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A Study of Instructional Practices and Recommendations of Thirty-Five Successful Biological Science Teachers in the Secondary Schools of Utah

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A STUDY OF INSTRUCTIONAL PRACTICES AND RECOMMENDATIONS OF THIRTY-FIVE SUCCESSFUL BIOLOGICAL SCIENCE TEACHERS IN THE SECONDARY SCHOOLS OF UTAH

by

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Gerald H. Raat

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CHAPTER I

INTRODUCTION

This study is concerned with the teaching of biology in Utah secondary schools. It is based chiefly on analysis of: (1) the teaching procedures used by thirty-five teachers of biology in Utah who were designated by their principals as being outstanding teachers, and (2) the facilities and equipment these teachers think are essential.

As long as schools exist there will be need for studies concerning teaching methods, facilities, and equipment. Man's ever-widening knowledge about science and the wide range in abilities of pupils in our schools make such studies in science particularly important. Perhaps the following will serve to emphasize this point of view.

Major (9, p. 95) pointed out in his thesis that the objectives of biological sciences have changed significantly in the last fifty years. By inference teaching procedures should also change.

Rivlin (15, p. 109) has discussed this relationship as follows:

> There is so close a relationship among the goals of education, the content and organization of the curriculum, the methods of teaching, that major changes in educational goals should be reflected in corresponding changes in the curriculum, and changes in the curriculum demand changes in methods of teaching.

Hoff (5, p. 115) has written:

> There is no royal road to learning, but there are techniques of imparting information and of effecting growth of pupils which are more efficient than other methods. It behooves those in the field of education to employ the methods which have been found to be more efficient in the light of our scientific studies in teaching procedure and educational psychology.

The Committee on the Teaching of Biology (14, p. 36) found that teachers want more and better special methods courses. The areas where they wished further emphasis were:

1. Improving laboratory and demonstration techniques.
2. Courses in observation and practice teaching.
3. Training in techniques for schools which have little equipment and material.

Stiles and Dorsey (17, p. 69) summed up the situation as follows:

> When the procedures of evaluation are focused upon teaching rather than the pupil, several glaring weaknesses are revealed. Teachers use poor methods. Teachers and laymen are little concerned about methods. Institutions preparing teachers have failed to provide opportunities for prospective teachers to observe the use of democratic methods in laboratory schools.

In view of the recognized importance of methods, facilities, and equipment to successful teaching of science, it was decided to undertake a study to see what the situation is in Utah secondary schools with respect to these matters. At the outset, consideration was given to conducting some kind of evaluation of the teaching of biology in every high school or junior high school in Utah in which the subject was taught. Since this seemed to be impractical, an alternative procedure was agreed upon. This was to devise a way of selecting a sampling of teachers considered to be especially successful, and then to have the study included only this particular group of teachers.

In order to select these teachers a letter was sent to each high school principal in Utah and to the principals of thirty-three junior high schools in which biology was taught. These letters indicated the general nature of the study and asked the principal to nominate a teacher to be included if he so desired. By this process thirty-nine teachers were named. It is recognized that this procedure may not

have produced the best teachers, but it did provide a list of teachers which were highly regarded by administrators.

Some consideration was given to making a personal visit with all teachers named. As a subsequent part of the study, a few such visits were made. To obtain the main body of data for the study, however, it was decided to construct a questionnaire which would seek answers to three main questions: (1) What teaching procedures or methods, and what physical facilities, both supplies and equipment, are being used by successful teachers of biology? (2) Assuming optimum conditions, what methods, supplies, equipment, and classroom facilities do these teachers recommend? (3) What are the reasons for any discrepancies which occur between teacher practices and recommendations?

In order to interpret these data some information about the teachers was also needed. Accordingly, the first section of the questionnaire was designed to gather specific information about the individual teacher.

Questions for the remainder of the questionnaire were obtained from a review of the literature as indicated in the next chapter of this report. A complete copy of the questionnaire is included in the appendix.

Chapter III deals with the presentation and analysis of the data, chapter IV with the summary and conclusions, and chapter V with the recommendations.

CHAPTER II

REVIEW OF THE LITERATURE

Biological science teaching procedures

The teaching methods, procedures, and techniques in biological sciences are many and varied. Probably few subjects in the curriculum of a modern secondary school so lend themselves to such a variety of teaching procedures. For this reason, it is impossible to list all the teaching procedures used in biological science; therefore, several authorities on this subject were consulted through their writings, and any desirable teaching procedures were recorded.

Before one observes this list, it should be noted that no one of the procedures can be considered best for all learning situations. The teaching procedure must depend upon the desired objectives of the course. Some teaching methods may be more desirable than others in certain instances, and some are used more frequently than others. Some are employed with greater success when experienced teachers apply them; some work well in a college environment and fail miserably in the high school; however, among successful teachers it was assumed that certain patterns of instruction would be found to be more generally successful than others.

Heiss and Obourn (4, pp. 114-138) describe and list the following teaching procedures:

I. Techniques for Developing Functional Knowledge

1. The lecture method
2. The demonstration method
3. The laboratory method
4. The textbook method
5. The individual method
6. The small group plan

7. The developmental method
8. The unit-problem method of instruction

II. Techniques for Developing Scientific Attitudes

1. The use of wide readings
2. The use of planned exercises
3. The use of the laboratory period to develop a desirable attitude
4. The study of superstition and unfounded beliefs
5. The influence of the teacher and the atmosphere of the classroom in developing desirable attitudes

III. Techniques for Developing Appreciations

1. Appreciations must be taught directly

IV. Techniques for Developing Interest

1. Occasional use of unusual demonstrations
2. Stalifying learning in itself may be dramatic and challenging

A. C. Kinsey (7, p. 18) has probably compiled one of the most comprehensive lists of teaching methods in biological science subjects. His list was one of the major contributors in the construction of the final questionnaire used in this study. His entire list is as follows:

1. Discussion
2. Recitation
3. Quiz
4. Teacher demonstration
5. Student laboratory
6. Field work
7. All-day picnics
8. Individual projects
9. Bulletin board exhibits
10. Class projects
11. Student reports on special readings or projects
12. Lecturettes by the students
13. Problem questions for home study
14. Demonstrations through microscopes or micro-projects
15. Lantern slide lectures
16. Moving pictures
17. Outside lectures
18. Wall charts, maps, and models
19. Museum collections
20. Student care of live plant and animal material
21. Borrowed collections
22. Special readings
23. Public exhibits

24. Competitions
25. Prizes for superior work
26. Junior academy of science
27. Question and answer box

After reading through this list, it should become apparent to the reader that the old teaching formula, lecture-assign-recite-experiment-write up, can and must be supplemented with more vivid and concrete experiences for the learner. Today, these additional methods of instruction can and should make learning more attractive, real, and concrete. The learning experiences in biological sciences need not be drudgery, nor should they be painful. Learning should be attractive to the learner. Probably the most beneficial way of improving the desirability of learning is through the application of adequate teaching methods.

Miller and Blaydes (11, p. 41) have prescribed the following classification of teaching methods:

1. The textbook - recitation method
2. The laboratory method
3. The demonstration - discussion method
4. The problem - project method

These authors further conclude, "These four groups include the elements of nearly all other methods which are, in most cases, modifications or combinations of them."

Another classification of teaching methods was proposed by Stiles and Dorsey (17, pp. 79-82) in their recent publication:

> Two patterns of teaching are controlled and dominated by teachers. They emphasize the memorization of subject matter and the kind of thinking that attempts only to supply the correct responses to teacher directed questions.
>
> Teacher-centric methods of teaching
>
> 1. The recitation

2. The lecture method

Pupil-centric methods are based upon the needs and problems recognized and accepted as important by the pupils.

Pupil-centric methods of teaching

1. The laboratory method of teaching
2. The project method
3. The dramatic method

Co-operative group methods of teaching

1. The socialized recitation
2. Group discussion method
3. Teacher-pupil planning

Grambs and Iverson in their book, Modern Methods in Secondary Education, (2, pp. 1-560) have discussed several different teaching techniques and methods. Some of the principal methods they mention in connection with science teaching are:

1. Group experiments
2. Demonstrations
3. Audio-visual aids
4. Unit plan
5. Project method
6. Problem approach
7. Field trips
8. Industrial excursions
9. Tours
10. Individual experiments
11. Write-ups
12. Drawings
13. Published manuals or workbooks
14. Student and teacher made laboratory workbooks
15. Experiments

Arthur G. Hoff (5, pp. 119-155) has presented a rather interesting classification in regards to teaching methods:

1. The unit plan
2. Lecture method
3. The reference method
4. The contract plan
5. The flexible assignment
6. The question and answer method

The author concludes that, "Critical evaluation on the basis of modern

philosophies of education gives the unit plan advantages over other methods of teaching."

Another classification, based on items which may lend reality and concreteness to the instructional procedure, is presented by A. D. Mueller: (11, pp. 205-206)

1. Visual aids - pictures, slides, motion pictures, specimens, collections, models, charts, maps, globes, graphs, and blackboards.
2. Field trips
3. Lecture - demonstration
4. Laboratory work by pupils
5. Dramatization

This author has also presented a list of the methods and techniques he believes are an indispensable part of classroom instruction. This list is presented as follows:

1. Textbook and collateral reading
2. Question and answers
3. The lecture or telling method
4. The problem method
5. Socialized class procedures
6. The project method
7. Measuring techniques

In many source books and materials pertaining to general teaching procedures in the secondary school there is a section or part devoted to special teaching methods and techniques in a science class. Hoff (5, p. 163) has included in his book what might be considered a typical section in this regard. The special methods he lists for science teaching are as follows:

1. Directed or supervised study
2. Conducting the laboratory
3. Demonstration and field trips
4. Evaluation or testing

Principles of good teaching methods

A further series of desirable teaching methods was gleaned from a variety of sources as indicated in the following quotations. In order

to prevent major duplications, each statement is numbered as are those in the subsequent lists, although these numbers do not appear in the original sources.

1. "Materials for learning should be presented in as many concrete ways as possible in order to reduce abstractions." (6, p. 12)

2. "The teacher who would avoid the dry rot of teaching must expose himself, as well as his students, to a variety of methods." (7, p. 17)

3. "The biology course will not effectively omit opportunities for the students to handle laboratory materials." (26, p. 113)

4. "I would like people to begin to walk before they try to fly, to be master of a few things before they become too dependent on the deductive procedure." (32, p. 24)

5. "We can all improve our teaching by making better use of living plants and animals in our laboratories. Then we would be teaching biology -- the study of living things." (33, p. 50)

6. "Every learning activity should be pointed toward definite aims." (15, pp. 60-106)

7. "Science resources of the community and environment are used." (19, p. 20)

8. "Particular emphasis is placed on experiments." (19, p. 20)

9. "Avoid technical terms before beginners." (7, pp. 14-15)

10. "To everyone who has any memory of his own youth, it would seem obvious that biology should center about live material and living processes." (7, p. 12)

11. "On the basis of data now available there seems to be no reason for substituting the teacher demonstration for more than a part of the individual laboratory." (7, p. 107)

12. "It causes less confusion in the minds of beginning students if plants and animal material are segregated." (7, p. 52)

13. "One method that has value in several directions is that of planning the course with the pupils instead of merely for them." (13, p. 188)

Harry N. Rivin (15, pp. 60-106) has compiled and formulated some interesting and useful principles in regard to teaching procedures:

14. The good teacher understands and respects his students.

15. The good teacher understands and respects the material he teaches.

16. The methods of teaching must be appropriate to the students, the subject matter, and the teacher.

17. Learning is an active process.

18. Things before ideas, and ideas before words.

19. Learning activities should be related to student needs.

20. Learning activities should be arranged in a graded sequence.

21. The development of attitudes and interests must be planned as carefully as is growth in knowledge and skill.

22. The teacher must help provide for individual differences in student's abilities and interest.

23. The textbook should be subordinated to its proper role as an aid to learning.

Paul De H. Hurd (6, p. 13) has produced a constructive group of principles which can easily be applied to successful biological science teaching:

24. Group activities requiring the co-operation of several students should be used, frequently, such as group demonstrations, panel discussions, and committee reports.

25. Students should be encouraged to work on individual problems of their selection.

26. Most teaching procedures produce better results when students read extensively in a wide variety of references rather than from a single textual source.

27. Science facilities can stimulate and make possible better teaching techniques or make good techniques extremely difficult.

28. A wide variety of teaching procedures in which active student participation is required is more likely to result in effective learning than the use of one method.

29. Teaching methods which provide the student with an opportunity to use or apply his knowledge to problems of daily living are highly desirable. A fair part of class time should be used for the application of concepts, principles,

scientific attitudes and methods to new situations and to problems directly related to the life of the student.

30. Better results are obtained by students in understanding the principles and concepts when only a comparative few principles are taught.

31. Students should be given considerable opportunity to become acquainted with and use a variety of sources in gathering data for a problem.

Another valuable source for the collection of these principles which may govern and influence effective science teaching was reproduced from the Utah Public School Survey Commission (19, p. 20). The following list is only a portion of the entire section devoted to science:

Evidences of the schools concern for providing opportunities for youth to mature with increased knowledge, attitudes and skills about the field of science.

32. Provisions are made for some pupils to use the science facilities outside of regularly allotted class time.

33. Practice is provided in applying important scientific principles in laboratory situations.

34. Manipulation of scientific equipment and measures with scientific instruments are required.

35. Opportunity is provided for pupils to design and construct technical or semi-technical apparatus and equipment.

36. Reading and interpreting various types of scientific publications is encouraged.

37. Opportunities for performing inductive and deductive laboratory experiments are provided.

The Cooperative Study of Secondary School Standards (1, p. 180) has contributed some important rules for successful science instruction:

38. Instruction is directed toward clearly formulated, comprehensive (or long range) objectives.

39. There is evidence of careful planning and preparation of the instructional activities.

40. Flexible or differentiated assignments are used to provide for individual pupils.

41. Science resources of the community and environment are used.

42. Pupils participate in planning, conducting and evaluating the instructional activities.

43. Particular emphasis is placed on experiments.

44. Models, charts, and specimens are used in the instructional activities.

45. Effective use is made of audio-visual aids in the instructional activities.

46. Field trips are conducted.

47. The classroom instructional activities are integrated, whenever desirable, with extra-class science activities.

48. Science activities of varying degrees of difficulty are provided.

William L. Wrinkle makes a significant statement which seems to supplement what has been listed above.

49. Whole learning is now recognized as an economical way of learning. The whole in science refers to the principle, generalization, or problem. Therefore the unit of work should be so organized that all of the learning situations will contribute to an understanding of the principle or generalization. (20, p. 152)

The above forty-nine principles were all included in one form or another in the questionnaire.

George Greisen Mallinson (29, p. 178) has reported in an experiment performed on secondary school biology students in New York State that the individual laboratory shows a slight trend toward better preparation of the students for the General Biology Regents Examination than does the lecture - demonstration method.

Paul Kahn, (27, pp. 31-39) attempted to compare the relative demonstration and the individual laboratory method in college biology. His results were: (1) The individual demonstration method resulted in an increase in the amount of subject matter learned and retained as compared with the individual laboratory method alone, (2) the

individual demonstration was best used in conjunction with the laboratory method and toward the end of specific units of work, (3) science students and pupils with low mental ability succeed greatest with the individual demonstration method.

Thomas W. Steen and Edyth T. Jones (34, pp. 95-97) conducted an experiment at the junior college level in physiology and anatomy classes. The results were: (1) Superior student profited more by the lecture - demonstration method, (2) students of limited scholastic aptitude profited more by the individual laboratory method, (3) no evidence supported the individual laboratory method over the lecture - demonstration method.

K. E. Anderson, F. S. Montgomery, and R. W. Ridgway (21, pp. 295-298) report in a study performed in eight Kansas high school biology classes the following results: (1) Of the four methods tested -- film method, laboratory method, traditional method, and a combination of these -- the group employing the combination of textbook, film, and laboratory method achieved better results on the concluding tests. The author concludes, "A combination of these aids (the four indicated above) will bring better results than aids of only one type."

William H. Barrand (23, pp. 388-390) reports that his findings indicate that the lecture method may be superior to the socialized recitation method in college courses.

John M. Mason and George W. Angell (30, pp. 296-304) report that students who had been given weekly tests did not score significantly higher on a departmental final examination in college biology than did students who were given no weekly tests but had the weekly tests available for self-testing and self-scoring.

W. W. Lundeman (28, pp. 630-632) made a study of college student evaluation of some teaching methods. His tabulated results are as follows:

1.	Discussion Method	206
2.	Lecture Method	175
3.	Question and Answer Method	170
4.	Socialized Method	163
5.	Special Report	87

His conclusions were:

1. There is value in each type of teaching.
2. Students do enjoy and profit by classroom participation.
3. The lecture method still stands as the best ground covering method.
4. Good college teachers will employ a mixture of methods to guarantee continued interest and student effort.

Recommendations for equipment and facilities

Recommendations for adequate equipment and facilities in biological science teaching are many and varied.

The Cooperative Study of Secondary School Standards (1, p. 179) has listed the following requirements for adequate biological science facilities.

1. Biology room area of sufficient size to accomodate largest class without crowding.
2. A work area, set apart from the regular science classrooms, is provided for activities by individual and small groups.
3. A fully equipped demonstration area or table is provided which is easily visible to all members of a class.
4. Science rooms are equipped for use of audio-visual equipment.
5. Audio-visual projection equipment is available.

6. Laboratory tables are provided for individual and small-group work.

7. Cabinets or cases are available for display of materials.

8. Storage space is provided for laboratory supplies and equipment.

9. Biology materials and equipment are provided for class use.

10. Demonstration equipment is readily available.

11. An aquarium is provided in each classroom used for biological sciences.

Arthur G. Hoff (5, p. 242) has stated that the biology room should be equipped with the following:

1. A demonstration desk with water and gas connections.

2. Two - or four pupil tables.

3. Southern or eastern exposure.

4. Projection for greenhouse, glass covered, with southern exposure.

5. An ample supply of glass cases should be available for the purpose of display of mounted specimens of different kinds.

He further concludes:

> Theoretically, there should be no difference between the recitation room and the laboratory room for the classes in science subjects because laboratory activities and experiments should be injected at any moment when it is necessary. (5, p. 241)

> There is some controversy concerning the efficiency of pupil-made equipment as compared with factory-made science equipment. The experience of the writer and other science teachers has been that factory-made science equipment is more efficient in the long run. (5, p. 241)

David Aptekar (22, pp. 33-37) makes the following appropriate recommendations for improved science teaching through the application of better science facilities and equipment:

1. A good library, including vocational books, reference books, supplementary texts, booklets, samples of materials, etc. is needed.

2. Since much interest is derived from newspapers, magazines, and similar sources a good filing cabinet must be accessible.

William L. Wrinkle (20, p. 164) has stated in connection with modern methods that, "A greater variety of equipment is needed to administer such a program of teaching than is needed where the conventional everybody-do-the-same method of teaching is used."

Some of Wrinkle's suggestions are:

1. Bookshelves arranged in convenient places.

2. No basic text, but several different textbooks are used.

3. Well-chosen selections of magazines, newspapers and bulletins be made available to the students.

4. Bulletin boards should also supply information.

The Cooperative Study of Secondary-School Standards (1, p. 181) has made some rather significant recommendations in terms of science equipment:

1. A variety of textbook and reference materials is available.

2. Reading material which provides for differences in reading abilities and science backgrounds of pupils.

3. Science pamphlets and nontextual materials are available.

4. Science magazines are available.

5. Well-edited book lists are available.

6. Teacher prepared materials (such as study guides) are available.

7. Films, filmstrips, and slides are available.

8. Microprojection apparatus is available.

9. Models and specimens are provided.

10. Charts, maps, and similar visual aids are provided.

11. Audio aids are available for classroom use.

It will be noted that the section on facilities and equipment in the questionnaire includes all the items referred to in the above lists.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

Identification of outstanding biological science teachers

As indicated earlier the teachers included in the study were designated by their principals in response to a letter of request from the writer and the committee chairman.

These letters were sent to one hundred and nine secondary school principals throughout the state of Utah. Seventy-five were senior high school principals and thirty-four were junior high school principals. More senior high school principals were selected because more courses in biological science were taught at this particular level. In fact, all the public senior high schools in the State were included in this preliminary survey, and many of the junior high schools -- particularly in urban areas -- were included.

The number of schools included and the returns from these schools are shown in table 1.

Table 1. The number and percentage of the schools in the preliminary survey and the number and percentage of the returned replies

	Total Letters Sent out	Percentage of Total Letters Sent out	Number Returned	Percentage Returned
Senior High School	75	68.8	42	56.0*
Junior High School	34	31.2	18	52.9

* It should be noted that principals were not asked to return cards if they desired not to recommend a teacher.

Many of the junior high schools and a few senior high schools indicated that no biological science was being taught in their schools. In these cases the subject was probably taught at the other level. Some junior high school principals indicated that, although no biological science classes as such were being taught, some biological science was being taught in general science classes.

The final results of this preliminary survey yielded some thirty-nine outstanding biological science teachers. Of these thirty-nine teachers, thirty-two, or eighty-two per cent, were in senior high schools; and seven, or eighteen per cent, were in junior high systems. These final selections were highly recommended by their individual principals.

The teachers who were nominated from senior high schools displayed a rather even geographical distribution in the State; both urban and rural areas were well represented. Small and large schools were also represented. In other words, this particular survey produced a fairly representative sample of the State's senior high schools.

The selections from the junior high schools were located in or near centers of heavy population. Because the vast majority of the junior high schools are located in or near population centers in Utah, these schools could probably be considered a typical sample.

Administering the questionnaire

In response to a first request, twenty-seven of the thirty-nine teachers replied; a second request produced eight more. The total return was ninety per cent. Most of the returned questionnaires were completely filled out, and in some cases even extra or additional responses were included. A large majority of the participants requested abstracts of the findings in this project. Apparently, a

great deal of interest and enthusiasm was generated.

Of the four teachers who failed to answer the questionnaire, two were rural senior high school teachers, and two were urban secondary school teachers -- one being a junior high school teacher and the other a senior high school teacher. These teachers were located in widely scattered sections of the State.

The questionnaire (see appendix) is constructed with an introduction and five separate parts. The introductory section is concerned with general factors related to the teacher and his teaching situation and can be answered by selecting the most appropriate response. Parts I and III are concerned with the frequency and desirability of the teaching methods selected for study and may be answered by checking the most appropriate alternative in the key. If no alternative in the key seems adequate, the reader may substitute one of his own selections. Parts II and IV have the same form as do Parts I and III; however, Part II is concerned with the adequacy of items and provisions for facilities and equipment, and Part IV is concerned with the teacher's judgment as to the necessity of these items and provisions for facilities and equipment. Part V is composed of two essay questions pertaining to any discrepancies in regard to the recommendations and practices of the preceding parts.

Some data concerning the teachers included in the study and their teaching assignment

Teaching combinations. Many of the reporting teachers indicated that they taught biological sciences only part of the day, and then taught some completely different subject or subjects the rest of the time.

General biology in senior high school was the most frequently taught biological science. General science, which is generally taught in the ninth grade, was the class ranked second. This class is a combination of physical and biological sciences and, therefore, cannot be considered a pure biological science; however, in a study of successful biological science teaching in Utah secondary schools this subject is important because in the case of many students this is the only contact or opportunity they have for studying biological sciences.

Table 2 shows a complete breakdown of the biological science classes these teachers were teaching.

Teaching majors and minors. Table 3 lists the teaching majors and minors of the thirty-five teachers in this study.

As a group, most of these teachers were trained in the biological sciences; however, five had majors in agriculture and eleven had majors in other areas. Apparently, four of these successful biology teachers had neither a major or minor in the subject.

Teaching load. The survey indicates that the teachers had heavy teaching loads both in terms of the number of students in their classes and also in terms of the number of periods taught per day.

The Committee on the Teaching of Biology (14, pp. 1-76) reported that on a basis of returns from 3,117 teachers an average of 28.2 pupils per class was reported in biology. The Western area averaged 27.6, with 29.4 in urban areas and 24.0 in rural areas. The average pupil load for biological science teachers of the nation as a whole was 124.4 students per teacher per day. Again, urban areas had greater enrollments than did the rural areas.

The teaching load of thirty-five teachers in the present study (see tables 4 and 5) was somewhat above the national average.

Table 2. Biological science teaching combinations of the thirty-five teachers

Subject	No. Reporting Teaching it	Percentage of Teachers Teaching it
1. Biology	27	77.2
2. General Science	15	42.9
3. Physiology	7	20.0
4. Health or Heredity	7	20.0
5. Zoology	5	14.3
6. Botany	5	14.3
7. Family Living	1	2.9
8. Health	1	2.9
Total	68	100

Table 3. College training of thirty-five outstanding biological science teachers

Teaching Majors	No. Reporting	Teaching Minors	No. Reporting
Biological Sciences	19	Biological Sciences	12
Agriculture	5	English	4
Chemistry	2	Psychology	3
Mathematics	2	Mathematics	2
Secondary Education M.S.	1	Economics	1
Physical Education	1	Physics	1
Educational Administration	1	History	1
Music	1	Sociology	1
Other than biological science, not specified	3	Geology	1
		Chemistry	1
		Animal Husbandry	1
		Wild Life Management	1
		Other than biological sciences, not specified	5

Table 4. The total number of periods taught each day and the total number of biological science periods taught daily by the thirty-five reporting teachers *

No. of periods	No. of Teachers Reporting Total No. of Periods	No. of Teachers Reporting Total No. of Biological Science Periods
1	1	3
2	2	3
3	1	7
4	1	4
5	14	9
6 or more	16	7

* Of the teachers contacted two were part-time counselors and one was a principal who taught biology two periods.

Table 5. The average number of students per class, as reported by the teachers in this study

No. of Students	No. of Teachers Reporting
15-20	1
20-25	5
25-30	11
35 or more	17

Degree of professional training and experience. As a whole, the teachers in this study were very well trained. Fifty per cent had master's degrees or the equivalent. No teacher reported training below that of a bachelor's degree or the equivalent. This extremely high degree of professional training may be one indication of what would constitute a good biological science teacher.

Professional experience, although a fairly consistent factor, did not show the degree of consistency as did professional training in this select group as shown in tables 6 and 7. Over fifty per cent of these teachers had over ten years of professional experience; however, twenty-five per cent had only from one to four years of experience. The remaining seven had from five to ten years experience.

Table 6. Professional training of the teachers included in this study

	Professional Training	Percentage of Total
Below B. S.	-	-
B. S. or equivalent	16	45.7
M. S. or equivalent	18	50.5
Ph. D. or equivalent	1	3.8

Table 7. Professional experience of the teachers included in this study

	Professional Experience	Percentage of Total
1 - 4 years	9	25.7
5 - 10 years	7	20.0
10 years or above	19	54.3

Practices and recommendations of successful biological science teachers

After many observations and trials with charts, graphs, and tables, the following procedures for analyzing the results of the questionnaire were devised.

Through observing the following tables, one may determine many of the practices and recommendations of successful biological science teachers. As the tables are studied, general patterns for teaching these subjects emerge. For example: science clubs are used only rarely; whereas student drawings are used frequently. It may also be observed that most teachers have an adequate supply of movie projectors but do not have enough microscopes.

These various tables will show: (1) the frequency with which some teaching methods are employed by these teachers, (2) the adequacy of certain items of equipment and provisions for certain facilities, (3) the desirability of certain specified teaching methods, and (4) the necessity of some items of equipment and facilities.

Tables 8, 9, 10, and 11 were arranged to show the actual number of responses each answer blank received and, also, to show the numerical mean or average for each separate question.

Table 8 is concerned with the frequency of use of nineteen teaching methods. The teaching methods used to the greatest extent with this group were: using motion pictures, film strips, and slides in the instructional activities; lecture and class recitation; using models, charts, and specimens in instruction; simple analytical drawings; and class assignments. The methods used least were field trips, science clubs, mineographed study guides, resource visitors, and using laboratory manuals and printed diagrams.

Table 9 shows the teacher ratings of the adequacy of certain items of equipment and facilities. The items selected as being the most adequate were bulletin board and blackboard space; room equipped for audio-visual aids; movie projectors, slide projectors, and screens; and a variety of reference materials. The least adequate items were museum areas, terrariums, laboratory work areas, and aquariums.

Table 10 is concerned with ratings of desirability of certain teaching methods. The teaching methods most often selected as highly desirable were field trips; using motion pictures, film strips, and slides; assignments requiring several sources; and assignments for individual differences. The teaching methods selected least were teaching from mimeographed study guides, class assignments, oral readings, and lecture and recitation.

Table 11 shows the teacher ratings concerning the necessity of certain items of equipment and facilities. The items selected as being most necessary were microscopes; a variety of reference publications; models, charts, and specimens; bulletin board and blackboard space; and laboratory work areas. The items selected as least necessary were greenhouses, musium areas, aquariums and terrariums, and demonstration desks.

Table 8. Frequency of use of nineteen teaching methods

Question	4 Very frequently	3 Frequently	2 Occasionally	1 Rarely	0 Never	Numerical Mean
1. Field trips	1	3	12	12	7	1.3
2. Laboratory exercises	3	11	12	7	2	2.2
3. Resource visitors	1	2	12	11	9	1.3
4. Group demonstrations, panel discussions and committee reports	9	10	9	5	2	2.4
5. Motion pictures, film strips, and slides are used in instructional activities	10	17	6	2	-	3.0
6. Simple analytical drawings	9	14	10	2	-	2.9
7. *Class assignments	17	9	7	1	-	3.2
8. Models, charts, and specimens are used in instruction	22	9	2	2	-	3.5
9. Lecture and class recitation	14	11	7	4	-	3.0

Table 8. (Continued)

Question	4 Very frequently	3 Frequently	2 Occasionally	1 Rarely	0 Never	Numerical Mean
10. Laboratory manuals and printed diagrams are used in instruction	5	3	6	11	9	1.4
11. *Written reports of laboratory work	6	10	8	4	7	2.2
12. *Mimeographed study guides	3	3	5	15	7	1.2
13. Using living specimens	7	13	12	3	-	2.4
14. Representative drawings	4	13	14	2	2	2.1
15. Science clubs	3	1	6	6	19	0.9
16. Assignments that require several sources	5	13	13	3	1	2.5
17. Students involved in survey, discussion and decision of teaching units	3	7	10	11	4	1.8
18. Individual assignments	8	13	8	4	2	2.6
19. Teacher demonstrations	7	15	12	1	-	2.8

* Each asterisk indicates an omission of the item by an answering teacher.

Table 9. Ratings concerning the adequacy of certain items of equipment and facilities

Question	4 Entirely Adequate	3 Adequate most of the Time	2 Inadequate	1 Missing but Needed	0 Missing	Numerical Average
1. Demonstration desk	20	4	1	4	6	2.5
2. Variety of reference materials	11	12	10	1	-	2.9
3. Room equipped for audio-visual aids	16	10	5	1	3	3.0
4. Movie projectors, slide projectors, and movie screens	21	11	2	-	1	3.5
5. Bookshelves, filing cabinets	12	14	8	1	1	3.1
6. Good film strips, films, and slides	9	17	7	-	2	2.6
7. Models, charts, speciments	6	16	12	1	-	2.5
8. Aquarium	13	5	6	5	6	2.4
9. Terrarium	11	2	4	11	7	1.7

Table 9. (Continued)

Question	4 Entirely Adequate	3 Adequate most of the Time	2 Inadequate	1 Missing but Needed	0 Missing	Numerical Average
10. Laboratory work area	11	5	8	5	6	2.3
11. Tables for group study	13	5	5	6	6	2.4
12. *Laboratory and lecture are combined	11	10	6	2	5	2.5
13. Bulletin board and blackboard space	17	12	6	-	-	3.3
14. Museum or museum area	7	5	3	8	12	1.3
15. Microscopes	11	4	15	4	1	2.6
16. Room located for window gardens	11	6	7	8	4	2.4

* Each asterisk indicates an omission of the item by an answering teacher.

Table 10. Rating concerning the desirability of certain teaching methods

Question	4 Highly Desirable	3 Desirable	2 Usually Desirable	1 Usually Undesirable	0 Undesirable	Numerical Average
1. Field trips	21	8	4	1	1	3.3
2. Student drawings	10	9	14	2	-	2.2
3. Motion pictures, film strips, and slides	23	9	3	-	-	3.6
4. Group discussions, panel discussions, committee reports	10	12	11	1	1	2.5
5. *Resource visitors	9	12	10	2	1	2.5
6. Student-teacher unit planning	6	15	10	3	1	2.3
7. Lecture and recitation	5	11	10	8	1	2.1
8. Teacher demonstrations	8	9	10	7	1	2.5
9. *Teaching from mimeographed study guides	3	12	10	8	1	1.9
10. Assignments for individual differences	18	8	7	2	-	3.2
11. *Class assignments	3	5	10	11	5	1.6
12. *Laboratory exercises	11	13	6	3	1	2.3
13. Individual written assignments	13	13	9	-	-	3.1
14. Assignments requiring several sources	16	16	3	-	-	3.4
15. *Oral reading in your class	3	9	7	13	1	1.9

* Each asterisk indicates an omission of the item by an answering teacher

Table 11. Ratings concerning the necessity of the following items of equipment and facilities

Question	4 Absolutely Necessary	3 Necessary	2 Necessary but Could do Without	1 Not Necessary but Helpful	0 Unnecessary	Numerical Average
1. Greenhouse *	1	2	10	16	5	1.3
2. Films, film strips and slides	11	19	5	-	-	3.0
3. Aquarium and Terrarium	8	16	9	1	1	2.8
4. A variety of reference publications	15	16	3	1	-	3.3
5. Microscope	24	9	1	-	1	3.6
6. Models, charts, and specimens	20	14	1	-	-	3.5
7. Display cases	10	10	13	2	-	2.5
8. Bookcases and filing cabinets	9	18	6	1	-	3.0
9. Bulletin board and blackboard space	30	5	-	-	-	3.9
10. Pupil tables	12	11	6	5	1	2.5
11. Audio-visual equipment and facilities	18	13	4	-	-	3.4
12. Laboratory work area	15	14	1	4	1	3.1
13. Laboratory manuals *	1	8	9	11	4	1.7
14. Museum area	5	6	11	11	3	2.0
15. Demonstration desk ***	12	14	4	2	-	2.3

* Each asterisk indicates an omission of the item by an answering teacher.

Tables 12, 13, 14, and 15 represent the rank order of each question in its particular section of the questionnaire (see appendix). These ranks were determined by the frequency with which the response occurred. In order to determine the relative importance of the rankings of the items in each of the five possible ranks, percentages were calculated for all of the responses. These are shown in tables 12 to 15 too.

Table 12 lists the rank orders of the nineteen teaching methods and also the percentage of teacher selections in each category of frequency. It may be noted on this chart that about fifty per cent of the teachers in this study used models, charts, and specimens; class assignments; and lecture and recitation methods very frequently. Whereas, about twenty-five per cent of the teachers never used science clubs, resource visitors, laboratory manuals and printed diagrams as instructional methods.

Table 13 lists the rank orders of adequacy of certain items of equipment and facilities and also the percentage of teacher selections in each category of adequacy. Items on the table which were near fifty per cent of being entirely adequate are movie projectors, slide projectors, and movie screens; bulletin board and blackboard space; and rooms equipped for audio-visual aids. Some items were listed as missing in about twenty per cent of the schools. They were aquariums, terrariums, tables for group study, and laboratory work areas.

Table 14 lists the rank orders of teacher ratings of desirability for certain teaching methods and also the percentage of teacher selections in each category of desirability. Teaching methods which were selected as being highly desirable by over fifty per cent of the answering teachers were: field trips, assignments for individual differences, and the use of motion pictures, film strips, and slides.

Table 12. The percentages and rank orders of frequency of nineteen teaching methods

Rank Order	Method	Very frequently	Frequently	Occasionally	Rarely	Never
1	Models, charts, and specimens are used in instruction	62.9	25.7	5.7	5.7	-
2 *	Class assignments	50.0	26.5	20.5	2.9	-
3.5	Lecture and class recitation	41.0	31.5	20.0	11.4	-
3.5	Motion pictures, film strips, and slides are used in instructional activities	28.6	48.6	17.2	5.7	-
5	Simple analytical drawings	25.7	40.0	28.6	5.7	-
6	Teacher demonstrations	20.0	42.9	34.2	2.9	-
7	Individual assignments	22.9	37.2	22.9	11.4	5.7
8	Assignments that require several sources	14.3	37.2	37.2	8.6	2.9
9.5	Using living specimens	20.0	37.2	34.3	8.6	-
9.5	Group demonstrations, panel discussions and committee reports	25.7	28.6	25.7	14.3	5.7
11.5	Laboratory exercises	8.6	31.5	34.3	20.0	5.7

Table 12. (Continued)

Rank Order	Method	Very frequently	Frequently	Occasionally	Rarely	Never
11.5*	Written reports of laboratory work	17.2	28.6	22.9	11.4	20.0
13	Representative drawings	11.4	37.2	40.0	5.7	5.7
14	Students involved in survey, discussion and decision of teaching units	8.6	20.0	28.6	31.5	11.4
15	Laboratory manuals and printed diagrams are used in the instruction	14.3	8.6	17.2	31.5	25.7
16.5	Resource visitors	2.9	5.7	34.3	31.5	25.7
16.5	Field trips	2.9	8.6	34.3	34.3	20.0
18 *	Mimeographed study guides	8.2	8.2	14.7	44.1	20.0
19	Science clubs	8.6	2.9	17.2	17.2	54.3

* Each asterisk indicates an omission of the item by an answering teacher.

Table 13. The percentages and rank orders of adequacy for certain items of equipment and facilities

Rank Order	Equipment and Facilities	Entirely Adequate	Adequate most of the Time	Inadequate	Missing but Needed	Missing
1	Movie projectors, slide projectors, and movie screens	60.1	31.5	5.7	-	2.9
2	Bulletin board and blackboard space	48.6	34.3	17.1	-	-
3	Bookshelves and filing cabinets	34.3	40.0	22.9	2.9	2.9
4	Room equipped for audio-visual aids	45.8	28.6	14.3	2.9	8.6
5	Variety of reference materials	31.5	34.3	28.6	2.9	-
6.5	Good films, film strips, and slides	25.7	48.6	20.0	-	5.7
6.5	Microscopes	31.5	11.4	42.9	11.4	2.9
9 *	Laboratory and lecture area combined	32.1	29.4	17.6	5.9	14.7
9	Models, charts, specimens	17.2	45.8	34.3	2.9	-
9	Demonstration desk	57.2	11.4	2.9	11.4	17.2
12	Room located for window gardens	31.5	17.2	42.9	11.4	2.9
12	Tables for group study	37.2	14.3	14.3	17.2	17.2
12	Aquarium	37.2	14.2	17.2	14.3	17.2
14	Laboratory work area	31.5	14.3	22.9	14.3	17.2
15	Terrarium	31.5	5.7	11.4	31.5	17.2
16	Museum or museum area	31.5	17.2	20.0	22.9	11.4

* Each asterisk indicates an omission of the item by an answering teacher.

Table 14. The percentages and rank orders of desirability for fifteen teaching methods

Rank Order	Method	Highly Desirable	Desirable	Usually Desirable	Usually Undesirable	Undesirable
1	Motion pictures, film strips, and slides	65.8	25.7	8.6	-	-
2	Assignments requiring several sources	45.8	45.8	8.6	-	-
3	Field trips	60.1	22.9	11.4	2.9	2.9
4	Assignments for individual differences	51.5	22.9	20.0	5.7	-
5	Individual written assignments	37.2	37.2	25.7	-	-
7 *	Resource visitors	26.5	35.3	29.4	5.9	2.9
7	Group discussions, panel discussions, and committee reports	28.6	34.3	31.5	2.9	2.5
7	Teacher demonstration	22.9	25.7	28.6	20.0	2.9
9.5	Student-teacher unit planning	17.2	42.9	28.6	8.6	2.9
9.5*	Laboratory exercises	32.1	38.2	17.6	8.8	2.9
11	Student drawings	28.6	25.7	40.0	5.7	-
12	Lecture and recitation	14.3	31.5	28.6	22.9	2.9
13.5*	Oral readings in your class	8.8	26.5	20.0	38.2	5.9
13.5*	Teaching from mimeographed study guides	8.8	35.3	29.4	27.5	2.9
15 *	Class assignments	8.8	14.7	29.4	32.3	14.3

* Each asterisk indicates an omission of the item by an answering teacher.

Table 15. The percentages and rank orders of necessity for certain items of equipment and facilities

Rank Order	Equipment and Facilities	Absolutely Necessary	Necessary	Necessary but Could do Without	Not Necessary but Helpful	Unnecessary
1	Bulletin board and blackboard space	85.8	14.3	-	-	-
2	Microscope	68.6	25.7	2.9	-	2.9
3	Models, charts, and specimens	57.2	40.0	2.9	-	-
4	Audio-visual equipment and facilities	51.5	37.2	11.4	-	-
5	Laboratory work area	42.9	40.0	2.9	11.4	2.9
7	Films, film strips, and slides	31.5	54.3	25.7	2.9	2.9
7	A variety of reference publications	42.9	45.8	8.6	2.9	-
7	Bookcases and filing cabinets	25.7	51.5	17.2	2.9	-
9.5	Display cases	28.6	28.6	37.2	5.7	-
9.5	Pupil tables	34.3	31.5	17.2	14.3	2.9
11***	Demonstration desk	36.7	42.8	12.2	6.1	-
12.5	Aquarium and terrarium	22.9	45.7	25.7	2.9	2.9
12.5	Museum area	14.3	17.2	31.5	31.5	8.6
14 *	Laboratory manuals	2.9	24.5	26.5	32.3	11.8
15 *	Greenhouse	2.9	5.9	29.4	47.0	14.7

* Each asterisk indicates an omission of the item by an answering teacher.

Teaching methods selected as being undesirable by over five per cent of the teachers were class assignments and oral readings.

Table 15 lists the rank orders of necessity of some items of equipment and facilities as selected by the answering teachers. The percentage of teachers selecting each category of necessity is also shown. It may be noted that over fifty per cent of the answering teachers believed that bulletin board and blackboard space; microscopes; models, charts, and specimens; and audio-visual equipment and facilities are absolutely necessary in biological science instruction. Whereas, over ten per cent of the answering teachers believed greenhouses and laboratory manuals are not necessary.

Discrepancies between practices and recommendations

Some discrepancies between the methods teachers use and those which they recommend as being more or less ideal might be expected to be found in any given school system. So, two essay questions were included in the questionnaire. The purpose of these questions was to help motivate the teacher to explain the reason or reasons for any discrepancies which might occur in regards to teaching methods in practice and those they recommend, and also to explain any discrepancies in regards to equipment and facilities on hand and those recommended.

The response to these questions showed that the teachers concerned were definitely interested. Some teachers elected to write pages of comments, whereas, others wrote only a paragraph. Much of the writing overlapped what had been said in the questionnaire; however, much of it was new and vitally significant to good biological science teaching. This material was analyzed as follows.

All the responses were carefully screened and nonessential material and duplications were largely omitted. Then each school was identified, not by teacher, but the physical characteristics of the school and the principal reason or reasons for the discrepancies indicated by the teachers was stated. In some cases, however, the responses to the problems seemed to be so pertinent that they have been quoted in full.

Before considering these statements, the principal areas of discrepancies were tabulated and these are shown in table 16. It should also be noted that discrepancies which averaged less than a numerical 0.6 were considered largely insignificant and are not included in the table.

Explanations for discrepancies in regards to equipment and facilities on hand and those recommended

Teacher No. 1, Large, Suburban Senior High School: The reason for these discrepancies is that our school is new. Over a period of years as funds are available our requirements should be filled.

Teacher No. 2, Small, Rural Senior High School: Finance is the limiting factor.

Teacher No. 3, Small, Rural Senior High School: "Many items are on order and will be purchased when money is available. When we buy, we buy the latest and the best."

Teacher No. 4, Small, Rural Senior High School: A lack of funds and equipment is the limiting factor.

Teacher No. 5, Small, Rural Senior High School: Lack of finance.

Teacher No. 6, Small, Rural Senior High School: The most serious limiting factor here is that our rooms are not equipped or built for

Table 16. The major areas of discrepancies between teacher practices and recommendations

Subject	Average rating Of Practice	Average rating Of Recommended Practices	Difference
Teaching Methods			
Field trips	1.3	3.3	+ 2.0
Motion pictures, film strips, and slides	3.0	3.6	+ 0.6
Class assignments	3.2	1.6	- 1.6
Lecture and class recitation	3.0	2.1	- 0.9
Resource visitors	1.3	2.9	+ 1.3
Assignments requiring several sources	2.5	3.4	+ 0.9
Equipment and facilities			
Good film strips, films, and slides	2.6	3.4	+ 0.8
Models, charts and specimens	2.5	3.5	+ 1.0
Laboratory work area	2.3	3.1	+ 0.8
Museum or museum area	1.3	2.3	+ 1.0
Microscopes	2.6	3.6	+ 1.0

ideal science work. It is a regular classroom without a storage room or sinks and water.

Teacher No. 7, Large, Urban Senior High School: The school is new and, therefore, we lack some items of equipment, especially a filing cabinet. Also, in the construction of this school no provision was made for a greenhouse.

Teacher No. 8, Medium, Urban Senior High School: Biological sciences are usually assigned to teachers who teach the major portion of the day in some other field and, therefore, lack the interest to build a well equipped department in all respects.

Teacher No. 9, Small, Rural Senior High School: The missing or inadequate facilities and equipment are due to the economics involved. We often select the more important equipment and facilities at the expense of other essentially important items.

Teacher No. 10, Medium, Suburban Senior High School:

(a) I don't feel that a green house is absolutely the thing we need, but it would be nice. I have taught with and without them I think I did about as good in either case.

(b) Pupil tables are fine and I wish I had them in our school. I have used them and not had them and oh boy is there a difference. I think tables are a must and for eleven years I have tried to get some. This spring once again they will be written down on my needs.

(c) Laboratory work areas for the average high school I don't think are at all necessary. I would personally rather have the additional money used for equipment and supplies.

Teacher No. 11, Small, Rural Senior High School: No response.

Teacher No. 12, Large, Suburban Junior High School: No response.

Teacher No. 13, Medium, Rural Junior High School: Lack of finance.

Teacher No. 14, Small, Rural Senior High School: The reasons for these discrepancies are: ". . . lack of funds and feeling by the board and superintendent that they are not necessary."

Teacher No. 15, Medium, Suburban Senior High School: No serious discrepancies.

Teacher No. 16, Small, Rural Senior High School: Lack of finance.

Teacher No. 17, Large, Rural Senior High School: No serious discrepancies.

Teacher No. 18, Large, Urban Senior High School: Now that I am established I have all the necessary equipment I need. What equipment and facilities a teacher may have is dependent to a large degree on his personality, drive, etc.

Teacher No. 19, Medium, Urban Senior High School: Our equipment is adequate in most cases.

Teacher No. 20, Large, Urban Senior High School: No serious discrepancies.

Teacher No. 21, Medium, Urban Senior High School: No serious discrepancies.

Teacher No. 22, Medium, Rural Senior High School: Lack of adequate funds.

Teacher No. 23, Small, Rural Senior High School: The reasons for these discrepancies are: (1) lack of money, (2) lack of space, (3) lack of time.

Teacher No. 24, Large, Urban Senior High School: No discrepancies.

Teacher No. 25, Large Suburban Senior High School: The only serious discrepancy I have is in regards to microscopes. The reason for the lack of these is their cost.

Teacher No. 26, Medium, Rural Senior High School: The equipment is not adequate because the school board does not have necessary funds. Also, the classroom was originally built with poor biological insights.

Teacher No. 27, Medium, Urban Junior High School: Our most serious discrepancy is in regards to available microscopes. Only one microscope is available to all our general science sections. The extreme cost involved in purchasing this item is probably the reason for its inadequacy.

Teacher No. 28, Medium, Urban Senior High School: The room I teach in is not equipped as a biological science classroom should be. It is no different from regular classrooms; and, therefore, many recommended items are not present.

Teacher No. 29, Large, Suburban Senior High School: No major discrepancies.

Teacher No. 30, Large, Suburban Senior High School: Lack of funds.

Teacher No. 31, Medium, Rural Senior High School: The reasons for these discrepancies are: (1) inadequate building, (2) lack of funds.

Teacher No. 32, Medium, Urban Junior High School: The reason for these discrepancies is that the administration does not co-operate with the needs of the biological science department.

Teacher No. 33, Medium, Urban Junior High School: No comment.

Teacher No. 34, Small, Rural Senior High School: No discrepancies.

Teacher No. 35, Medium, Urban Junior High School: No discrepancies.

The most serious cause of the discrepancies between recommended equipment and facilities and that actually possessed was finance as reported by these teachers. Fifteen teachers reported that financial factors were the chief cause of their inadequate equipment and

facilities. Five reported that many of their inadequate conditions were due to improper construction of school buildings. Two reported that disinterest on the part of the administration had caused them to have inadequate or missing equipment and facilities. Ten teachers reported that in their schools there was no serious discrepancies between the equipment and facilities on hand and those desired. Three teachers failed to respond in this question.

The schools where the teachers felt their equipment and facilities were inadequate or missing but desired were largely situated in rural areas.

Explanations for discrepancies in regards to teaching procedures in practice and those recommended

Teacher No. 1, Large, Suburban Senior High School: No serious discrepancies exist.

Teacher No. 2, Small, Rural Senior High School: The principal reason for these discrepancies in a number of cases is the lack of desirable teaching aids.

Teacher No. 3, Small, Rural Senior High School: Plant facilities make it quite difficult to utilize some teaching methods and equipment.

Teacher No. 4, Small, Rural Senior High School: No serious discrepancies exist.

Teacher No. 5, Small, Rural Senior High School: No serious discrepancies except in the use of motion pictures. Our particular room cannot be darkened for good movies.

Teacher No. 6, Small, Rural Senior High School:

> The most serious discrepancy in our school is with regards to field trips. We are limited for transportation facilities to and from areas. Also, most places of interest are a full day's activity and require absence from school.

On saturday most of the students work. However, I do take small groups of students out on saturday.

Teacher No. 7, Large, Urban Senior High School:

My experience has demonstrated to me that teaching methods or assignments that require groups of students to work as committees fail to produce adequate returns for the time spent. Certainly student participation is the thing desired but in the initial phases of teaching it has to be held to a minimum and supervised very carefully. I feel that, without trying to be too critical, what is sometimes called good student activity is really very questionable and borders on the nonsensical.

After students have been disciplined to the point where they know how to recognize real values, then they may be guided into some of the jobs of helping to plan the procedures in the classroom.

The greatest task in class work for me has been to get students to squarely face a problem and honestly try to solve it. Some of the highly recommended free discussions in classes is worse than a waste of time. Unless the maximum of control is exercised, the students 'flit' from one topic to another in an aimless manner and fail to go deeply enough into any topic.

The greatest amount of class participation possible, but very carefully guided and controlled, (has been more suitable for my classes).

Teacher No. 8, Medium, Urban Senior High School: No serious discrepancies.

Teacher No. 9, Small, Rural Senior High School: No serious discrepancies.

Teacher No. 10. Medium, Suburban Senior High School: The reasons for these discrepancies are:

(a) Student drawings are in many cases of a poor quality and do not represent much thought or effort. There are many students that are unable to draw and therefore, the thing you are trying to establish you kill or spoil.

(b) Group demonstrations work if you have a place and the equipment to use, if not, little value is gained. There are some places and certain parts that will lend themselves to the idea. If you have groups of 45 students, the problem is more difficult.

(c) Teacher performed demonstrations tend to become a fixed route with little demonstration or learning for the students. A student or two with teacher aid will do better.

(d) Class assignments have to be made when all of the students buy the same text. I hate this idea but haven't been able to have any change yet. I favor a variety of texts on the student level.

(e) Written assignments in high school, as in college, tend to be a busy work project and not a great aid to the students. You do my math and I will do your biology is all too often the theme. To set up a type written report and pile on the ink and sheets of paper is not giving the student much of an opportunity to learn. Remember your own case; did you learn more from the written assignment or from some other sources.

(f) Oral reading is a dangerour practice in high school unless you are sure of your ground. Some poor little guy may not be able to read very well, and if you have him read or attempt to read orally there may be two people who wish he hadn't. Oral reading is fine (when it) is done by the ones you are sure can do it well; but lets watch our step.

Teacher No. 11, Small, Rural Senior High School: no response.

Teacher No. 12, Large, Suburban Junior High School: Oral reading on the level of 8th and 9th grade students doesn't produce the results it should.

Teacher No. 13, Medium, Rural Junior High School: Adequate supplies and equipment for demonstrations are a must in teaching general science; our school does not have these necessary items. Field trips have not been taken because of the "platoon school system".

Teacher No. 14, Small, Rural Senior High School: The reasons for these discrepancies are: ". . . lack of proper facilities and in some cases lack of biological knowledge to conduct proper" (methods).

Teacher No. 15, Medium, Suburban Senior High School: No serious discrepancies.

Teacher No. 16, Small, Rural Senior High School: There is not

enough time to perform field trips. No laboratory exercises are possible because we have no facilities. Resource visitors have never been tried with regards to biology classes.

Teacher No. 17, Large, Rural Senior High School: No serious discrepancies.

Teacher No. 18, Large, Urban Senior High School:

> My big problem is the field trip. I know my students miss valuable learning situations. Some teachers have tried them. I found that the social studies trip ruined a unit for me. My film (motivation in this case) arrived while half my class was on this trip. I hesitate to use class time of other teachers. I tried Saturday and Sunday trips. My students work. They can't take such trips.

Teacher No. 19, Medium, Urban Senior High School:

> In the main we have to dispense with some field trips even though (they might be) desirable. The size of classes together with the number of classes taught (makes these trips impractical). Past experience has proven to me that field trips must be planned to the Nth degree or they become more of a holiday than anything else.
>
> In my classroom procedure may vary from day to day. It may be lecture or supervised study or a combination of both. We make much use of material that we have in our museum case.

Teacher No. 20, Large, Urban Senior High School: No serious discrepancies.

Teacher No. 21, Medium, Urban Senior High School: "Individual assignments and laboratory exercises are desirable but not practical with large classes and a heavy teaching load."

Teacher No. 22, Medium, Rural Senior High School: Any discrepancies which might occur are directly dependent upon the initiative and capabilities of the teacher as well as upon the resourcefulness of the group with which he is working.

Teacher No. 23, Small, Rural Senior High School: We lack the necessary equipment and facilities for some methods. Our season is

short; so we do not have much outside work.

Teacher No. 24, Large, Urban Senior High School: No discrepancies.

Teacher No. 25, Large, Suburban Senior High School: "With 35 to 45 students per class in five classes and only having the students available to me for one hour — field trips, are next to impossible as are many other teaching procedures."

Teacher No. 26, Medium, Rural Senior High School:

(a) Field trips should be an important part of a class in biological sciences. However, our school board and faculty have ruled out all field trips during the week except saturday. Also, the amount of money involved for transportation and the use of school buses for transportation presents another problem. (I personally feel that if there was some way to spell "biological sciences" so that it sounded like "athletical sciences" the board and faculty would support us.)

(b) Smaller classes would greatly aid in assignments on an individual basis. This is somewhat overcome by giving assignments to the whole class on a particular laboratory problem. Then the written report is left up to the individual ability of the student and to his resourcefulness. Individual help and instruction is given during the laboratory periods.

(c) Resource visitors are certainly desirable; but, it is extremely difficult to have a person come in to talk all day so that each through the day may hear him. Possibly if fewer classes were taught — or arrangement for more than one person to come at different times to discuss the topic at hand, (the condition could be elevated).

Teacher No. 27, Medium, Urban Junior High School: A lack of good facilities and equipment prohibits the use of many good teaching methods.

Teacher No. 28, Medium, Rural Senior High School: The greatest single reason for these discrepancies is lack of time for preparation.

Teacher No. 29, Large, Suburban Senior High School: No major discrepancies.

Teacher No. 30, Large, Suburban Senior High School:

> Field trips are one of the best learning devices for students. Because of certain practices at our school, these have to be practically eliminated; also because of lack of funds, individual laboratory work has to be held to a minimum.
>
> I have always deplored the use of work books and many of the brief unmeaningful experiments in them. I have always encouraged problems about the school, home, community, etc.

Teacher No. 31, Medium, Rural Senior High School: The reasons for these discrepancies are: (1) administration prohibits them, and (2) the expense of some training aids rules out their practical use.

Teacher No. 32, Medium, Urban Junior High School: Lack of administrative interest.

Teacher No. 33, Medium, Urban Junior High School: No comment.

Teacher No. 34, Small, Rural Senior High School: No discrepancies.

Teacher No. 35, Medium, Urban Junior High School: Field trips are very difficult when the teacher has six periods a day. Individual experiments are desirable but not practical on the junior high school level.

It may be noted that eleven teachers reported no discrepancies between teaching methods in practice and those recommended. Seven teachers reported that because of the pressure of heavy teaching loads they could not find time to use all of the desirable teaching methods. Six teachers reported that although some teaching methods are desirable; they were impractical in their particular situations. Two teachers stated that their administration discouraged some desirable teaching methods, and two teachers failed to respond to this question.

Many of the teachers from small rural schools reported that the principal reason for not employing a greater variety of desirable teaching methods was due to inadequate equipment and facilities.

The remaining reasons for not using reported, desirable teaching methods came from a combination of both large and small, and rural and urban schools.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

The teachers selected for this study taught general biology and general science more than any other secondary school subject, and they were also well educated in the biological sciences. Their individual teaching loads were somewhat above the national average, and their respecitve degrees of college or university training were also above what one would expect for a national average. In fact, fifty per cent had a Master's degree or the equivalent.

Some teaching methods were employed with great frequency by these teachers while others were rarely used. The teaching methods which were used most frequently were, the use of models, charts, and specimens in the instructional program; giving the entire class an identical assignment; using lecture and class recitation methods; utilizing motion pictures, film strips, and slides in instructional activities; requiring simple analytical drawings from the students; and performing teacher demonstrations. The teaching methods used least frequently were organizing science clubs, utilizing mimeographed study guides, going on field trips, and bringing in resource visitors.

The use of motion pictures, film strips and slides; assignments requiring several sources; field trips; and individual assignments were all designated as being highly desirable teaching methods while identical assignments for the entire class, teaching from mimeographed study guides, oral reading, and lecture and recitation methods were selected as being less desirable.

Items of equipment and provisions for facilities were checked for adequacy, and movie projectors, slide projectors, movie screens, bulletin boards, blackboard space, bookshelves, filing cabinets, rooms equipped for audio-visual aids, and a variety of reference materials were listed in most cases as being adequate; whereas, museums, terrariums, laboratory work areas, aquariums, and tables for group study were selected as generally being inadequate or missing.

Bulletin boards, blackboards, microscopes, models, charts, specimens, and audio-visual equipment and facilities were generally listed as being absolutely necessary for effective science teaching; whereas, greenhouses, laboratory manuals, museum areas, aquariums, and terrariums were generally listed as not absolutely necessary.

Some discrepancies between actual practices and recommendations were noted. The areas where practices exceeded recommendations were class assignments and lecture and class recitation methods. In the large majority of cases recommendations exceeded actual practices. The areas where this situation principally occurred were field trips; the use of motion pictures, film strips, and slides; resource visitors; and assignments requiring several sources.

The equipment and facilities which each teacher actually possessed and how necessary these items were recommended to be yielded some discrepancies. The items where these teachers felt the greatest degree of necessity but actually did not possess them to any marked measure were motion pictures, slides, strips, models, charts, specimens, laboratory work area, museum area, and microscopes.

Conclusions

The following conclusions seem to be supported by the evidence in this study: (1) successful biological science teachers are in agreement as to the methods and procedures of instruction they recommend and use; (2) successful biological science teachers use a variety of teaching methods rather than base their instruction on a few isolated ones; (3) although much of the biological teaching equipment found in Utah schools is considered adequate, this equipment is by no means ideal; (4) biological science facilities in Utah secondary schools are generally considered less adequate than is the biological science teaching equipment; (5) equipment and facilities are unequally divided among the schools. Urban schools usually have the most adequate equipment and facilities; however, teachers who have been established in a rural area, and who have initiative and other personality attributes often have acquired adequate equipment and facilities; (6) most successful biological science teachers in Utah have a high degree of professional training; (7) most successful biological science teachers have a considerable amount of specialized college training in biological sciences; (8) as a rule, successful biological science teachers in Utah have teaching loads above the national average; (9) as a rule, rural biological science teachers are expected to teach classes outside of their college major; (10) most successful biological science teachers are aware of their discrepancies between practices and recommendations and are also vitally concerned with closing this gap; (11) generally speaking, good biological science teachers are greatly concerned with teaching methods and procedures; (12) most successful biological science teachers would like to integrate the immediate community into more of their instruction activities but find this is

virtually impossible under the existing conditions; (13) most of these good teachers recommended pupil-centered teaching methods as opposed to teacher-centered teaching methods; (14) extreme teaching loads with the teachers in this study made assignments for individual differences very difficult; (15) successful biological science teachers center their teaching activities around concrete, as opposed to abstract, subjects where possible and practical.

Mrs. Aleen B. Ivie, a biology teacher at West High School in Salt Lake City, Utah (35) has stated that:

> Most of us (biology teachers) lack necessary funds to do an ideal job. We do the best we can with our funds, and we struggle to correct our faults. I am on most of the biology committees and I try to give constructive criticism which I hope improves our city situation. I feel we will never have <u>enough</u> money; so I am convinced we must study the <u>best</u> teaching methods with limited funds.

This statement probably describes a major problem for biological science teachers in Utah.

CHAPTER V

RECOMMENDATIONS

Through several different sections in this study recommendations have been made. Many of these were drawn from books or magazine articles written by authorities in this field. However, many recommendations came as a result of analyzing the questionnaires, or interviewing the teachers. It is this latter type of recommendation with which this section is mostly concerned.

Recommendations for equipment and facilities

1. Biological sciences can not be taught effectively in regular classrooms. Even where crowded conditions exist, it is undesirable to teach these subjects in rooms which are not constructed for this particular kind of instruction.
2. Emphasis should be placed on obtaining an adequate supply of desirable teaching aids.
3. Opaque projectors have been very helpful in teaching biological sciences.
4. Each biological science classroom should have some type of library which is situated in the individual class. Too often library materials are located in the general school library and are not widely used.
5. Desks which cannot be moved are generally undesirable in biological science classrooms.
6. A good window location should be supplemented with suitable materials for growing plants.

7. An adequate classroom would contain storage space and sinks and water.
8. The teacher who intends to use the room should be consulted concerning its design wherever possible.
9. A variety of good textbooks is superior to one primary textbook.
10. Pupil tables are highly desirable in enhancing biological science teaching.
11. More bioscopes should be purchased in connection with concrete biological science teaching.
12. A large felt board is desirable in biological science teaching.
13. Animal cages are very helpful in biological science teaching.
14. Tables of various shapes and sizes for group procedures are recommended.
15. Storage space is a very necessary item in science classrooms.
16. A usable micro-projector is highly recommended, especially in advanced biological science classes.
17. A balopticon projector is valuable in making the subject matter realistic and concrete.
18. A demonstration desk with gas and water facilities is essential for certain aspects of successful biological science teaching.
19. The practice of changing classrooms for certain demonstrations, films, etc is an overall undesirable practice if facilities can be made available in the one classroom.
20. The administration of secondary schools should foster and encourage teaching methods which bring the community and the student into direct contact for mutual improvement.

Recommendations for teaching procedures

1. Encouraging students to take notes has been quite successful in several of the schools reporting in this study.
2. Teaching procedures which require the use of groups of students (e.g., committee reports, panel discussions, etc.) are helpful but must be carefully planned.
3. Teachers who teach biological sciences most of the day will usually develop better biology departments; therefore, this kind of situation should be fostered where possible.
4. Where it is possible, smaller teaching loads would help to insure greater use of individual assignments.
5. Where students do drawings of organisms, the stress should be on labels and not on representative drawings.
6. In biological science teaching units it is often desirable to have the teaching method, subject matter, etc. chosen and changed by group procedures.
7. Many of the teachers in this study recommend that student-teacher planning of teaching units should be carefully directed by the teacher because the pupils may stress a few units and eliminate necessities.
8. Individual research by superior students often produces outstanding results.
9. Oral readings produce the best results when they are employed in connection with new data, unavailable data, and difficult material.
10. Successful field trips must be carefully planned and executed.
11. The desirability and adequateness of most teaching methods are dependent upon the initiative and capabilities of the teacher as

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Letters

(35) Letter to author from Mrs. Aleen B. Ivie, biology teacher, West High School, Salt Lake City, Utah, dated April 6, 1955.

APPENDIX

To Utah Junior and Senior High School Principals

Dear Colleagues:

Among our students working for the Master's degree here at the College is Mr. Gerald Raat. For a thesis problem he would like to study the teaching of biology in our secondary schools. Specifically, he hopes to identify a few teachers who are recognized by their principals and superintendents as being outstanding in this field. If he could get the names of such teachers his study would be limited to them.

A few years ago this general approach was tried by one of our graduate students in the teaching of literature. I believe that study achieved some significant results.

The purpose of this letter to you is to ask if you would be willing to name any teacher of biological science to be included in the study. Your reply will be kept strictly confidential and the follow-up work with the teachers will be such as not to indicate that they have in any way been chosen because of their superior qualities. Rather, we hope, that it will look like a general sampling of the biology teachers has been made.

If you do have teachers in your system that you would like to nominate to include in the study, please write the name and address on the enclosed, stamped card. You will note that this does not call for your signature. Suit yourself about signing it.

Sincerely yours,

(signed) John C. Carlisle

Professor of Education

JCC/jcb

Enclosure

UTAH STATE AGRICULTURAL COLLEGE

SCHOOL OF EDUCATION

March 11, 1955

One of our graduate students, Mr. Gerald Raat, is making a study of the teaching of biology in the secondary schools. Your principal has suggested you might be willing to cooperate with him.

Enclosed herewith is a questionnaire which he would appreciate your filling out. You will note that it is organized in such a way as to take a minimum amount of time. When the information is received from all the schools, he feels he can draw some significant conclusions.

A stamped envelope is enclosed for your reply. Please return the completed questionnaire just as soon as possible. You may be assured that your responses on this questionnaire will be kept strictly confidential. After the results are compiled, we will be glad to send you a copy of the findings if you wish one.

Sincerely,

(signed) John C. Carlisle

Professor of Education

JCC/jcb

Questionnaire for Teachers of Biological Science Subjects

Please check the appropriate items.

Biological science (s) you teach: Zoology ____, Biology ____, General Science ____, Botany ____, Health or Heredity ___, Physiology ____, Others (please specify) ____.

College training: Biological science teaching major____, Biological science teaching minor____, Other teaching majors and minors _____, _____.

Number of periods you teach daily: 1 ____, 2 ____, 3 ____, 4 ____, 5 ____, 6 or more ____.

Number of periods you teach Biological subjects or General Science: 1 ____, 2 ____, 3 ____, 4 ____, 5 ____.

Average number of students per class: 15-20 ____, 20-25 ____, 25-30 ____, 35 or above ____.

Professional training: Below B. S. ____, B. S. or equivalent ____, M. S. or equivalent or above ____.

Professional experience: 1-4 years____, 5-10 years____, 10 years or above___.

- -

Part I.

What is the frequency or extent in which you employ the following teaching methods or procedures in your biological science classes or units?

Instructions: Please indicate your answer in the blank in the response column by selecting the most appropriate word or words in the key.

KEY

a. very frequently
b. frequently
c. occasionally
d. rarely
e. never
f. other (please specify) _____

1. ___Field trips are taken to places of biological interest outside of the immediate school area.

2. ___Laboratory exercises are performed by individual students or small groups of students.

3. ___Resource visitors from the community are brought into the class to help discuss or present a particular topic.

4. ___Group demonstrations, panel discussions, and committee reports are performed by the students.

KEY

a. very frequently
b. frequently
c. occasionally
d. rarely
e. never
f. other (please specify) _____.

- -

5. _____Motion pictures, film strips, and slides are utilized in instructional activities.

6. _____Simple analytical drawings of organisms are required.

7. _____Assignments are made for all in the class rather than on an individual basis.

8. _____Models, charts, and specimens are used in instructional activities.

9. _____Lecture and class recitation methods are used.

10. _____Laboratory manuals and printed diagrams are used in the instructional activities.

11. _____Written reports of laboratory work are required.

12. _____Mimeographed study guide sheets or "syllabus" including student study exercises to be completed are used.

13. _____Living specimens are brought into the instructional activities.

14. _____Representative drawings of the organisms being studied are required.

15. _____Science clubs are utilized to promote interest and understanding in biological studies.

16. _____Individual assignments are made which require the use of several sources. (e.g., newspapers, magazines, and books).

17. _____Students are involved in the survey, discussion, and decision of teaching units.

18. _____Assignments are made in recognition of individual differences.

19. _____Teacher demonstrations are being performed before the class.

20._____Others (please specify)_____.

Part II

Please indicate the adequacy of the following items of equipment or facilities which are considered desirable in biological science teaching.

Instructions. Indicate your selection in the response column by using the alternatives in the Key.

KEY

a. Provision (s) or condition (s) is entirely adequate.
b. Provision (s) or condition (s) is adequate most of the time.
c. Provision (s) or condition (s) is inadequate.
d. Provision (s) or condition (s) is missing and needed.
e. Provision (s) or condition (s) is missing.

- -

21. _____A demonstration desk.

22. _____A variety of textbook and reference materials.

23. _____A room equipped for audio-visual aids.

24. _____Movie projectors, slide projectors, and movie screens.

25. _____Bookshelves and filing cabinets are present.

26. _____Good films, film strips, and slides are present.

27. _____Models and charts and specimens are provided for.

28. _____Aquarium is provided for.

29. _____Terrarium is provided for.

30. _____A laboratory work area is provided for.

31. _____Tables to accommodate two or more pupils for group study are provided for.

32. _____A laboratory and lecture area are combined into one room.

33. _____Bulletin boards and blackboard space are provided for.

34. _____Museum or museum areas are available to biology classes.

35. _____Microscopes are provided for.

36. _____Room is located so that biological specimens may be grown in window gardens.

37. _____Others (please specify) _____.

Part III

In terms of your experience which of the following methods or procedures of instruction would you recommend for effective life science teaching if you had the necessary facilities and equipment?

Instructions. Please indicate your answer at the blank in the response column by selecting the most appropriate word or words in the key.

KEY

a. highly desirable.
b. desirable.
c. usually desirable.
d. usually undesirable.
e. undesirable.
f. other (please specify).

- -

38. _____Field trips.

39. _____Student drawings.

40. _____Motion pictures, film strips and slides.

41. _____Group demonstrations, panel discussions, and committee reports.

42. _____Bringing resource visitors, etc., from the community.

43. _____Student-teacher planning of units.

44. _____Lecture and recitation methods.

45. _____Teacher performed demonstrations.

46. _____Teaching from mimeographed study guides or "syllabus" including student study exercises.

47. _____Assignments made in recognition of individual differences.

48. _____Assignments made for whole class rather than on an individual basis.

49. _____Individual written assignments.

50. _____Individual laboratory exercises.

51. _____Assignments requiring the use of several sources.

52. _____Oral readings in your class.

53. _____Other (Please specify) _____.

Part IV

If you were told you could order or prescribe any item or condition to aid effective learning in biological sciences, what equipment and facilities would you order?

KEY

a. absolutely necessary.
b. necessary.
c. necessary but could do without.
d. not necessary but helpful.
e. unnecessary.
f. other (please specify) _____.

- -

54. _____Greenhouse.

55. _____Films, film strips, slides.

56. _____Aquarium and terrarium.

57. _____Variety of reference publications.

58. _____Microscopes.

59. _____Models, charts, and specimens.

60. _____Display cases.

61. _____Bookcases and filing cabinets.

62. _____Bulletin board and blackboard space.

63. _____Pupil tables.

64. _____Audio and visual equipment and facilities.

65. _____Laboratory work area.

66. _____Laboratory manuals.

67. _____Museum area.

68. _____Others (please specify) _____.

Part V

Essay: Please indicate your answer (s) by writing a short explanation.

1. In the preceding sections you may have checked some teaching methods as highly desirable or desirable, but you may have also indicated that their frequency of use was either rarely or never. If so, your explanation for the difference would be helpful.

2. In the preceding sections you may have checked some items of equipment or provisions for facilities as being inadequate or missing, but you may have also recommended these as necessary. If so, your explanation for the lack of these necessary items would be helpful.

3. I am anticipating a follow-up visit to some of the classrooms which are included in this study. The purpose of this visit would be to determine some factors not included in this questionnaire. If I may visit you and your school, please indicate below.

Teacher _____

School _____

Room No. _____

Best Time _____

Sincere thanks for your response and prompt return of this questionnaire.