infinitives and on the other a topical outline. It may be taken for granted that the teacher wishes pupils to obtain a knowledge of the topics in an outline and it is, therefore, questionable whether the addition of infinitives is any contribution.

One wonders what is the psychology of learning which underlies such a series of objectives. On the one hand, one finds objectives which are general methods of procedure, and on the other, objectives which apparently deny the existence of generalizations as a basis for transfer of learning. For example, according to the list, the ability to raise a family of mice is one specific, another is to raise turtles and by implication it would seem necessary to include the ability to raise every kind of animal which man might conceivably wish to raise. To the investigator, many of the specific objectives seem to be incompatible with any underlying viewpoint in education or psychology of learning. The foregoing criticism is not directed toward what is commonly called an "activities curriculum"; it applies to the interpretation which curriculum makers have made of the idea.

The formulation of specific objectives after the fashion just described has left a very definite mark upon our courses of study. A large percentage of the modern courses make use of the plan and apply it in various ways in the organization of courses. In many cases the description of the nature of these objectives given in the preceding paragraph applies; in some the nature of these objectives has been changed after the manner to be shown later in this chapter.

Unit method of organization.—Since few, if any, of the courses appearing before 1926 were divided into what were referred to as units, it is probably a safe assumption that the widespread use of term "unit" after this date in courses of study is due to Prof. H. C. Morrison. Professor Morrison's book, "The Practice of Teaching in Secondary Schools," appeared in that year. According to Professor Morrison, a learning unit may be defined as a "comprehensive and significant aspect of the environment, of an organized science, of an art or of conduct, which being learned results in an adaptation in personality" (p. 21). The problem of organization in general science is "a search for the comprehensive and significant aspects of the environment in the field being studied—*comprehensive* in that each aspect explains a great deal, and *significant* in that it is important and essential" (p. 182). In the special sciences, physics, chemistry, and biology, the unit is "a comprehensive and significant principle or complex of principles and the meaning and bearing of the terms 'comprehensive' and 'significant' are the same as before" (p. 193). "The critical test of any unit in the science type is, Does it tend to contribute understanding rather than a descriptive account?"

An analysis of the courses divided into units indicates that the term "unit" has been taken over as a convenient term to replace the word "topic," rather than as a principle of organization. For example, the following units are found in courses in general science: Astronomy, Air, Looking through a Telescope, Bread, Oxygen, Nature of Chemical Change, The Telephone, Buried Treasure, Animals, The Grasshopper, Chemistry Flowers, Machines, Water, Obtaining a Food Supply, Carbon Dioxide, and How Living Things Grow. It is evident that many of the titles listed are not units in the sense in which Professor Morrison uses the term, while others are. Many of the courses consist of true units mixed with topics.

If we apply the analysis of a unit still further, it is evident that certain elements enter into the understanding which is implied by the unit. Direct learning of the unit requires mastery of the elements out of which the understanding grows, but it does not require mastery of all the principles or associated elements which do not contribute to the understanding. While it is true that different teachers might differ to some degree as to the elements which they would include within a unit, a fairly high uniformity of opinion should result. An analysis of the unit "Air," which was included in 15 of the courses studied, was made to determine the content included. The outline for this unit included the following principles, phenomena, and devices: Matter and its properties; weight, pressure, compressibility, composition, structure, elasticity, and inertia of air; effect of heat upon air; oxidation; photosynthesis; weather, including winds, humidity, evaporation, condensation, forms of precipitation, lightning, thunder, and forecasting; devices such as suction pumps, siphon, barometers, thermometers, windmills, compressed air devices, vacuum cleaners, airplanes, refrigerators; chemical changes, including elements, mixtures, and compounds; physical changes; conduction; radiation; convection; structure of the ear; musical instruments; nitrogen cycle;

carbon cycle; hygiene of breathing; nature of sound; weathering; boiling point; freezing point; distillation; friction; radio; treatment of burns; fire prevention; balloons; respiration; ventilation; stoves and furnaces; composition of water; water supply; bacteria, yeasts, and molds; vaccination; and the life history of flies and mosquitoes.

The foregoing examples seem to point to several conclusions: (1) The idea of what a unit is is not clearly defined; (2) the title of the unit does not indicate the nature of the content to any high degree; (3) the emphasis is placed upon the subject matter or assimilative materials rather than upon the elements through which the intelligent attitude implied by the unit is attained, in the sense in which the term unit is applied by Morrison. It is, of course, not obligatory to accept Professor Morrison's viewpoint concerning the nature of a unit. What is valuable in what he has written rests upon the validity of his reasoned analysis. Mere consensus of opinion, even though it represents the opinion of 99 per cent of our population, establishes nothing. The validity, after all, rests on the disclosures of the underlying sciences of psychology, biology, and anthropology. It is to these sciences that we must turn if we are to establish clearly the nature of learning products. These sciences have already collected many data concerning the development of the nervous system, methods of learning, and the ways in which our institutions have developed. A truly valid curriculum awaits further disclosures from these sciences and the application of the findings in the establishment of objectives and in methods of attaining them.

Methods used in the development of topics.—An attempt was made to classify the courses of study on the basis of the method employed in the development of each unit or topic. This proved to be very difficult because of the diverse nature of the courses. It was possible, however, to distinguish 11 distinct methods of organization. These methods and their frequency are as follows:

1. Each unit or topic is taken from a single textbook which the course follows (15 courses).
2. Each unit or topic is divided into a series of subtopics indicating the nature of the subject matter (96 courses).

3. Each unit or topic is divided into a series of subtopics indicating the nature of the subject matter and also includes one of the following—
   (a) A list of laboratory activities (5 courses).
   (b) A list of laboratory experiments, demonstrations, and applications (2 courses).
   (c) A list of demonstrations and suggested questions (1 course).
   (d) A list of minimum exercises to be performed (1 course).
   (e) A list of laboratory exercises and references (1 course).
   (f) A presentation, pretest, and a series of exercises (3 courses).
4. Each unit or topic is outlined as a series of specific assignments to various textbooks (1 course).
5. Each unit or topic takes the form of a short presentation of the topic (1 course).
6. Each unit or topic is outlined in terms of specific objectives to be attained and includes one of the following—
   (a) An outline of subject matter, references, and activities (1 course).
   (b) An outline of subject matter, home projects, demonstrations, and laboratory activities (1 course).
   (c) An outline of subject matter, class activities, outcomes, and references (3 courses).
   (d) Suggested activities (2 courses).
   (e) Suggested minimum activities and additonal activities (1 course).
   (f) Suggested activities, suggested procedures, and desirable outcomes (3 courses).
   (g) Pupil activities and teaching suggestions (1 course).
   (h) Pupil activities, topics for investigation, problems with specific aims, and demonstrations and references (1 course).
7. Each unit or topic is organized around a body of core material consisting of laboratory exercises (1 course).
8. Each unit or topic is outlined as a series of pupil activities (1 course).
9. Each unit or topic is divided into a series of problems (9 courses). In five of these courses each problem includes one of the following—
   (a) The specific objectives to be attained, the general objective of which each specific objective is a part, and a list of general meanings to be attained (1 course).
   (b) A development, summary of ideas to be attained, and suggested reports (2 courses).
   (c) Specific objectives, an outline of content, suggested activities, experiments, visual and reading aids (1 course).
   (d) An outline of content (1 course).

10. Each topic or unit is organized in terms of concepts, ideas, principles, and generalizations to be attained. Each unit includes one of the following—
    - (a) General objectives outlined in terms of specific objectives (1 course).
    - (b) Statements of major concepts, statements of minor concepts, each of which is divided into problems (1 course).
    - (c) Specific aims in the form of statements, followed by an outline of subject matter (3 courses).
    - (d) Specific aims in the form of statements followed by pupil activities and additional topics (2 courses).
    - (e) An outline of subject matter and reference to generalizations stated at the beginning of the course (3 courses).

The results of the complete analysis show that approximately 10 per cent of the courses of study consisted of a list of the topics to be covered, and that 60 per cent of the courses consisted of a topical outline of each unit or topic. The remaining 30 per cent of the courses exhibit a great variety of methods of organization.

The results raise the problem, What is the function of a course of study? Should it function merely to indicate what should be taught or should it suggest methods of procedure?

Promising variations in methods of organization.—Several courses present interesting variations from the dominant procedure. In the belief that these will be of value to future curriculum makers, a few of the more promising types will be included.

In the course in general science of Rochester, N. Y., each unit is regarded as a significant understanding and the name is phrased as a complete sentence. Each unit is then divided into a series of minor concepts, also formulated as statements. A series of problems is then raised, through the solution of which the pupil arrives at the concepts listed. The emphasis is, therefore, on a generalization or concept which is reached through the mental process of problem solving. A brief excerpt from this course follows:

TOPIC I: WATER

UNIT I. *Major concept. The continuance of life upon the earth is dependent upon the water cycle*

A. MINOR CONCEPT. Water is one of the necessities for all life.

1. Problem: How do animals use water? Why?
   (*a*) With food and drink;
   (*b*) For bathing;
   (*c*) As a home.
   NOTE.—Problems 1 and 3 are observational problems.
2. Problem: How do plants use water? Why?
   (*a*) As food manufacturing material;
   (*b*) As a home.
3. Problem: How do you use water? Why?
   (*a*) With food and drink;
   (*b*) For cleaning and bathing, etc.
   NOTE.—In each problem have pupils consider how, if at all the activity or use could be carried on without water.

B. MINOR CONCEPT. Water occurs in a variety of forms on the earth and in the atmosphere.

1. Problem: How does water get into the atmosphere?
   (*a*) Evaporation from bodies of water, land, and wet surfaces. (Call for pupils' experiences.)
   Experiment 1. What causes water to evaporate?
   (*b*) From air exhaled by living things.

The same general method of organization is presented by the Denver Course in general science. An excerpt from this organization follows:

UNIT I. *Air and water. General objective. Air and water are dominant factors in the physical environment*

SPECIFIC OBJECTIVE. 1. Air is a substance and has properties which are the same as the properties of other substances. The following are contributory meanings:

1. Air occupies space. Demonstrations, T. L. pp. 2–3; other demonstrations, H–1, p. 14.
   Problem: Invert a small-necked bottle full of water. Why does the water bubble out instead of running out in a steady stream?
2. Air has weight, etc.

This course is similar to the Rochester course in that the attention is focused upon major concepts or understandings.

The course in chemistry of Passaic, N. J., has at the beginning of the course an outline of the important generalizations and principles to be taught. These generalizations are referred to in the outline of each topic. For example:

TOPIC I: OXIDATION

A. Combustion.

Generalization A. 2. [This reference is to the following generalization which appears in the list "Oxidation is a fundamental source of heat and other forms of energy into which man has learned to transform heat."]

1. Solid oxides and gaseous oxides.
2. Increase of weight and burning, etc.

This method of organization, presenting as it does, generalizations and topics probably marks a transition between courses stated in the form of understandings and those containing only topics.

Teaching units at the University High School, University of Chicago, are analyzed into elements which are focused upon the understanding of the unit. These elements are then reworded in the form of problems which are given to the pupil for study. For example:

UNIT I. *The chemical nature of matter*

(*a*) Everything which occupies space and has weight is matter.
(*b*) Matter may exist in three physical states—solid, liquid, and gaseous.
(*c*) Matter is made of simple substances; pure complex substances, compounds; mixed substances; and mixtures.
(*d*) The ultimate unit of an elementary substance, an element, is the atom.
(*e*) For the purpose of interpreting chemical phenomena the atom may be conceived as a structure made of protons and electrons.

The above series of statements is not given to the student. Instead he is given the following series of problems:

1. How does the chemist measure matter?
2. How does the chemist recognize materials?
3. How does the chemist classify materials?
4. Why do scientists believe materials are made of molecules?
5. Of what are molecules composed?

The organization of courses around major ideas, concepts, principles, laws, understandings, or generalizations presents a distinct departure from the conventional topical method of presentation. An example of this difference is clearly seen in the organization of the topic on hydrogen and the unit on the chemical nature of matter. In the latter type of course the facts of chemistry are merely the means; that is, they furnish the raw materials from which principles may be derived or verified. The focus of attention is the principle; it is this principle and mode of arriving at the principle which places the student in possession of the method of thinking employed by the chemist. This method of organization of courses presupposes a list of the important concepts and principles of each field of science. Analyses of textbooks, popular-science literature, newspapers, and job analyses have been made to determine what these principles are. The task is not yet complete, but a start in this direction has been made. After the concepts and principles are collected there yet remains the task of evaluating them in terms of their contribution to the objectives of science teaching.

Implications of the analyses.—The multitude of types of organization shows very clearly the lack of a fundamental theory of education. Until educators and science teachers have clearly formulated an adequate theory of education it is probable that we may continue to expect the chaos which now prevails in the organization of science courses. It is significant to note that the more innovating courses have been organized in school systems which have a director of curriculum or a science supervisor, or who have called in outside experts. These facts seem to argue that a wider point of view than can be obtained from teachers who have specialized in certain branches of science is necessary if we are to view our courses in terms of their contribution to the aims of education and in light of the nature of the learning process. This does not mean that subject-matter specialists need not take an active part in curriculum construction; it does mean that their work should be guided by a specialist in the field of science teaching or in the field of curriculum. It is, of course, possible that the teachers who specialize in the different fields might become sufficiently interested in the field of science teaching to study the problem of curriculum making in its general aspects. That many of them have not become interested is attested to by their answers to one of the questions put by the present writer. Curtis[1] has published two books which contain excellent summaries of the investigations which have been made in the field of the teaching of science. During visits to school systems the investigator had more or less extended conversations with some of the teachers. One teacher only of 26 interviewed had ever heard of the summaries just mentioned. Seven supervisors were interviewed, all of whom seemed to be well acquainted with the content of these summaries.

[1] Curtis, Francis D. Investigations in the Teaching of Science. Philadelphia, Blakiston, 1926. 339 pp.

——— Second Digest of Investigations in the Teaching of Science. Philadelphia, Blakiston, 1931. 423 pp.

CHAPTER V : ORGANIZATION OF COURSES IN THE VARIOUS SUBJECTS

The preceding chapter has dealt with the general types of organization employed; the following paragraphs will deal with the types of organization in the different subjects into which the field of science is divided.

The organization of courses in general science.—Courses in general science were first organized according to the logical division of the whole field of science. For example, a section would be devoted to physics, another to chemistry, etc. Each section contained what was thought to be the easiest material from that field. The Committee of the National Education Association on the Reorganization of Science in Secondary Schools in 1920 recommended that the subject matter of general science be selected to a large extent from the environment and that the principles of the various sciences be brought in wherever necessary for the interpretation of the environment. Analysis of the 58 courses in general science represented in this analysis disclosed but one course which was organized in terms of the special sciences. Nine courses were found which were hybrids; that is, which consisted in part of topics drawn from the special sciences, and in part of environmental topics. Forty-seven courses were formulated primarily in terms of environmental topics or units.

In order to classify the courses on this basis it was necessary to examine the detailed outline appearing under each topic or unit. For example, two courses might include the same topic, such as "Light." In one course, the outline consisted of the following parts: Straight line path of light, angle of reflection, refraction, change of direction by retardation of lenses, prisms, etc. For the purposes of this study, this topic was considered by the writer as a special science development. In another course the topics were as follows: History of lighting, kinds of lighting systems, lighting the home, etc. This was considered as a general-science development. There still exist many topics phrased in terms of the special science which are developed in the outline from an environmental point of view.

Studies were made of the content of the courses in terms of units or topics presented. The results obtained did not differ from excellent studies which have already been made by others and reported.[1] It would, therefore, be gratuitous to draw on new studies here, especially as the findings of these more recent studies are practically identical with those of the studies previously published.

Table 3 shows the number of units covered in the courses analyzed. The courses were classified into 3-year courses, 2-year courses, and 1-year courses. The results show the great divergence of practice in the placement of general-science units and in the number of units covered per year. The difference in the number of units is caused primarily by differences in the conception of the nature of a unit. These results reinforce those in an earlier chapter which indicated the lack of a definitive idea as to the nature of a unit. For example, in one course plants are considered as a unit. In another course roots, stems, etc., are considered as units. The units of the same course are often not consistent with each other. For example, in one course, the following units are listed: Forms of Matter; A Study of a Match; Light; A Study of the Soil; Sound; Oxygen; Weather; Astronomy; Ventilation; Work and Energy; A Study of Water and Its Use; Foods; Magnetism and Electricity; A Study of Bread; and The Airplane. This mixture of devices, phenomena, materials, processes, and principles is the rule rather than the exception.

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[1] Curtis, Francis D. A Synthesis and Evaluation of Subject-Matter Topics in General Science. Boston, Ginn & Co. 1929. 83 pp.

TABLE 3.—*Number of units or topics included in courses in general science*

3-year				2-year				1-year				1-year				1-year			
City	Grade			City	Grade			City	Grade			City	Grade			City	Grade		
	7	8	9		7	8	9		7	8	9		7	8	9		7	8	9
1	9	21	13	16		7	4	22			17	37		15		52		16	
2	8	3	3	17	2	4		23			8	38			10	53			21
3	6	10	7	18		7	16	24		11		39		26		54			17
4	7	7	4	19		12	9	25			7	40			10	55			17
5	6	5	6	20	15	12		26			17	41			13	56			13
6	4	3	8	21	4	4		27		12		42			13	57			17
7	6	9	8					28			17	43	18			58			17
8	7	5	3					29			8	44			23				
9	14	10	9					30			18	45			10				
10	8	7	3					31			12	46		11					
11	4	6	9					32	19	10		47			17				
12	4	9	11					33		12		48			17				
13	9	9	8					34			18	49			5				
14	5	5	6					35			8	50			12				
15	10	6	6					36			11	51			4				

An attempt was made to discover any agreement in the amount of time which should be spent on different topics. Twenty-seven courses indicated the time allotment for each unit. Because of the diverse nature of the units, it was difficult to get a comparison over a comparable body of material. The results obtained from an analysis of courses in which the number of periods per week were identical are shown in Table 4.

TABLE 4.—*Number of courses requiring a specified time on certain units*

Unit	Number of weeks									
	1	2	3	4	5	6	7	8	9	10
Weather	1	1		3						
Electricity			1	3				2		
Heating homes	1				1					
Foods		1	1		1	1				3
Machines	1	3					1			
Lighting homes			2							
Transportation					2				1	
Communication							2		1	
Clothing	1		1		2					
Air and its uses		1	1	1				2		
Heavenly bodies		1		1		1		1		

It is evident from the results that either the outline of the topic does not indicate the extent to which the details are covered or there are different standards of attainment in different systems. Owing to limitation of space it is impossible to show the grade placement and sequence of topics in the courses. This analysis was made and the results of the study show, however, that a given topic may be included as the first topic in the seventh grade of one course and as the tenth topic in the ninth grade of another course. In other words, grade placement and sequence of topics evidently rests upon no established principle of organization. Such a principle must take into account the complexity of the ideas presented and the intellectual maturity of pupils at different levels.

The organization of courses in biology.—The number of topics included in the various courses in biology is shown in Table 5. The range is from 5 topics to 29 topics. It is rather surprising to note that the range is greater than that of the general-science courses. The differences in the number of topics are not due so much to differences in the content of the courses as they are to variations in the scope of material included under a topic. For example, one course may have one topic on plants while another may have topics on roots, stems, etc.

TABLE 5.—*Distribution of the courses in biology according to the number of units included*

Number of units	Number of courses	Number of units	Number of courses	Number of units	Number of courses	Number of units	Number of courses
5	2	13	1	20	2	26	2
7	4	15	2	21	1	27	1
9	3	16	2	22	3	28	2
10	2	17	2	23	2	29	2
11	1	18	1	24	3		
12	2	19	3	25	2		

Two distinct points of view are represented by the courses analyzed. According to one viewpoint, the objectives of biology can be attained through a detailed study of the various plants and animals. According to the other viewpoint, the objectives are achieved through a study of the activities and processes of living things. The following paragraphs will make clear this distinction.

Forty courses of the 45 analyzed have divided the field of biology into three major divisions: One devoted to plants, one focused on animals, and another directed toward a study of man. In other words, the three sciences, botany, zoology, and human physiology, provide the framework of the courses. The development of each of these divisions is similar in content and organization to the specialized courses from which they are taken. The part devoted to plants presents topics on roots, stems, leaves, buds, seeds, and flowers, together with a consideration of the great groups of plants or type studies of one or more of their representatives. The section pertaining to animals, as a rule, consists of a description of the various phyla or of type studies from the different groups. Each phyla or animal is studied from the standpoint of its general structure, habitat, internal structure, habits, and economic importance. The characteristics of the groups may be determined from a study of the group as a whole, or through type studies. Man is usually studied from a physiological viewpoint through such topics as foods, digestion, circulation, respiration, excretion, muscular system, nervous system, and organs of the special senses. Some courses emphasize hygiene and do not have separate topics on physiological processes. The general principles such as heredity, evolution, variation, etc., are as a rule treated as separate topics at the end of the course. Some courses treat these principles under topics such as plant breeding, animal breeding, and soils, in which case the principles are means rather than ends.

Courses organized on the above basis appear from their content to focus the attention of the pupils on a body of isolated facts concerning different living things. A study of a grasshopper or a crayfish consists primarily in securing a description of the structure, habits, and economic importance of these animals. Observation in the classroom justifies this implication from the courses of study. Two observations which are typical of many of the classes visited are offered in support of the same inference. In one class the topic under discussion was the earthworm. The following questions were asked by the teacher:

(*1*) In what ways does the dorsal surface differ from the ventral surface? (*2*) How many somites are there from the anterior end to the girdle? (*3*) What is the extent of the body cavity, posteriorly and anteriorly? (*4*) How does the earthworm move? (*5*) How does the earthworm reproduce? (*6*) Tell what you know about the digestive apparatus of the earthworm.

Twenty-six questions, of the type just mentioned, were asked during a 45-minute period. In another class, pupils were seated at tables. Each table was supplied with a preserved crayfish and a textbook for each pupil. Each pupil had a set of mimeographed questions to answer. A few of the questions were as follows:

(*1*) Tell a few things about the external structure of the crayfish. (*2*) Can you distinguish two definite divisions in the body? Name them. (*3*) Is there any advantage in having an exo-skeleton? Name one advantage. (*4*) Can you locate any eyes? Describe them in a few words. (*5*) Make a drawing of the crayfish. You may make it like the drawings on either page 180, 181, or 185 of your book.

Recitations and laboratory exercises such as those described set up the accumulation of facts about plants and animals as the goal of the course. The type of test also presents evidence concerning the above implication. Some of the items included in one of the tests which was being administered when the investigator visited the class follow:

Mark the following statements as true or false—

1. A collar cell contains flagella.
2. A 2-year-old sponge contains mesoglœa.
3. The osculum is the mouth of the sponge.
4. The sponge may be reproduced by regeneration.
5. Sponges are marine animals.
6. An amœba and a paramœcium move by cilia.
7. The oral surface is the ventral surface of the starfish.
8. The starfish is radially symmetrical.
9. A paramœcium has a macronucleus.
10. A water vascular system is characteristic of the Echinodermata.

The type of test given determines to a large extent the type of study done by the pupil. If he is to be tested on the details of structure and physiological processes of animals, he will focus his attention upon these details and attempt to "learn" them in order to pass the course. It may be necessary to determine if the pupil has the information necessary for the understanding of life processes and such a test may be legitimate for this purpose. It is questionable, however, if such a test is an adequate test for achievement in biology.

According to the second point of view, the units or topics are determined by an answer to this question, "What are the fundamental life processes and activities of living things toward which an individual should have an intelligent attitude?" A new syllabus just published by the University of the State of New York presents an example of this viewpoint.[2] This course includes 11 units as follows:

(*1*) Man is one species among millions of diverse species; (*2*) There is unity among all living things; (*3*) Living things and their environment are constantly changing; (*4*) All living things have the same problems; (*5*) Living things bear different nutritional relations to their environment; (*6*) Living things have to be able to relate themselves to their environment; (*7*) Reproduction is race preservation; (*8*) Variation and

[2] Tentative Syllabus in General Biology. The University of the State of New York, Albany, 1931.

heredity are the bases for race modification; (9) Man is learning to control and improve his environment; (10) Man makes use of biological discoveries in understanding his own body and in promoting health; and (11) The progress of man is a biological phenomenon.

Organized on this basis, the different plants and animals supply assimilative materials and are studied to supply data which will help in the solution of the problem set by the unit. For example, to supply an answer to the problem, How do living things grow? the teacher might well have the pupil study an amœba, a seed, a tree, an egg of a chicken, a horse, and a potato tuber. Through the study of the growth of these living things, the pupil will discover the nature of growth and the factors influencing it. The emphasis in such a course is on the life processes and activities rather than on a descriptive account of living things. Organization around different plants and animals emphasizes the dissimilarities of living things; organization around life processes and activities emphasizes the similarities of living things. It is, of course, possible to arrive at an understanding of biological principles by either method. There is no evidence to indicate that one method of organization is superior to the other. The two viewpoints are included in this report because they represent a fundamental difference in the attack upon biology. Recent opinion as indicated by the New York State syllabus and the report of the committee in the Thirty-first Yearbook of the National Society for the Study of Education tends to support the latter viewpoint.

The organization of courses in physics.—Courses in physics present a marked contrast to the courses in biology and general science. The topics in all the courses were classified easily under the headings: Mechanics, heat, magnetism and electricity, sound, and light. There was some difference in the order of the topics presented and also in the divisions which were included under the main headings, but in general one obtains an impression of order and uniformity. As far as could be observed in the courses of study, there appeared to be little if any difference between the courses of study and the standard textbooks in the field; therefore, no detailed analysis is presented. To be sure, some few courses included references to local situations and specific references to different books, but the organization shows as a whole that teachers of physics have accepted the organization of the writers of textbooks. Physics, of course, is a relatively old subject as compared with general science, biology, and chemistry. Blake's Natural Philosophy, published in 1835, shows approximately the same organization as the physics textbooks of to-day, with the exception that astronomy, then included in the course, has become a separate field of instruction. It may be that the final word on the organization of a course in physics has been said. On the other hand, the decline in the enrollment in the subject at least suggests that a reorganization with a change of emphasis might be desirable.

The organization of courses in chemistry.—The topics included in courses in chemistry are of three types: (1) Those dealing with descriptions of elements or compounds; (2) those dealing with principles of chemistry; and (3) those dealing with applied chemistry. As a rule, courses contain all of these types of topics; for instance, any course which has topics on oxygen, chemical equilibrium, and fertilizers is a case in point. Apparently chemistry courses closely parallel courses in biology as previously described.

Commonly an element is studied from the standpoints of occurrence, preparation, physical properties, chemical properties, important compounds, and uses. As such the topic presents a description of the element under consideration. In all the courses it has been found necessary to insert topics on the gas laws, the chemical nature of matter, solutions, periodic law, chemical nomenclature, and formulas and equations. Sixty-eight per cent of the courses included topics such as fuels, food, clothing, fertilizers, cleaning agents, poisons and antidotes, glass, clay products, paints, and alloys.

A few of the newer courses have approached the organization of chemistry from a different angle than the method just described. The generalizations and principles to be taught are first determined. These are listed at the beginning of the course and are included in the topics in the same manner as described in the chemistry course. (See p. 25.) These courses still retain the descriptive method of organization with the generalizations included here and there in the topical outline. Attention is still focused on the details concerning each element; the generalization is simply added to the descriptive material which is characteristic of the older courses. One instructor who worked on a course of this kind and who believed that the main objective of chemistry is the understanding of principles rather than a collection of facts concerning chemicals, remarked, "If we had organized the course in terms of principles, the old-type chemistry teachers would have been lost; they would not know what to do and they would have thrown the whole course overboard. By this method, we are trying to get them used to the idea, and our next step will be a course organized around the principles of chemistry." The resulting course is, therefore, a hybrid, but it is intended to be a step toward a new form of organization.

The final step in this direction is shown by a course organized around the important principles of chemistry. This course is in the process of being tried out and undoubtedly will undergo some revision. The units are as follows: Unit 1, The Nature of a Chemical Change; Unit 2, The Chemical Composition of Matter; Unit 3, How the Chemist Represents Chemical Reactions; Unit 4, The Nature of the Metallic Elements; Unit 5, Oxidation and Reduction; Unit 6, The Relation of Solution to Chemical Change; Unit 7, Acids, Bases, and Salts; Unit 8, The Nature of Nonmetallic Elements; Unit 9, The Nature of Carbon Compounds; Unit 10, The Periodic Classification of Elements. This type of organization is similar to that proposed by the New York Syllabus in the course in biology. The problem of organization discussed in connection with biology is thus applicable here, and to conserve space it will not be repeated.

Seven of the courses in chemistry acknowledged their indebtedness to the American Chemical Society for their topics and objectives. The influence of this organization was apparent in many of the courses examined. In two courses, mention was made that the organization met the demands of the College Entrance Examination Board.

CHAPTER VI : SELECTION OF SUBJECT MATTER

Investigation of the selection of subject matter.—The criteria used in the selection of the subject matter of the courses are stated in but two of the courses examined. Indirectly the statement of objectives is a statement of criteria since the objectives should control the selection of material. Only one course refers to the studies which have been made in the field of science curriculum. In general such studies may be grouped under the following types: (1) Analysis of human activities; (2) analysis of children's interests (*a*) through questionnaires, (*b*) through pupils' questions to magazines, and (*c*) through exposure to nature materials; (3) findings of committees, based largely on the consensus; (4) surveys of current literature, including (*a*) topical analysis of textbooks; (*b*) topical analysis of courses of study; (*c*) analysis of textbooks to discover principles treated; (*d*) analysis of textbooks to discover the types of activities treated; (*e*) analysis of topics and principles treated in newspapers, magazines, popular science publications, Government bulletins, etc.; (5) analysis of mistaken notions and superstitions; (6) analysis of adult interests; (7) judgment of laymen on value of certain principles and topics of science; and (8) synthesis of the results from the sources listed above. The great majority of these studies have been summarized by Curtis.[1] The two volumes of Curtis are indispensable to those who are working on courses of study.

Examination of the studies which have been made discloses that the sole emphasis has been upon the determination of the principles or subject matter which should be included in our science courses. Apparently no studies have been made of the difficulty of these materials. Placement of the topics or principles in the various courses is determined by the logical demands of the subject rather than by the psychological characteristics of the learner. While the studies which have been carried on are necessary, parallel

[1] Op. cit., p. 45.

studies should be made of the difficulty of these materials to pupils at different levels of maturity. Another interesting disclosure of such an examination is that these investigations treat science solely as a matter of content; research on science as a method of thinking is totally absent. Here again the problem of how pupils progress in the development of the ability to use science as a method of thinking should be investigated and should be a major factor in determining the content and organization of the materials of instruction.

The trend in subject matter.—It is difficult, if not impossible, to evaluate a course of study in terms of its success in providing materials to attain the objectives set forth. In general it is assumed in courses of study that the teacher has a background of experiences which will supplement the course outlined. The success of the course in meeting the objectives is thus largely dependent upon the teacher. The trend of courses is to provide more adequately for the interpretation of the forces, materials, and phenomena than has been done in the past. This is evidenced in physics by the inclusion of more material on devices and by additional problems focused on everyday science. In chemistry courses new materials have been provided largely through the addition of topics on applied chemistry such as fertilizers, cement, etc., and the inclusion of special topics upon which pupils may report to the class. Biology has provided for practical materials in somewhat the same manner as chemistry. The general science courses are focused upon interpretation of the environment and the topics and problems make a direct attack upon the problems of everyday life.

Only a few of the courses include materials or suggestions dealing with scientific attitude and methods of scientific thinking. Three courses deal more or less perfunctorily with scientific attitude and thinking in an introductory topic. One course has a topic on "superstitions." In general, however, one must assume that curriculum makers believe that scientific attitude and methods of thinking can not be attacked in a direct manner or that they result automatically from the study of science or that they should be attacked incidentally as occasion arises. A more detailed discussion of this problem will occur in a later section of this report.

Duplication and overlapping of courses.—Duplication or overlapping of courses is most common in the case of general science and physics. The following topics in general science cover to a considerable degree the qualitative side of the principles presented in physics: Air, lighting, buildings, communication, transportation, electricity, weather, water supply, machines, and heating buildings. For example, the pupil is introduced to air pressure, evaporation, buoyancy, and many other principles of physics. In the general science course, the principles are drawn in as they are needed to explain the environment. In physics, of course, the principles are organized around the logical divisions of the subject. The physics course of to-day is essentially the same course as far as content is concerned as the physics course of 1910. Practical applications are stressed more to-day than in 1910, but the course has not changed so far as the principles are concerned. This indicates that the teachers of physics have not considered their course in light of the contribution which they might expect from a course in general science. Conversations with teachers of physics confirm this statement. Their attitude is often, "They do not remember any of their general science." If this is true, it is a serious indictment of general science. What we need, of course, are experiments which will either validate the claims of the teachers of physics or disprove them. Through such experimentation we should be able to determine what not to teach in physics of the materials given in general science.

Some duplication also occurs between courses in general science and biology. The topics in general science which overlap the courses in biology are foods, health, human physiology, plants, and animals. Where the biology is taught in the junior high school as a part of a 2-year or 3-year course in science this duplication is not often found. In 4-year high schools, where general science is offered in the ninth grade and biology in the tenth grade, this overlapping is always present. The fact that courses can be organized without duplication indicates that teachers of biology either do not believe that the course in general science is efficiently taught or that they have organized their course without regard to what has gone before.

The evidence presented concerning the overlapping of courses is further proof of the tendency of the teachers of a special field to regard their subjects as distinct parts of the curriculum wholly unrelated to the rest of the curriculum. To some extent the teachers of the special sciences are justified in this viewpoint; pupils do not take all of the courses in sequence, hence the degree of preparation for a given course varies widely. A distinct lack of sequence appears in science courses, both from the standpoint of content and from the standpoint of difficulty. Apparently, we need a new organization of courses beginning at the bottom and working upward.

CHAPTER VII : SUGGESTIONS ON INSTRUCTIONAL TECHNIQUE

Types of suggestions.—Some courses of study which were analyzed included suggestions for the teachers on various phases of instructional technique. The items in Table 6 are significant in that they show the aspects of teaching which the curriculum committees believe to be important and in which guidance is necessary. The low frequency of these suggestions indicates that curriculum makers as a whole do not believe it necessary to include suggestions on methods of teaching. In one course, for instance, the statement is made that "no methods of instruction are indicated because the personality of the teacher determines results vastly more than any other factor." Committees, in general, believe that the method of teaching should not be prescribed, that the individual teacher should be permitted the utmost freedom.

TABLE 6.—*Types of suggestions offered to teachers*

Suggestions	Number of courses	Suggestions	Number of courses
Flexibility	16	Talks by pupils	4
Revision	14	Field trips	20
Method	20	Bulletin board	4
Demonstrations	12	Current events	2
Experiments	22	Visual materials	8
Notebooks	15	Collections	2
Recitation	13	Types of pupil activities	3
Use of textbooks	3	Projects	7
Tests	13	Question box	2
Vocabulary	5	Reference material	21
Science clubs	2	Books on method	12
Science library	1	Books for advanced study	8
Science exhibits	1	Guide sheets	6
Science assemblies	1	Sample lessons	6
Term reports	5	Sample units	2

***Relationship of methods of teaching to the attainment of objectives.*—A consideration of the objectives of science teaching suggests that many of the most important results are the product of the method of teaching employed rather than of the subject matter covered. For example, training in scientific method is not secured by learning the facts of**

science; the training is the outcome of the technique employed in attaining an understanding of scientific principles and their application in new situations. One learns to think scientifically by employing the safeguards which make thinking critical and by abundant practice in thinking of this character.[1]

If the viewpoint presented in the preceding paragraph is correct, it is evident that the learning products attained from any given course of study will depend largely upon the method of instruction employed. Curriculum makers have assumed that teachers can and do employ those methods which will attain the objectives of science teaching. Observation of several hundred teachers during the past five years supplemented by conversations with principals, superintendents, and others has led the writer to doubt the validity of this assumption. While it is probably true that the great majority of our skilled teachers should be permitted to teach according to the methods which they have tried and found successful, what about the great army of inexperienced teachers in our school systems? Curriculum makers, perhaps wisely, are unwilling to prescribe methods to any great degree, because many teachers believe that they are as well qualified to formulate methods as are the members of the committee. This consideration does not apply, however, to the young and inexperienced teachers. They have few preconceived ideas and set habits and are eager for suggestions. Committees preparing course outlines should probably recede from the extreme position which they have taken and make more provision for the guidance of those teachers who have not reached perfection or complacency. Until a more uniform method of instruction is adopted it is doubtful that we will be able to organize science courses which are sequential in the development of the ability to do scientific thinking and in the development of the other abilities which

[1] Beauchamp, W. L. Analytical Study of Attainment of Specific Learning Products in Elementary Science. Unpublished doctor's dissertation, University of Chicago, 1930.

Downing, E. R. The Elements and Safeguards of Scientific Thinking. Scientific Monthly 20 : 231–243, March, 1928.

Shafer, B. F. The Relationship Between a Knowledge of the Principles of Science and Laws of Physics and the Ability to Make Applications. Unpublished Master's thesis, University of Chicago, 1928.

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result from the method employed rather than from the content. Data bearing on the above statement will be found later in this chapter and also in the chapter immediately following.

The extent to which courses of study determine what is taught.—It is difficult, if not impossible, to make a general statement concerning the extent to which the course of study actually determines what is taught. In four of the school systems visited detailed courses of study with many suggestions for teaching had been constructed. These were followed very closely by the teachers of the junior high school. This was evidenced by the fact that these teachers invariably handed the visitor a copy of the course, indicating the lesson under consideration. In these same school systems, the teachers of the senior high school never referred to the course of study when conferring with the visitor and, when asked for a copy of the course, more than three-fourths did not have a copy in the classroom. In certain cities, teachers frankly admitted that they paid no attention to the courses of study. Others said that they taught the topics indicated, but otherwise made no use of the material. If generalizations are possible from these observations, they are—(1) that junior high school teachers follow the courses of study more closely than senior high school teachers, and (2) that the more detailed the course (in terms of outline and teacher's suggestions) the greater the use made of the course.

Adapting instruction to individual differences.—Each course was checked to discover if provision had been made for individual differences and to determine the kinds of recommendations with reference to individual differences which were made. The course was checked under "General mention," if there was a general paragraph or more concerning adaptation to individual differences included in the course. In some courses specific provisions for individual differences were stated for each unit. In some courses a list of optional topics or projects was given at the end of the outline. The frequency noted in Table 7 indicates that the problem of adapting instruction to individual differences has received little attention in the courses of study. (See Monograph

No. 13 of the National Survey of Secondary Education for a discussion of provisions for individual differences.)

TABLE 7.—*Number of courses making certain types of provisions for individual differences*

Suggestions	General science (58)	Biology (45)	Physics (27)	Chemistry (30)	Total (160)
1	2	3	4	5	6
General mention	6	2	4	2	14
Two or three track plan	1	2	----------	2	5
Optional topics	3	6	2	----------	11
Optional experiments, etc.	9	3	1	2	15
Optional topics or projects at end	9	6	2	3	20
Supplementary references	17	12	6	7	42

NOTE.—The numbers in parentheses indicate the number of courses, which include some recognition of such provisions.

The methods listed in Table 7 are based primarily upon a quantitative provision for pupils of different interests, needs, and abilities; that is, they provide a minimum content for all pupils plus additional materials to meet different interests and different abilities. One suggestion only is made which might indicate that pupils of different abilities may work on different qualitative levels and hence the types of activities and subject matter should be different for pupils of different abilities. Some investigations to determine if pupils of low intelligence can profit from the courses of science, as they are now organized, are necessary in order to determine qualitative differences in the courses designed for pupils of different native abilities.

CHAPTER VIII: TYPES OF PROBLEMS IN CLASSROOM TEACHING

Sources of problems.—The data presented in the preceding chapter listed the general types of suggestions offered for the guidance of teachers. To discover the problems which arise from these suggestions, a detailed analysis of all suggestions included in courses of study was made. The results show a considerable difference of opinion as to the best methods of instructional technique, and thus indicate unsolved problems in the teaching of science. The opinions gathered from the courses of study were then supplemented by the data obtained from classroom visits. The final list of major problems is thus a composite of the data obtained from these two sources. In the paragraphs which follow the writer will attempt to enumerate these problems and to indicate the types of research which have been made and the types of research which still remain to be carried on. Owing to limitations of space it is impossible to summarize the research which has been done. The reader is referred to the two volumes by Curtis for excellent summaries of this material.

The size of a learning unit.—It is claimed by some that each day's lesson should be complete in itself. Each day's work should start with a certain problem, be followed by a regularly prescribed procedure, and end with a solution to the problem and possibly the application of the results in some new situation; this is believed to be particularly advantageous at the junior high school level, where classes meet but two or three times per week. Others assert that this method will break the continuity of the course and result in a series of isolated lessons. Furthermore, they claim this will break the learning units into divisions that are too small. They therefore believe in comprehensive problems which may require several days for a solution. Which is the better method? Or is a combination of the two methods more desirable than either?

The use of several textbooks.—If teachers in some schools are asked, "What textbooks are you using?" some of them reply with evident pride, "We don't use one textbook, we use several textbooks." In these schools it is generally the custom to provide several sets of textbooks which are kept in the classroom. The student, as a rule, therefore, does not have a book of his own that he may take to the study period or home. How does this method compare with the method in which a pupil has his own book? Another problem relates to the use of several books. Assignments are often made on a given problem or topic to several books in which the content is entirely repetitious. Pupils wander around the room looking for books and waste a great deal of time. Since the content is repetitious could the time have been spent more advantageously in studying one book? The organization of the different books usually varies to a considerable degree. To make assignments to a specific topic in any given book often takes the content out of its setting in the book and in many cases makes the material misleading or unintelligible. For example, if one book covers air pressure in an early part of the book and the pupils are assigned to a later part of the book dealing with water supply, it is assumed that air pressure has been covered and the material is dealt with accordingly. The class may not, however, have covered air pressure in their regular classroom work, so that the new material is unintelligible. The same problem occurs with many courses of study. They are put together without regard to any existing materials on the content represented. The result is that the pupil must read one paragraph on page 311 of one book, one paragraph on page 22 of another book, and so on for the other references. In the classes visited a large portion of the time supposedly used by pupils for supervised study was spent in looking for books or looking up isolated passages in books. The problem is probably not so much that of deciding whether one book or many shall be used as it is that of providing a technique which will result in the most efficient use of the pupils' time.

The committee method.—In the junior high school a great deal of the work is done by what one may call the committee method. This method is carried on in several ways. By one technique the large topic under consideration is broken up into smaller topics and each of these smaller topics is assigned to be reported upon by a committee. By this method a pupil prepares only for that part of the topic for which he is responsible. Each committee reports and the rest of the pupils listen. In the classes visited, the reports were often dull and received the attention of but a small minority of the pupils. In some classes, the teacher had discovered this and required pupils to take notes and pass a test on the information given. This procedure assumes that the report is for the purpose of giving information to the student and, since a large amount of the class time is spent in reporting, this really becomes the major objective of the course. Contrasted with this method is that in which each individual is responsible for the development of the entire topic. Several issues, of course, are involved here. Committee work is assumed to have a value in the socialization of the individual. On the other hand, it may tend toward producing a lack of feeling of responsibility on the part of the individual. In one class several problems were raised which the teacher thought it advisable not to answer. She appointed on the spot a committee to report the next day and told them she would be glad to help them find material. She then went on with the regular class discussion. In another class of this same teacher, the first question asked by a pupil was, "What did they find out about that submarine?" "They" referred to a committee which had been appointed the previous day. This use of a committee appeared to be very effective. The problem raised would seem to be, What is the best method or methods of utilizing the committee method of investigating and reporting upon problems?

The topical method.—In one class visited the topic was "Mammals." The teacher announced, "We shall have 10 minutes for study." At the end of 10 minutes she asked, "Who is ready to recite on the first topic?" (naming the boldface heading in the book). A pupil volunteered. During his recitation the majority of the members of the class had their books open, following what the pupil said or preparing on the next topic. When the pupil finished the teacher asked, "Does anyone have any corrections or additions to make?" Several pupils raised their hands and volunteered isolated bits of information which had been omitted. This procedure continued to the end of the period. In another class in the same school system, the same topic was under discussion. The teacher raised the question, "Why are mammals important to us?" As different uses were named she wrote them on the board and then asked, "How can we classify those used?" Pupils suggested ways, such as transportation, food, etc. Both classes had the same source of data and actually gave back to the teacher approximately the same facts. One attack was topical in character and the other was problem-solving. Perhaps most of us will agree that the second method was better than the first, but no data are available which can be shown to the first teacher to prove it.

The use of scrapbooks, posters, and related materials.—In junior high school classes one often finds a vast collection of posters, scrapbooks, and exhibits which have been made by pupils. Arranged properly in a room they are impressive to the visitor and if mixed judiciously with living materials and apparatus make an effective atmosphere for the science classroom. Two questions, however, arise in this connection, namely, (1) Is the use of classroom time legitimate for making materials of this sort? and (2) What values are derived from this type of work? In many schools these projects are carried on voluntarily outside the classroom. Several classes were visited, however, in which scrapbook making was, at least during that day, the sole activity. The work consisted in cutting out colored pictures of foods, machinery, newspaper clippings, etc., and mounting them in a book. In some cases captions were written under them and in others not. In some of the notebooks the material was classified under different headings and in others not. In some cases the material collected related to the topic under discussion and in others not. All in all, the notebooks represented a miscellaneous collection of materials collected in a more or less haphazard fashion. In one of the classes, the entire period was spent by different pupils holding their notebooks up in front of the class (the majority of the class could not see them) and telling the class, "This is a picture of ———." If one considers this procedure in relation to the objectives of the course, it is hard to conceive of any value beyond "securing an interest in science," and it is questionable if this is an outcome. Scrapbooks undoubtedly have a legitimate place in junior high school science, but we need to determine what the function is.

The use of guide sheets.—In many schools guide sheets are given to pupils to direct their study. In some cases the pupils are required to answer the exercises in writing and in others they are merely guides for study. These guide sheets vary in content. Some consist of a long list of questions such as the teacher would ask under the ordinary assignment-recitation technique, the only difference being that they are now in written form. They are focused on the details of the subject matter and can usually be answered by finding a sentence which contains the same words as the exercise. In one of the classes visited, the investigator asked to see one of the best notebooks, an average notebook, and a poor notebook. On examination, the answers to the exercises were found to be identical. On checking back with the textbook it was found that questions had been asked which were answered directly in the book. The only difference in the notebooks was in neatness. All degrees between the example thus cited and the guide sheet which consists of a few comprehensive problems can be found. A recent study by Hurd[1] indicates that, properly used, guide sheets may prove of value. Many teachers object to guide sheets because they say that they rob the pupils of initiative and make them dependent. This, therefore, is a problem requiring further investigation.

Another problem is concerned with the type of exercises which should be included on the guide sheet. Still other problems arise in the administration of the guide sheet. Some teachers aim to help the pupil by answering the questions; others question the pupil and direct him to other sources of data. Some teachers require that the exercises be completed in class; others allow pupils to complete them

[1] Hurd, A. W. Teacher Opinion and Suggestions on Teaching Units in Physics. School Science and Mathematics, 32 : 39-42. January, 1932.

at home. Some teachers have the students read their answers to the class, focusing attention on the exercises as ends. Others use the exercises merely as learning activities necessary to arrive at certain definite understandings. There are probably as many kinds of guide sheets and methods of using them as there are teachers. Some systematic study of their values and limitations is desirable.

The use of the pupil work book.—Another type of guide sheet which is being rapidly introduced into schools is in the form of "pupil work books." These vary like the guide sheets as to the types of exercises which they include. As a rule they contain blank spaces to be filled by words, phrases, sentences, or paragraphs. In one class visited, the pupils were told to read their texts and fill out the blanks on a certain page. The teacher then sat at her desk and filled out the blanks. Ten minutes before the end of the period, the pupils were called to attention. The teacher read the first question and called for a volunteer. If the correct answer was not forthcoming, she called on other pupils until she got it. The pupils were instructed to check the answers which were not correct and to write out the correct answer on a separate sheet of paper. This is probably not the procedure which would be recommended by the writers of work books, but it is what actually took place in one classroom. Many teachers object to the use of a work book, because they claim that it does not provide for a unified view of the whole topic or unit under discussion. Others are enthusiastic about work books. Further experimental evidence as to their value and as to the value of different methods of using them should be obtained.

The unit method of instruction.—There are many advocates of the so-called "unit method" of instruction. As has been pointed out before, the term "unit" has nearly as many meanings as there are courses. A few studies have been made in which attempt was made to prove or disprove the value of this method. The issue, however, is confused because the studies have not separated distinctly the idea of organization from instructional technique. Organizing a course in terms of units is one thing; teaching by the 5-step technique is something different. In some cases topics taught by the "unit technique" have been compared with topics taught by the assignment-recitation technique. The writer knows of no clear-cut experiment which reliably determines the value of the unit organization as compared with a topical organization or the value of the unit technique as compared with the assignment-recitation technique. The major difficulty is one of devising adequate instruments to measure the outcomes.

Initiation of new work.—The suggestions given in courses of study often refer to the initiation of new work. For example, some believe that a new topic or unit should take its point of departure directly in some problem which arises in connection with the environment. Others believe the work should be initiated by a demonstration. Still others believe that the work should start in individual laboratory work. In practice it was observed that in many cases the work began by an assignment in the textbook. Some courses suggest that all work should be initiated in a prescribed manner. Is there any best method of initiating new work on a given topic or does it vary with the type of topic? Some of the courses state that the laboratory should furnish the core of the course, textbooks and other materials being selected to supplement the experimental work. In other courses, the laboratory supplements or parallels the work in the textbook. An analysis of the types of experiments recommended disclosed the following purposes of experimental work: (1) To determine effects resulting from certain conditions; (2) to discover relationships; (3) to determine unknowns; (4) to demonstrate laws; (5) to determine constants; (6) to compare; (7) to secure practice in using instruments and operating scientific devices; (8) to evaluate methods, devices, etc.; and (9) to verify certain facts. It is evident from this analysis that certain types of experiments are adapted to initiation of work and others for verifying, paralleling, or supplementing the regular classroom work. It seems possible that one might devise an experiment using different methods of attack upon principles to discover if there is a best method which is general in its application or if the method depends upon the principle being presented.

The use of the project method.—The investigator expected to see schools in which the project method was employed; that is, where pupils selected the projects upon which they worked, either individually or in groups. No classes of this sort, however, were discovered, unless the scrapbook courses could be included under this heading.

Lecture demonstration versus individual pupil experimentation.—The war is apparently still raging concerning the problem of lecture demonstration versus individual pupil experimentation.[3] In the schools visited, the large majority of the classes in general science were taught by the teacher-demonstration or pupil-demonstration method. In a few of the classes in the special sciences the instructors combined the two methods. No school was visited in which the special sciences were taught wholly by the demonstration method. This is owing in part to the demands of colleges and other standardizing agencies, in part to the lack of belief on the part of teachers of special science as to the validity of the findings of the experiments which have been carried on, and in part to the fact that many of the teachers have never heard of the experiments. When one considers the financial pressure upon the schools at the present time and the demand for economy, it would seem advisable that the present experiments should be extended to the point that they may definitely prove to the satisfaction of the colleges, school administrators, and teachers that the "lecture demonstration" either is as valuable, is not as valuable, or is equivalent to

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[3] Anibal, F. G. Comparative Effectiveness of the Lecture Demonstration and Individual Laboratory Method. Journal of Educational Research, 13: 355-365, May, 1926.

Cooprider, J. L. Teacher versus Student Demonstrations in High-School Biology. School Science and Mathematics, 23: 147-155, February, 1923.

———. Oral versus Written Instruction and Demonstration versus Individual Work in High-School Science. School Science and Mathematics, 22: 838-844, December, 1922.

Downing, E. R. A Comparison of the Lecture Demonstration and the Laboratory Methods of Instruction in Science. School Review, 33: 688-697, November, 1925.

Johnson, P. O. A Comparison of the Lecture Demonstration, Group Laboratory, and Individual Laboratory Experimentation Methods of Teaching High-School Biology. Journal of Educational Research, 18: 103-111, September, 1928.

Kiebler, E. W., and Woody, C. The Individual Laboratory versus the Demonstration Method of Teaching Physics. Journal of Educational Research, 7: 50-58, January, 1923.

Knox, W. W. The Demonstration Method versus the Laboratory Method of Teaching High-School Chemistry. School Review, 35: 376-386, May, 1927.

Riedel, F. A. What, if Anything, Has Really Been Proved as to the Relative Effectiveness of Demonstration and Laboratory Methods in Science? School Science and Mathematics, 27: 512-519, May, 1927; 620-631, June, 1927.

the individual pupil experimentation method in achieving the objectives of science.

Methods of demonstration.—A great deal of pupil or teacher demonstration was observed in the junior high school classes. Many different methods were noted. In one class the teacher demonstrated the "convection box." As he proceeded with his demonstration, he raised questions which the class answered in unison. After each answer he restated the result observed. When this was completed he wrote the following outline on the board:

> Problem—What were we trying to find out?
> Material—What did we use?
> Method—Windows all open. Trial I, etc., Sketch box to show currents for each trial.
> Observation—When did the candle stay lighted the longest? When were distinct air currents produced?
> Conclusion—What is the best method of ventilating a bedroom? What is the best method of ventilating another room while absent from the room? (Both of these questions had been answered by the teacher during the experiment.)
> Application—How can you insure a supply of healthful air in your sleeping room?

In another class the same general procedure was employed with the exception that the outline given above was placed on the board before the demonstration was made. The pupils thus were aware of what questions they were to answer. The questions were not answered orally and hence every pupil in the class was obliged to solve the problems for himself. Other methods of demonstration are contained in the suggestions quoted from the courses of study. There is abundant opportunity here to devise different methods of demonstration and evaluate their efficiency.

Methods of recording laboratory exercises.—Various methods are in use for recording the results of laboratory work. Among these are: (1) Formal presentation under prescribed headings, such as purpose, method, results, and conclusion; (2) answering a series of questions about the experiment; (3) writing up the results of the experiment in connection with some problem which has been raised; (4) filling blanks in a printed laboratory manual; (5) combining two or more of the methods indicated above. Some experimental study of these methods has been undertaken.[3] A problem of major importance is that of the rôle of the laboratory work. In many schools the laboratory work tends to become an end in itself. This tendency is intensified if the laboratory work is recorded in a formal way. In some schools, the laboratory is considered to be a source of data for the solution of problems. Problems are raised during the classroom discussion and the pupils are sent to the laboratory to solve them; one difficulty with this method is that the laboratory work will not necessarily fall upon the scheduled double periods. Some schools, however, have worked out a system which overcomes this difficulty. An experiment could be devised which would compare the different methods of recording experiments; the relative value of experiments as ends or means could also be determined.

The suggestions included in courses of study are distinctly opposed to detailed drawings of the picture type. Observation of classroom work in biology indicates, however, that a large amount of the laboratory period is spent in preparing such drawings. The picture in the textbook is usually the model for such drawings. In one class a pupil asked the teacher for carbon paper and then traced the drawing in his notebook. The teacher explained that she allowed this practice because it saved time. In another class pupils were drawing leaves. The leaf was placed on paper and its outline traced. The entire leaf outline was then filled in with ink. A period of 40 minutes was required by one pupil to draw a maple leaf and an elm leaf. In some classes outline drawings of animals are given to the pupils and the pupils are required to name the parts indicated on the drawing. A considerable amount of experimental work has already

[3] Baird, D. O. A Study of Biology Notebook Work in the State of New York. Teachers College, Contributions to Education No. 400, 1929.

Moore, F. W., Dykhouse, C. J., and Curtis, F. D. A Study of the Relative Effectiveness of Two Methods of Reporting Laboratory Exercises in General Science. Science Education, 13: 229-236, May, 1929.

Phillips, T. D. A Study of Notebook and Laboratory Work as an Effective Aid in Science Teaching. School Review, 28: 451-458, June, 1920.

Stubbs, M. F. An Experimental Study of Methods for Recording Laboratory Notes in High-School Chemistry. School Science and Mathematics, 26: 233-240, March, 1926.

Turner, H. A Question and Answer Method of Writing Physics Experiments. School Science and Mathematics, 26: 63-67, January, 1926.

been done in this field.[4] Further experimentation, however, would be highly profitable.

The use of detailed or general laboratory directions.—A considerable difference of opinion exists in regard to the type of laboratory directions to be given to the pupil. The common method is to supply the student with detailed directions as to procedure. This sometimes results in a mechanical method of doing laboratory work. For example, the directions say "Obtain a test tube," the pupil gets one; "Pour in an inch of water," the pupil does so; and so on for the rest of the experiment. The purpose of the experiment is forgotten or never realized since the attention of the pupil is on the details of performance. In contrast with this procedure, one class was observed in which the pupils were almost entirely on their own resources. For example, the problem is raised and the pupils devise their own experiments. The class observed was a chemistry class. Pupils were given direction sheets on "Methods of Recording Data," "Collection of Products," "Selection of a Generator," "Methods of Identification," "The Separation of Mixtures," etc. In preparing oxygen, for example, the pupil selected his own method, the type of generator needed, the method used to identify the product, and the method of recording his data. Magazines on industrial chemistry were available in the classroom and pupils consulted them to find suitable methods of presenting their materials. Before doing the experiment, the student presented his method to the teacher for his approval. The class was visited during a laboratory period. The investigator asked questions of the students. All knew exactly what they were doing, how they were going to do it, and what they were trying to discover. The method is mentioned as one which offers a

[4] Ayer, Fred C. The Psychology of Drawing with Special Reference to Laboratory Teaching. Baltimore, Warwick & York, 1916.

Ballew, A. M. A Comparative Study of the Effectiveness of Laboratory Exercises in High-School Zoology With and Without Drawings. School Review, 36 : 284–295, April, 1928.

Cooprider, J. L. Shall the Drawings Be Inked? School Science and Mathematics, 25 : 69–73, January, 1925.

Colton, H. S. Drawing a Factor in the Training of Students in a Course in General Science. School and Society, 24 : 463–464, October 9, 1926.

Miller, W. L. Shall Biology Students Draw or Not? School Science and Mathematics, 28 : 247–254, March, 1928.

promising variation of the ordinary "recipe" method of carrying on experiments.

The use of visual aids.—Some school systems are well equipped with motion-picture machines and other devices for visual instruction. Five methods of using motion pictures were employed in the classes observed—(1) the picture was shown without comment; (2) pupils were provided with questions which they were to answer; (3) the machine was stopped at certain points and the instructor asked questions or gave added information; (4) pupils were permitted to ask questions during the showing of the picture, the machine being stopped whenever a question was raised; (5) pupils were given questions to answer after the picture had been shown. Experiments[5] have shown the value of visual instruction for certain kinds of topics. Experimentation, however, is needed to discover the most effective method of using motion pictures.

Training in scientific thinking.—Science courses commonly include, as one of the major objectives, "the ability to do scientific thinking." Twenty-six teachers visited were asked the question, How do you train pupils to do scientific thinking? The answers were of five types: (1) The study of science results automatically in this ability because of the nature of the subject matter of science: (2) it is not possible to train a pupil to think; (3) we had a lesson on that last week, or we will have a lesson on that next week; (4) we take that

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[5] Brown, H. E. Motion Picture or Film Slide. School Science and Mathematics, 26: 517–526, May, 1926.

Davis, I. C. The Use of Motion Pictures in Teaching General Science. General Science Quarterly, 7: 102–112, January, 1923.

Finegan, T. F. An Experiment in the Development of Classroom Films. General Science Quarterly, 12: 391–407, January, 1928.

Husband, D. E. A Comparative Study of the Effectiveness of Models, Charts and Teacher's Drawings in the Teaching of Plant Structures. School Science and Mathematics 29: 65–70, January, 1929.

Hughes, J. M. A Study of the Content of the Course in High-School Physics, With Suggestions of Needed Changes. School Science and Mathematics, 28: 619–628, June, 1928.

Hunter, G. W. An Attempt to Determine the Relative Values of Visual and Oral Instructions in Demonstration and Experimental Work in Elementary Biology. School Science and Mathematics, 22: 24–29, January, 1922.

Valentine, C. F. The Stereopticon as an Aid to Physics Teaching. School Science and Mathematics, 29: 78–80, January, 1929.

Wilbur, H. An Experiment in the Use of Visual Methods of Instruction. General Science Quarterly, 12: 480–484, March, 1928.

Wood, B. D., and Freeman, F. N. Motion Pictures in the Classroom. Houghton Mifflin, 1929.

up in the introduction to the course; (5) the pupils learn the method by watching the procedure of the teacher. None of the answers was sufficiently definite to give the investigator a clear idea of what was being done in this direction. This does not necessarily mean that no training in scientific thinking is being carried on but it does mean that such training is not given in a systematic fashion. The responses given by the teachers raise several questions: (1) Is it possible to train pupils to think scientifically? (2) Should this training be incidental or should it be placed in the direct focus of attention? (3) Does the study of the subject matter in science automatically result in training in scientific method? (4) Should training in scientific method be covered as a unit in the course or should it be an essential part of procedure in every class hour taught? (5) Does training in scientific method result from the subject matter included in the course or from the method of teaching employed? (6) What techniques result in training in the ability to do scientific thinking? Similar questions may also be raised concerning the objective, "the inculcation of the scientific attitude of mind."[6]

Testing the results of instruction.—An examination of the tests included in courses of study and collected during visiting reveals that for the most part they are tests of the ability of pupils to remember facts. This is particularly true of the tests in general science, biology, and chemistry. Tests in physics, as a rule, contain numerical problems, and problems which test the pupil's ability to apply principles in

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[6] Beauchamp, W. L. An Investigation of Pupil Progress in Elementary Science. "Studies in Secondary Education," 2: 14-33, Supplementary Monograph, School Review, February, 1926.

Bennet, J. O. A Study of Pupil Errors in Chemistry. Journal of Chemical Education, 4: 45-57, January, 1927.

Curtis, F. D. Extensive Reading of General Science as a Means of Increasing Knowledge of Scientific Facts and Principles. Teachers College Contributions to Education, No. 163.

Dalley, B. W. The Ability of High-School Pupils to Select Essential Data in Solving Problems. Teachers College Contributions to Education, No. 190, 1926.

Downing, E. R. The Elements and Safeguards of Scientific Thinking. Scientific Monthly 26: 231-243, March, 1928.

Herring, J. P. Measurements of Some Abilities in Scientific Thinking. Journal of Educational Psychology, 9: 535-558, December, 1918.

Nichols, M. L. The High-School Student and Scientific Method. Journal of Educational Psychology, 20: 196-204, March, 1929.

Parker, S. C. Problem Solving or Practice in Thinking. Elementary School Journal, 21: 16-25, September, 1920; 98-111, October, 1920.

addition to factual information. Teachers, in general, distrust the results obtained by experimentation as to the values of different methods of teaching on the ground that the tests are one-sided, that is, they test only one of the products of science teaching, namely, information. This criticism is well-founded in relation to certain of the experiments which have been made. To meet this criticism it will be necessary to formulate tests which really determine the extent to which all the objectives are being attained; we must test facts, attitudes, major ideas, and ability to do reflective thinking. Research along the line of test-building is clearly required.

Types of pupil activities.—Some courses of study list the types of pupil activities which should be carried on in the study of science. The activities suggested in one course were analyzed. The results are shown in Table 8. Inspection of this list indicates the indefiniteness of many of the activities focused on the recall or memorization of facts. Each of these activities should be scrutinized in terms of their contribution to the objectives of science teaching or one might begin with the objectives and ask the question, What activities will result in the attainment of the different objectives?

TABLE 8.—*Frequency of types of activities suggested*

Activity	Frequency	Activity	Frequency
Reading	10	Observing to note characteristics	26
Reviewing	15	Discover relationships	3
Recalling	46	Discover effects	6
Solving quantitative problems	21	Note differences	1
Making graphs	6	Learning:	
Making diagrams	11	That certain facts	3
Interpreting tables	1	That certain principles	12
Interpreting graphs	3	How	1
Interpreting diagrams	5	Why	1
Making models	1	Meaning of terms	2
Making devices	6	Studying:	
Connecting instruments	1	General	18
Taking devices apart	2	How	3
Experimenting to determine effects	34	Considering:	
Discover relationships	6	A given fact	9
Determine unknowns	6	Why	1
Demonstrate laws	19	How	2
Verify facts	12	Effects of	3
Discover principles	22	That certain principles	16
Operate devices	6	That certain facts	10
Use instruments	4	Noting a certain fact	3
Compare	34	Listing:	
Determine constants	9	Uses	6
Evaluate	4	Devices	6

TABLE 8.—*Frequency of types of activities suggested*—Continued

Activity	Frequency	Activity	Frequency
Listing—Continued.		Explaining—Continued.	
Values	1	Purpose of	11
Advantages and disadvantages	6	Why	27
Oral activities:		Differences	2
Telling how	8	How	21
Telling why	3	Effects	4
Telling what	2	Differentiating	2
Reporting	1	Investigating	11
Discussing	21	Suggesting new applications	6
How	1	Evaluating	6
Effect of	3	Synthesizing	2
Summarizing	3	Citing evidence	1
Making surveys	1	Finding relationships	3
Comparing	8	Estimating	1
Applying principles	4	Predicting	1
Explaining:		Analyzing	3
Meaning of	19		
Value of	4		

CHAPTER IX : CONCLUSIONS

1. The data presented indicate that, in general, the courses of study are not based upon an adequate and clear-cut theory of education. This is suggested by a lack of uniformity in organization and content in individual courses, which indicates that principles of organization and criteria for the selection of the materials of instruction have not been formulated.

2. The data presented raise the question of whether or not it is advisable to proceed in the revision of existing courses of study until more evidence is obtained to serve as a basis for such revision. The data available from scientific studies at the present time are directed solely upon the content of the courses. Little, if any, experimentation has been carried on to indicate grade placement of these materials, and no investigations have been made to discover the steps in the acquisition of the methods of thinking employed by the scientist. These two phases of the curriculum are, in the judgment of the writer, fundamental to the preparation of a science curriculum.

3. Observation of classroom teaching and the different suggestions given in the courses of study indicate great confusion as to the methods to be employed in teaching science. Since the great majority of school systems leave the choice of method to the teacher, it is evident that, beyond the prescription of the topics to be taught, the course of study has little effect upon the day-by-day teaching. Only a certain limited quantity of a teacher's time is available for additional work. The question is therefore raised, Will the teacher's available time be more effectively utilized if the time is spent in investigating methods of instructional technique or in working on courses of study? That is, which use of the teacher's time will result in the greater improvement of teaching?

4. The analysis of courses of study and classroom observation indicate certain practices which may be considered as innovating and hence should be carefully examined and

evaluated by those who are engaged in curriculum building and who are desirous of improving instruction in science. These practices are as follows:

(*a*) A shift has occurred from the organization of courses in terms of topics and subtopics to organization around certain major ideas or concepts. These ideas may be generalizations or principles of science or important ideas underlying the understanding and control of certain phases of man's environment.

(*b*) A shift has taken place from the topical method of developing a topic to the problem method of development. Each problem is focused on some important idea or generalization of science.

(*c*) A greater emphasis on the interpretation of the environment is observed in the more recent courses. This is indicated in the courses in physics and chemistry by a more marked emphasis on the qualitative aspects of the science with an accompanying decrease in emphasis on the quantitative aspects.

(*d*) A widespread use of illustrative materials supplied by newspapers, magazines, and Government bulletins was also observed in all science classes.

(*e*) The use of the classroom period for oral recitations has been replaced to a considerable extent by the use of the period for study purposes under the supervision of the teacher.

(*f*) The introduction of materials to serve as study guides is apparently widespread. These take the form of mimeographed guide sheets, containing directions for study and exercises to solve, and commercially printed work books. A study of the guide sheets indicates that the first formulation usually consists of a large number of questions focused on the various facts presented in the text. A marked similarity exists between these questions and the questions asked by the teacher in the oral recitation. Revision of this first set of guide sheets usually results in a great reduction in the number of exercises. The exercises of the revision are centered on ideas involving the use of facts rather than upon the accumulation of a series of facts. Work books vary in their emphasis. Some of them have not evolved past the first stage of development. The use of work sheets and work books undoubtedly has resulted in a greater emphasis on pupil activity and a consequent decrease in teacher activity.

(*g*) The more recent courses of study include a much greater number and variety of suggestions for teaching than the older courses. This appears to be a recognition of the principle that the products of a given course are largely dependent upon the method employed. This is a distinct shift from the older viewpoint which assumed that a course of study consisted solely in the enumeration of the content to be covered.

(*h*) Teacher or pupil demonstration has replaced individual experimentation to a marked degree in the junior high school. A great increase in the use of the demonstration is also observable in the specialized science courses.

(*i*) The laboratory work in the specialized sciences has, in the past, often been divorced from the work in the textbook. The organization of courses in terms of problems requiring a synthesis of the laboratory results and data from the textbook, has unified these two aspects of instruction. The solution of problems has been elevated to the focus of attention. The data obtained from the laboratory and the textbook are thus used as sources of data. This has resulted in some schools in a decreased emphasis upon the formal record of laboratory experiments. This shift in emphasis has been accelerated by the use of the demonstration method.

(*j*) More attention is being given to visual aids than ever before. Experiments have shown the value of films and slides for imparting information. In some schools a large portion of the instruction is carried on through visual aids. It appears that there is some danger that too great an emphasis upon visual material may neglect two of the fundamental objectives of science teaching, namely, the inculcation of the scientific attitude and increased efficiency in critical thinking.

This list of innovating practices does not necessarily indicate the changes which should be brought about in the teaching of science. The trends do, however, disclose the variations from the dominant practice which may well result in progress and which, as already stated, should be given careful consideration by those who are undertaking the improvement of instruction in science at the secondary school level.