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DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
John Tull Starling, B.Sc., M.Sc.

********

The Ohio State University
1964

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CHAPTER I

NATURE OF THE STUDY

Paramount in any educational endeavor is the need for the continuous search for new and better methods of teaching. Thomas H. Huxley once said, "I care not what subject is taught if only it be taught well."

The Educational Policies Commission of the National Education Association had this to say about the adaptation of new teaching methods and techniques by both individual teachers and school systems:

More important than any official preparation in "methods" is the quality of mind—the flexibility which permits experimentation, improvisation, and growth. The willingness to try a new technique without prejudice, and to learn through practice, has always been a characteristic of good teachers. As new devices develop this quality will grow more significant. The school system can no more afford to wait until a clear-cut series of techniques using new technology is officially embedded in the curriculums of teachers colleges than it can wait until a head count is secured on the first day of school before beginning its plan for adding to the building. There will always be new devices, new possible approaches in a profession as creative as teaching.

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Agriculture, like the rest of the economy, is undergoing rapid and accelerating changes due to technological and scientific developments and improved methods of organization and management.

It is a recognized fact that agriculture is becoming increasingly technical in nature and that specific facts learned soon become obsolete. It is also evident that increased impetus will be given to science in the years ahead and instruction in vocational agriculture should become more science-oriented to keep pace with the scientific and technological developments in agricultural production. This is emphasized by the following statement from a recent article in The Agricultural Education Magazine:

The intelligent performer is one who understands "why" as well as "how" a certain procedure is to be followed. His understanding of "why" distinguishes him from the "rule of thumb" performer.

If a farmer, or future farmer, is to possess initiative and resourcefulness, and develop ability to think intelligently through the problems of production and distribution it seems essential that he have a working knowledge of the sciences underlying and closely related to agriculture.3

Since many agricultural problems lend themselves to an application of biological principles, this study should provide direction for improving instruction in vocational agriculture and provide a means for a better understanding of biological principles basic to agriculture through an inductive method of teaching.

A forerunner to this study was conducted at the University of California, Davis, with Sidney S. Sutherland, Professor of

Agricultural Education, University of California, and W. Earl Sams, Consultant, Bureau of Secondary Education, State Department of Education, serving as co-ordinators of the project.

The California study was conducted to determine the effectiveness of a biological principles approach to teaching vocational agriculture. To test this approach, a pilot and control group design was used with a pre- and post-test administered to each group.

This study is patterned after but expanded beyond the California study.

Need for the study

Teachers of vocational agriculture have become concerned about the explosion of knowledge and the rapid technological developments. They realize the need for ways to adjust their programs to keep pace with the changing times. This need is also emphasized by the following statement:

Little change has been made in vocational agriculture education since its inception. The content of the courses in vocational agriculture as well as its place in the curriculum need re-examination. Educational leaders need to determine the proper emphasis to be given in courses in order to broadly educate young people who, to the limit of their respective abilities, can adjust to changing times.

If we lean heavily toward applied training, the student may be better prepared for his first job. On the other hand,

applied training may become out-of-date by the time the student has been on the job for a short while. In the long run, a basic understanding of principles may serve him better than simply knowledge of how to do things.

The "principle approach" lends itself to instruction which is directed toward the development of understanding and the ability to make appropriate application to a wide range of agricultural problems. It has long been accepted that principles should be taught with application and that the most effective teaching results when principles and application are presented in the closest association with each other.

The writer is of the opinion that students should be trained to think and use facts in solving agricultural problems or the problems of everyday life.

John M. Mason said, "The aim of education should be to convert the mind into a living fountain and not a reservoir. That which is filled by merely pumping in will be emptied by pumping out."\(^5\)

Recent studies have shown that there will be a decreasing number of opportunities for vocational agriculture graduates to enter farming in the future—thus, making it necessary for them to find employment in jobs related to agriculture. With the rapid changes in technology, it is anticipated that the educational

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competencies for these jobs will change many times in the next few years. This is substantiated by the following quotation:

Since jobs will change materially during the working lives of many in the future, a reassessment of our vocational education should be made by the states and the federal government. With the changing careers we contemplate, rigid vocational training seems to be of doubtful value. 

As better means of transportation are developed and we move toward more unified international educational programs, it is reasonable to assume that more people will find employment in foreign countries. The skills and abilities needed for these jobs would most likely be much different from those needed for the jobs in the community in which the individual was trained.

Technological developments are needed and taking place in other countries as is indicated by the following quotation taken from Phi Delta Kappan Magazine:

Agriculture has been traditionally regarded as the occupation of the shoeless, a concept with roots in the early colonization period. A few landlords were masters of land and life over a great portion of the population. The "peon-patron" relation which evolved still prevails in most countries. It is a cultural heredity likely to survive for many years.

Inevitably, this condition affects concepts of agricultural education. For years, it was believed that no training is needed by those who till the soil and take care of animals. Such tasks had been performed throughout the ages by the less educated or non-educated. Fortunately, this concept is changing, even though slowly. The main impetus for this change comes from technological advances.

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The need to keep pace with technological developments is not confined only to agricultural education but to all phases of education. In addition to the many technological developments, socioeconomic changes have caused educators to focus attention on broadening all educational programs. Studies have shown that one out of every five persons move each year and consequently a person educated in New York may find employment in California or vice versa. The constant increase in automation eliminates some jobs while creating others and the competencies needed for these jobs is continually changing.

In a recent national seminar held at The Ohio State University, Benjamin C. Willis, Superintendent of Schools in Chicago, said:

"We must not only broaden our educational spectrum and expand it, but also build more flexibility into it and make our judgments of its effectiveness more individualized and varied. Broad principles must form the foundation for any educational program. It is futile to prepare individuals for specific kinds of work which may or may not exist tomorrow without providing them with the general skills that will permit them to modify specific capabilities as the need arises."

With the complexity of our American society, we are challenged to search for new and better methods of teaching. Much research is being conducted in the field of education as is emphasized by the following statement:

"One need but glance at a recent volume of the "Encyclopedia of Educational Research" to become"

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impressed with the great body of knowledge about education and the educative process that is accumulating year by year.\(^9\)

The writer is of the opinion that teachers of vocational agriculture have an excellent opportunity to teach scientific principles and help students see the practical application of these principles, thus making science courses more meaningful to students. With the increased emphasis placed on science some educators have expressed the opinion that the emphasis has been placed on science as a course without giving students an opportunity to see its relationship to other fields of knowledge. This thought is expressed in the following statement: "We have so exalted the power of science that we sometimes forget its relation to other fields of knowledge."\(^10\)

Since we have this opportunity in vocational agriculture we need to conduct research to determine the feasibility of this approach and to determine the best methods to use.

In designing this study, the thought was expressed that while students were gaining understanding of biological principles they might sacrifice understanding in agriculture or tend to lose interest in agriculture so this study was broadened over the California study through the inclusion of the agricultural achievement and interest inventory tests.


In discussing this study with a number of people, several questions were presented as to what effect such factors as: number of principles taught, age of student, student status in biology, student I.Q., and student interest would have on the degree of achievement in agriculture and biology.

Since these questions were presented it seemed that further study was needed to determine the relationship of these factors to the degree of achievement in agriculture and biology.

As a result of the California study it was apparent that the students in the pilot schools did better than those in the control schools; however, since a measure of central tendency was the only statistic employed, it was difficult to determine the significance of the gain from the biological principles approach. Since this was the case it seemed that a more detailed statistical analysis was needed to make the results more meaningful.

It is hoped that this study will add to and further substantiate the results of the California study. It is also hoped that the results of this study will be used to provide direction for improvement of instruction in vocational agriculture and serve as a guide for further study in the application of principles in other areas such as farm mechanics and farm management.

**Purpose of the study**

The purpose of this study was to determine the feasibility of integrating biological principles with instruction in vocational agriculture at the high school level in Ohio.
Specific objectives

The major purpose of the study was—

1. To determine the significant difference between the pilot and control schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

2. To determine the significant difference between pilot schools that are first year participants and those that are second year participants relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

3. To determine the correlation between the dependent variables change in achievement in agriculture and biology and the following independent variables:
   a. Year in the project.
   b. Number of principles taught.
   c. Age of the student.
   d. Status in biology.
   e. California Mental Maturity score.
   f. Agricultural interest score.
   g. Science interest score.

4. To determine which independent variables are most important in influencing the dependent variables.

5. To determine the desirability of integrating the biological principles with instruction in vocational agriculture in Ohio.

6. To determine the changes needed to make the biological principles approach more effective.
Hypotheses

In the development of this study, four major null hypotheses were formulated:

1. There will be no significant difference between the pilot and control schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

2. There will be no significant difference between first and second year pilot schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

3. There will be no relationship between the independent variables and the dependent variables change in achievement in agriculture and biology.

4. None of the independent variables will be significant in predicting the dependent variables.

Procedures employed in the study

The general procedures employed in this study included the selection of fifteen pilot schools and eight control schools. The teachers in the pilot schools integrated the teaching of biological principles into their teaching in solving agricultural problems. The teachers in the control schools conducted a traditional program without any change from the usual methods used in the Ohio vocational agriculture program. A pre- and post-test were given to each group and the test results were analyzed to determine the difference in achievement between the pilot and control group.

A subjective evaluation was accomplished through the use of a questionnaire to secure teacher opinions.
As previously reported, the first efforts in this biological principles approach to teaching vocational agriculture were conducted at the University of California, Davis. This study was patterned after the California study in that the design involved a pilot group and a control group both given a pre-test and a post-test. However, this study went beyond the California study in that Agricultural Achievement and Interest Inventory tests were given in addition to the Biological Principles and California Mental Maturity tests used in the California study. This study also made use of a more comprehensive statistical analysis as is presented in Chapter III.

This project was conducted over a two-year period which included the school years 1962-63 and 1963-64. Seven of the fourteen pilot schools participating in 1962-63 continued in 1963-64 in order to have a means of comparison with first year schools. Only the results obtained during the 1963-64 school year were analyzed in this study; however, a table showing the mean difference in scores between the pre- and post-test for the pilot and control schools during the 1962-63 school year is included in the appendix of this study.

The same general procedures were followed both years; however, a more detailed explanation of the procedures employed during the 1963-64 school year is given in Chapter II of this study.

The California study.—Financial assistance for the original California project was provided by the National Defense
Education Act of 1958 and the project was conducted through the cooperative efforts of the University of California, Davis; the Bureau of Agricultural Education; Bureau of Secondary Education; and the California State Department of Education.

In designing this project, biologists, agriculturalists, and agricultural educators from the College of Agriculture, University of California, Davis, specialists in biology from the State Department of Education, instructors in agriculture and biology from state colleges, junior colleges, and high schools were used as resource persons. One of the major contributions of this staff of specialists was the development of a list of twenty-two biological principles having definite application to agriculture. A list of these principles is included in the appendix of this study.

This staff of specialists also developed a manual, "Biological Principles in Agriculture," which included several examples of demonstrations and experiments for teachers to use in integrating biological principles with instruction in agriculture.

The principles could be taught in many ways; however, the inductive approach was suggested as the best method. The following statements by Sutherland describe the appropriateness of inductive teaching as a method of teaching the biological principles:

The key to inductive teaching is to withhold any statement of a principle until students have observed, studied, and considered several instances that involve
These instances may be experiments conducted by students, demonstrations by the teacher, experimental data presented by the teacher, problem situations presented by the teacher, or field observations. All of these activities involve the question "Why?" "Why does this occur?" "Why do we get these results?" The answer to these questions will eventually lead to the discovery of the underlying principles. Inductive thinking, then, generally begins with observed effects and leads eventually to the cause or causes.  

In order to test this approach, six vocational agriculture departments were selected to integrate the biological principles into their teaching of agricultural problems in high school vocational agriculture classes. Nine departments served as a control group for the purpose of comparison. In the analysis of this approach, both objective and subjective evaluations were made. The objective evaluation was secured through the use of a multiple choice test of biological principles and the California Mental Maturity Test. These tests were administered as pre- and post-tests and the change in achievement between the pilot and control schools was calculated. The subjective evaluation was secured through the use of a one-page evaluation sheet and from observations and experiences of teachers, students, and the project director.

At the end of the year, the objective evaluation showed a difference in mean score of 8.43 on the biological achievement test in favor of the pilot schools. A complete summary of the California test results is included in the appendix of this study.

Relative to the subjective evaluation based on experiences and observations, the following conclusions and recommendations were drawn:

1. That the experimental phase of this project be continued for another school year, and the number of pilot schools increased to twelve.

2. That a preliminary edition or working draft of the teaching materials be published for limited distribution.

3. That teachers in schools other than the experimental who may wish to use this material be requested to attend short workshops designed to provide them with an orientation to this material and instructions on how to use it.

4. That a statement be included in the working draft defining the term "principle," and explaining the inductive approach to the teaching of principles.

5. That the same general design followed in the current year's experimental program be followed next year.12

The research was continued in California and it has stimulated interest in further research in the inductive approach to teaching principles in vocational agriculture, not only biological principles but principles in farm management and farm mechanics.

The writer became involved in this particular project in April, 1962, after Sutherland explained the California project at the regional conference held in Denver, Colorado. Some members of the Ohio Vocational Agriculture staff were in attendance at this meeting and in a conference with Sutherland, the thought was

expressed that it would further substantiate this project if it could be tested in other states.

**Basic assumptions**

1. It is assumed that since the twenty-two biological principles were developed by leaders in the areas of Agronomy, Animal Science, Botany, Plant Biochemistry, Plant Pathology, Soil Microbiology, Veterinary Medicine, and Zoology that they have definite application to agriculture.

2. It is assumed that the California Mental Maturity, Interest Inventory, Agricultural Achievement, and Biological Achievement tests used in this study are valid evaluation instruments.

3. It is assumed that the teachers of vocational agriculture in the selected pilot schools have sufficient background in science to give the biological principles approach a fair trial.

**Limitations of the study**

1. This study is limited by the factors such as time and teacher experience which made it impossible for all of the teachers in the pilot centers to integrate all twenty-two of the principles into their course of study.

2. This study is limited by the time that was available to staff members in the Department of Agricultural Education to provide instructional materials and aids for teaching the principles.
3. This study is limited to the extent of the equipment that was available in the pilot schools for use in performing experiments and demonstrations.

**Definition of terms**

1. **Principle:**

   A principle is a fundamental truth. A law of conduct which has general applications, and which is a basis for action. It is a generalization based upon facts and upon elements of "likeness" common in a number of situations.

2. **Biology:**

   The science of life; the branch of knowledge which treats of living organisms both plant and animal.

3. **Inductive Teaching:**

   This process involves "going from the concrete to the abstract." Instruction starts not with a statement of the principle but with observed or described situations which illustrate the principle and which should lead students eventually to discover and state it with the assistance of the teacher. Inductive thinking generally begins with observed effects and leads eventually to the cause or causes.

4. **Pilot School:**

   A school used in this study where the teacher of vocational agriculture integrated the principles into the course of study in the solving of agricultural problems.
5. Control School:

A school used in this study in which no attempt was made to integrate the principles into the course of study, a traditional program was taught and they were used for comparison purposes only.

6. Pre-test:

The Agricultural Achievement, Biology Achievement, California Mental Maturity, and Interest Inventory tests that were administered near the beginning of the school year.

7. Post-test:

The Agricultural Achievement, Biology Achievement, and Interest Inventory tests administered near the end of the school year.
CHAPTER II

SELECTION OF SCHOOLS, SELECTION AND DEVELOPMENT OF EVALUATIVE TESTS

In order to appraise this teaching approach it was necessary to make a careful selection of pilot and control schools. It was also necessary to select and develop evaluative tests.

Procedure for selecting pilot schools

As reported in Chapter I, the research design of this study involved the use of pilot and control schools. A review of educational research seemed to indicate that this would be the best research method to be used in testing this teaching approach. This is substantiated by the following statement:

Research, even in agricultural education, needs to be weaned away from nearly exclusive use of survey procedures. The whole range of techniques usable in research should be tried out in the solution of problems. Case studies, particularly the use of "pilot centers" seem to be especially adapted to the field. 13

This method is further substantiated by the following statement by Campbell and Stanley in the Handbook of Research on Teaching:

One of the most widespread experimental designs in educational research involves an experimental group and a control group both given a pre-test and a post-test,

but in which the control group and the experimental group do not have pre-experimental sampling equivalence.\textsuperscript{14}

In the field testing of this teaching approach, it was necessary to make a careful selection of pilot schools. In making this selection, assistant state supervisors of vocational agriculture were asked to recommend schools, in their respective districts, that in their opinion would give this teaching approach a fair trial. The supervisors considered such factors as: geographic location, size of school, administrator attitude, and teacher competency. A letter of explanation was sent to the teachers of vocational agriculture and administrators in the recommended schools asking them if they were willing to participate in this project. A copy of the letter is included in the appendix of this study.

From the list of eighteen schools recommended by the supervisors, fifteen schools agreed to serve as pilot centers in which the teachers would integrate the biological principles into their course of study in vocational agriculture. Four hundred thirty-seven students in the pilot schools took the pre-tests with four hundred twenty-two students completing the post-tests.

Table 1 shows the average total school enrollment in the pilot schools to be 1,269.3 students with an average of 44.1 students enrolled in vocational agriculture. Two of the departments in the pilot schools were multiple teacher departments.

The teachers in pilot schools had an average of 9.44 years of experience and six of the seventeen teachers held a Masters degree.

### TABLE 1. Some selected characteristics of pilot schools

<table>
<thead>
<tr>
<th>School Number</th>
<th>Total School Enrollment</th>
<th>Vocational Agriculture Enrollment</th>
<th>Number of Teachers of Voc. Agr.</th>
<th>Number of Years of Experience</th>
<th>Degree Held</th>
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<tr>
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</tr>
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<td>9</td>
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<tr>
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<td>1552</td>
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<td>1</td>
<td>3</td>
<td>M.Sc.</td>
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<tr>
<td>15</td>
<td>1218</td>
<td>58</td>
<td>2</td>
<td>20</td>
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<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>1269.3</strong></td>
<td><strong>44.1</strong></td>
<td><strong>1.13</strong></td>
<td><strong>9.44</strong></td>
</tr>
</tbody>
</table>

### Procedure for selecting control schools

In order to have the most valid means for evaluating the biological principles approach control schools were selected to serve as a means of comparison.

Borg emphasizes the value of using a control group by the following statement in *Educational Research:

The major limitation of the single-group design is that, as no control group is used, the experimenter must
assume that change between the pre-test and post-test were brought about by the experimental treatment. There is always some chance, however, that one or more extraneous variables brought about all or part of the change noted between the pre-test and the post-test scores.\textsuperscript{15}

He further emphasizes the value of a control group by this statement:

The essential difference between the single-group design and the control-group design is that the latter employs at least two groups of subjects, one of which is called the experimental and is included primarily to make it possible to measure the effect of external factors upon the post-test of the dependent variable, the treatment of the experimental and control groups is generally kept as close to identical as possible with the exception that the experimental group is exposed to the experimental treatment. Using control-group design, if external variables have brought about changes between the pre-test and post-test, these will be reflected in the scores of the control group. Thus, only the post-test change of the experimental group that is over and above the change that occurred in the control group can be attributed to the experimental treatment.\textsuperscript{16}

The Ohio vocational agriculture supervisory and teacher training staffs were consulted in making a selection of control schools. It was decided that the control schools should be selected from the cooperating schools or schools used for the purpose of training teachers of vocational agriculture. These departments are theoretically the best in Ohio. The thought was expressed that if there was any significant increase in achievement for pilot over control schools, selected from the best, that the increase should be greater when compared with average schools.


\textsuperscript{16}Ibid., p. 295.
Ten schools were recommended to serve as control schools and the teachers of vocational agriculture and administrators were sent a letter of explanation and asked if they would be willing to serve as a control school in which they would participate only in the testing phase of the program with no change in their vocational agriculture program. A copy of the letter is included in the appendix of this study. From the ten schools recommended, eight schools agreed to serve as control centers. Two hundred forty-eight students took the pre-tests in the control schools with two hundred thirty-five students completing the post-tests.

Table 2 shows the average total school enrollment in the control schools to be 1,904.3 students with an average of 51 students enrolled in vocational agriculture. Three of the departments in the control schools were multiple teacher departments. The teachers in the control schools had an average of 9.1 years of experience and five of the eleven teachers held a Masters degree.

In making a comparison of the pilot and control schools, it can be noted that in both groups there was some small rural schools and some large consolidated schools. The average total school enrollment in the pilot schools was 1,269.3 while in the control schools the average total school enrollment was 1,904.3. The average enrollment in vocational agriculture was somewhat higher in the control schools with an average of 51 students while the average in the pilot schools was only 44.1. The
TABLE 2.—Some selected characteristics of control schools

<table>
<thead>
<tr>
<th>School Number</th>
<th>Total School Enrollment</th>
<th>Vocational Agriculture Enrollment</th>
<th>Number Teachers of Voc. Agr.</th>
<th>Number Years Experience</th>
<th>Degree Held</th>
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</thead>
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<td>M.Sc.</td>
</tr>
<tr>
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<td>3157</td>
<td>62</td>
<td>1</td>
<td>23½</td>
<td>M.Sc.</td>
</tr>
</tbody>
</table>

Average: 1904.3  51  1.37  9.1

experience of the teacher was quite comparable in both groups with the teachers in the pilot schools having an average of 9.44 years of experience and those in the control schools having an average of 9.1 years of experience. Six of the seventeen teachers in the pilot schools held a Masters degree and five of the eleven teachers in the control schools held a Masters degree.

Procedures used in working with the teachers in pilot schools

After a selection of schools was made, a meeting of the teachers in the pilot schools was held in August, 1963, at The Ohio State University with the writer in charge of this meeting. At this meeting ideas as to how the principles should be taught were presented with emphasis on an inductive method of teaching.
As a benchmark for this discussion, a quote from Sidney S. Sutherland was used:

This is inductive teaching. It proceeds from the concrete (situation) to the abstract (principle). It starts with observing—observing situations on field trips; observing results of experiments or of demonstrations; and requires students to find the basic cause or causes.\(^\text{17}\)

Kenneth B. Henderson in the *Handbook of Research on Teaching* presents the same general idea:

1. Presenting instances of the item of knowledge to be taught in order to enable the students to form hypotheses.

2. Presenting evidence—perhaps more instances—serving either to confirm or disconfirm the various hypotheses students state or appear to be acting on.

3. Stating or having a student state the item of knowledge which is a warranted influence from Steps 1 and 2.\(^\text{18}\)

At this meeting it was emphasized that the biological principles should not be taught as a separate subject. Instead, when an agricultural unit was being taught to which one of the principles applied, teach the principle then, as a part of that agricultural subject or unit.

Ideas were also presented as to suggested demonstrations, teaching aids, and references to be used in teaching the principles. The basic reference recommended was the one developed in California, *Biological Principles in Agriculture*, A manual for

\(^\text{17}\)Sidney S. Sutherland, "Suggestions for Teaching Biological Principles in Agriculture," University of California, Davis, 1963, p. 2.

high school teachers integrating biological principles with instruction in agriculture.

The writer visited the pilot schools during the month of October, 1963, to observe the teaching of the biological principles and to assist the teachers in planning their course of study to include the teaching of as many of the principles as possible.

During the month of March, 1964, small group meetings of the teachers in the pilot schools were held at three locations throughout Ohio. At this meeting a summary of the principles taught was developed and a plan for the remainder of the school year was formulated. The teachers also presented ideas as to teaching aids and references that they had found helpful thus making it possible for more teachers to utilize the resources of the entire group. The writer felt this was a very worthwhile meeting because at this stage the teachers had had an opportunity to teach several of the principles and were in a position to give a good analysis of various procedures and techniques they had used.

Procedure used in developing and selecting evaluative tests

The objective evaluation in this study was expanded over the original study conducted in California through the addition of an Agricultural Achievement and an Educational Interest Inventory test. The reason for the addition of these tests was to have a means of comparing change in achievement in other areas in addition to understanding of biological principles. In
designing this study the thought was expressed that while students were gaining understanding of biological principles, they might sacrifice understanding in agriculture or tend to lose interest in agriculture so that agricultural achievement and interest inventory tests were added to determine if this were true.

In the development of the agricultural achievement test, it seemed advisable to test for achievement in the major areas of the Ohio vocational agriculture program which are crop production, livestock production, farm mechanics, farm management, and Future Farmers of America.

It seemed necessary to develop an agricultural achievement test especially for Ohio because no suitable standardized test was available. This is supported by the following statement:

> From time to time, efforts have been made to develop tests suitable for wide range usage in measuring achievement in vocational agriculture, but the differences in the types of agriculture among the states and communities have handicapped this movement.¹⁹

In the formulation of a test to measure achievement in these areas a list of one hundred fifty multiple choice questions was developed. The multiple choice type of questions were used because they seemed to be the most effective means of testing for understanding and the most convenient to score. This is supported

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by the following statement from the *Encyclopedia of Educational Research*:

The long slow test of time has gradually convinced test constructors of the generally superior versatility and convenience of multiple choice items. Other forms (true-false, matching, et cetera) can be used with high effectiveness in special situations, but there is none which has proved so widely applicable and so generally effective as the multiple choice forms.

The list of one hundred fifty questions was submitted to the Agricultural Education Staff for review. They were asked to select the questions they considered most effective and appropriate for measuring achievement of students in the Ohio vocational agriculture program.

From the one hundred fifty original questions, one hundred were selected to make up the agricultural achievement test used in this study. A copy of this test is included in the appendix of this study.

The biological principles test used was the same as the one used in the California study. Since this test was developed by the specialists who developed the principles and this study is a continuation of the California study, it seemed to be the best means of evaluating understanding of biological principles. This test consisted of seventy-five multiple choice questions; a copy of it is included in the appendix of this study.

Since a number of standard I.Q. and Interest Inventory tests were available, the Division of Guidance and Testing, Ohio State Department of Education, was asked to recommend an

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intelligence and interest inventory test. As a result, of their recommendation, the California Short-Form Test of Mental Maturity and Educational Interest Inventory by James E. Oliver, which included a section on agriculture, were the tests selected.

The writer is aware of the fact that the validity of the I.Q. test has long been a debatable issue; however, a review of literature reveals that it is one of the best means of comparison we have at the present time. This is supported by the following statement:

While intelligence is a many-facted thing and an intelligence quotient may not always be the best determinant of a person's ability to succeed in adult life, it is nevertheless a fairly accurate yardstick by which a student's ability for academic achievement in school may be measured. In determining pupil potentiality in terms of academic achievement, the teachers will necessarily want to refer to the individual pupil's intelligence test scores, usually a part of the school testing program and generally a part of the student's cumulative record maintained in the school office.21

In designing this study, some predicted that students with high I.Q. scores would have a much higher degree of achievement than those with lower I.Q. scores. There seems to be some basis for this prediction in the following statement:

Traxler called aptitude a condition, a quality, or a set of qualities which is indicative of the probable extent to which an individual may be able to acquire, under suitable training, some knowledge, understanding or skill. In other words, it is a present situation that indicates the potentialities for the future. An aptitude is not an ability, but it helps to predict the probable development of certain abilities. A test of

aptitude may reveal abilities as well as skills, but the significance of the test is in revealing potential abilities and skills.\textsuperscript{22}

The interest inventory test employed in this study was a forced choice type test where the student had to indicate a preference between one of two statements. This test was designed to provide a measure of relative interest in activities associated with the curriculum underlying most educational endeavors. It is recognized that student interests may change with stages of maturity or as students gain experience in certain areas; however, interest inventories are an indication of real present interests. This is supported by the following excerpt:

The interests, the likes, and the dislikes revealed by interest inventories are in most cases, real present interests and as such have a great deal of value even though they are often not safe guides for the future choice of an occupation. These interests should be utilized by teachers and counselors as a means of widening and enriching the knowledge of the pupil and developing in him an understanding and appreciation of different types of occupational life.\textsuperscript{23}

The California Mental Maturity and Interest Inventory Tests employed in this study are standardized tests and may be secured from the Division of Guidance and Testing, Ohio State Department of Education, or they are on file in the Department of Agricultural Education, The Ohio State University.


\textsuperscript{23}Ibid.
Procedure used in administering the evaluative tests

The pre-test which included the Agricultural Achievement, Biological Achievement, California Mental Maturity and Interest Inventory was administered in both the pilot and control schools the first week in October. This time was selected because it seemed to be the time with the least interruptions in the daily schedules within the schools and still allow for adequate teaching time between the pre- and post-test. Complete instructions for administering each test were sent to the teachers in both the pilot and control schools in an effort to secure maximum uniformity in the testing procedure. A copy of the instructions is included in the appendix.

The post-test was administered the first week in May with the California Mental Maturity being excluded from the battery of tests during this testing period because the I.Q. scores were obtained from the pre-test. Again, this time was selected because it seemed to be the time with the least interruptions in daily schedule within the school. Even though the teachers had the experience during the pre-test, complete instructions for administering each test were again sent to the teachers in order to maintain uniformity in testing procedure.

Procedure used in scoring the evaluative tests

The teachers in both the pilot and control schools were instructed not to discuss the test questions with their students
and to return all tests to the Department of Agricultural Education as soon as possible. All tests were scored and the results recorded by clerical assistants in the Department of Agricultural Education. In cases where students took the pre-test but did not take the post-test, they were eliminated from the data used in the analysis of this study. In a few instances, it was impossible to interpret student answers to questions and these were also eliminated from the data used in the analysis.

The writer considers the percentage completion to be excellent because 92 percent of the students in the pilot schools who took the pre-tests completed the post-tests and 94.5 percent of the students in the control schools who took the pre-tests completed the post-tests.

Procedure used in securing teachers' evaluation of the biological principles approach

Teachers' evaluation of the biological principles approach was secured through the use of a three-page evaluation instrument. A copy of this instrument is included in the appendix.

The writer developed a rough draft of this instrument based on teacher comments and observations as a result of working with teachers in the pilot schools. The rough draft was presented to members of the writer's graduate committee for their suggestions. Their suggestions were incorporated and the evaluation instrument was developed into its final form.
The writer met with all the teachers in the pilot schools the second week in May, 1964, and the teachers reacted to all the items on the evaluation instrument. A summary of the teachers' evaluation is presented in Chapter IV of this study.
CHAPTER III

STATISTICAL ANALYSIS OF TEST RESULTS

The statistical analysis of the data presented in this chapter includes a discussion of the mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest. In addition, this chapter contains a statistical analysis of the effect certain independent variables have on the dependent variables, (1) change in achievement in agriculture, and (2) change in achievement in biology.

Procedure used in handling data

After all the tests had been scored and the results recorded on master data sheets, it was necessary to devise a method for coding the data to be punched on data processing cards. A coding sheet was developed for this purpose and a copy of the coding sheet is included in the appendix. The punching of the coded data into the data processing cards was performed by the Statistical Laboratory of The Ohio State University.

Selection and use of statistical models

In order to select appropriate statistical models for this study, the writer consulted Professor D. Ransom Whitney,
Director of the Statistical Laboratory, Department of Mathematics, The Ohio State University.

Since one of the major objectives of this study was to determine the significance of the difference in change in achievement between the pilot and control schools, the "t" test of significance was selected, as being the most appropriate. Support for this test is given in the following statement:

The most widely used acceptable test is to compute for each group pre-test—post-test gain scores and to compute a "t" between experimental and control groups on these gain scores. 24

The "t" test was employed to determine the significance of the difference in changes in scores between the pilot and control schools on the following tests:

1. Agricultural Achievement
2. Biology Achievement
3. Agricultural Interest
4. Science Interest

The following is a model for this statistic:

\[
\frac{\bar{X} - \bar{Y}}{\sqrt{\frac{s_x^2}{n} + \frac{s_y^2}{m}}}
\]

Using Agricultural Achievement as an example, \( \bar{X} \) is the mean of the differences, post-test minus pre-test for the control schools, and \( \bar{Y} \) is similarly the mean of the same differences for

the pilot schools. \( s^2_X \) and \( s^2_Y \) are estimates of the variance of these differences for control and pilot groups. When using the student "t", the researcher tests the hypothesis that an increase on the Agricultural Achievement test for the control group is statistically equal to that of the pilot group. A larger value of "t" rejects this hypothesis at either the 5% or 1% level of significance, and if the hypothesis is rejected, the alternative to be accepted is that the group with the largest mean difference made the most improvement from pre-test to post-test.

The "t" test was also employed to determine the significance of the difference in achievement between ninth and tenth grade students in pilot schools participating in the project the first year and ninth and tenth grade students in pilot schools that were second year participants.

Another objective of this study was to determine the relationship between the dependent variables, achievement in agriculture and biology and the following list of independent variables:

- Mental maturity score
- Number of principles taught
- Grade level of the student
- Age of the student
- Agriculture interest score
- Science interest score
The statistic employed for this analysis was the correlation coefficient \( r \). \( \text{"The correlation coefficient (r), commonly referred to as the product-moment correlation, provides a quantitative measure of relationship between two variables } \text{X and Y."}^{25} \]

\( \text{"This statistical model not only provides a measure of strength but also the direction of association, expressed either as positive or negative."}^{26} \]

In calculating the correlation between the independent variables and the dependent variables, change in achievement in agriculture and biology, each independent variable was considered separately with the other independent variables held constant.

After determining the correlation between the dependent and independent variables through an analysis of the results of this study, it was still believed that some of the independent variables were more important than others in determining the dependent variables, change in achievement in agriculture, and change in achievement in biology.

The following independent variables were considered:

1. Year in the project
2. Number of principles taught
3. Age of the student
4. Year in high school


5. Status in biology
   (a) had biology in a previous year
   (b) taking biology concurrently
   (c) has not had biology

6. California Mental Maturity Score (pre-test)
7. Agricultural Interest Score (pre-test)
8. Science Interest Score (pre-test)

In order to determine the most important variables, the analysis of covariance "F" test was applied to the data. The following is a model of this statistic:

\[ Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + a_1 \text{ Biology Previously } \\
+ b_6 x_6 + b_7 x_7 + b_8 x_8 + a_2 \text{ Biology Concurrently } \\
+ a_3 \text{ No Biology} \]

In one problem \( Y \) is change in achievement in agriculture, and in the other, change in achievement in biology and \( x_1 - x_8 \) corresponds to independent variables 1 to 8. The \( a_1, a_2, a_3 \) are effects due to status in biology and the \( b \)'s are regression coefficients which are estimated.

The measure of central tendency selected was the mean because "The arithmetic mean is the most widely used measure of central value."  

Presentation and interpretation of data

The data which was received from the statistics laboratory is presented in tabular form as a means of making the data more

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easily interpreted by the reader. The writer has attempted to emphasize points of significance, make comparisons with the California study and present implications as they appear in each table.

Comparison of mean test scores for pilot and control schools

Perhaps the first question asked after completing a study of this type would be: What was the difference in mean test score between the pilot and control schools?

Table 3 shows that the students in the pilot schools showed greater achievement between the pre- and post-test than the students in the control schools. The greatest difference was in biology achievement where the students in the pilot schools showed a net gain of 5.23 whereas the students in the control schools showed a net gain of only 1.44.

The net gain of 5.23 in biology achievement for the pilot schools was less than the net gain the California study showed since they had a net gain of 10.59. Perhaps the best explanation for this difference is that the California Agricultural Education staff spent more time working with the teachers participating in this program.

Four hundred twenty-two students were involved in this study while only one hundred thirty students were involved in the California study.

Table 3 shows a decrease in agriculture interest for students in both the pilot and control schools; however, the
students in the pilot schools showed less decrease than those in
the control schools.

TABLE 3.—Mean scores on pre and post agriculture, biology, agri­
culture interest, science interest, and California Mental Maturity
tests for pilot and control schools

<table>
<thead>
<tr>
<th>Test</th>
<th>Pilot</th>
<th>Control</th>
<th>Net Gain or Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Net Gain or Loss</td>
</tr>
<tr>
<td>Agriculture Achievement</td>
<td>43.47</td>
<td>47.36</td>
<td>3.89</td>
</tr>
<tr>
<td>Biology Achievement</td>
<td>25.76</td>
<td>30.97</td>
<td>5.23</td>
</tr>
<tr>
<td>Agriculture Interest</td>
<td>13.02</td>
<td>12.92</td>
<td>-.102</td>
</tr>
<tr>
<td>Science Interest</td>
<td>10.88</td>
<td>11.08</td>
<td>.20</td>
</tr>
<tr>
<td>California Mental Maturity</td>
<td>98.68</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is quite significant to note that the students in both
the pilot and control groups had almost the same mental maturity
score with a mean score of 98.68 for students in the pilot schools
and 98.87 for students in the control schools. The two groups
were so near the same that one could say there was no difference
so far as mental ability was concerned.

Significance of difference in change
in student achievement between the
pilot and control schools

Even though the foregoing table shows a greater increase
in change in achievement for the pilot schools over the control
schools, it might appear that this increase was not significant. When the "t" test was applied to the data the increase for the pilot over the control schools on all tests was significant at either the .01 or .05 level of confidence.

The .01 level of confidence means that in one out of one hundred cases the difference could be due to chance while the .05 confidence level means that in five out of one hundred cases the difference could be due to chance. The other ninety-five times the difference would be due to something other than chance.

Table 4 shows the mean difference in agriculture achievement between the pre- and post-test for the pilot schools to be 3.89 while the mean difference for the control schools was 2.16. This was significant at the .05 level of confidence as is shown by the "t" value of 2.455.

The mean difference in achievement in biology between the pre- and post-test for the pilot schools was 5.23, while this difference was only 1.44 for the control schools. This was quite significant as can be seen by referring to Table 4. This table shows a "t" value of 6.63 which is significant at the .01 level. The writer feels that this analysis is highly important because it shows that the students who were taught the biological principles showed greater achievement in biology than those who were not taught the principles.

As is shown in Table 4, there was a decrease in interest in agriculture between the pre- and post-test in both the pilot and control schools; however, the decrease was less for the pilot
schools than for the control schools. There was a significant difference between the pilot and control schools. This difference was significant at the .05 level in favor of the pilot schools based on a "t" value of 2.416.

Table 4 also shows there was an increase of .20 in science interest between the pre- and post-test in the pilot schools while the control schools showed a decrease of .25. This difference in science interest is significant at the .01 level of confidence.

In Chapter I of this study the hypothesis was stated that there would be no significant difference between the pilot and control schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science. Based on the results of this study, it was necessary to reject this hypothesis...
and accept the alternative that students who were taught the principles showed greater increase in achievement than those who were not. The implication can be made that students of vocational agriculture who have biological principles integrated into their course of study show greater achievement in agriculture and biology and are more interested in agriculture and science.

Significance of difference in change in achievement between ninth grade students in first year pilot schools and second year pilot schools

As it was reported in the procedures for this study, seven of the fifteen pilot schools were participating in this project the second year. Some might conclude that a year of previous experience might cause them to do better than the first year schools. Others might conclude that the first year schools would do better because of the "Hawthorne Effect."

Table 5 shows that there was a significant difference at the .05 level of confidence in difference in change in achievement in agriculture between ninth grade students in pilot schools participating in the project the first year and ninth grade students in pilot schools participating in the project the second year. The mean difference for the students in the second year pilot schools was 6.208 while the mean difference for the students in the first year pilot schools was only 3.066.

There was also a significant difference at the .05 level of confidence in difference in science interest between ninth grade students in first year pilot schools and ninth grade
students in second year pilot schools. The mean difference between the pre- and post-test for the first year students was .039 while the mean difference for the second year students was .794.

TABLE 5.--Mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest for ninth grade students in first year pilot schools and second year pilot schools

<table>
<thead>
<tr>
<th>Test</th>
<th>1st Year n = 61</th>
<th>2nd Year n = 101</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Difference</td>
<td>Mean Difference</td>
<td></td>
</tr>
<tr>
<td>Agriculture Achievement</td>
<td>3.066</td>
<td>6.208</td>
<td>2.059^b</td>
</tr>
<tr>
<td>Biology Achievement</td>
<td>5.132</td>
<td>5.089</td>
<td>.033</td>
</tr>
<tr>
<td>Agriculture Interest</td>
<td>-.016</td>
<td>.455</td>
<td>.936</td>
</tr>
<tr>
<td>Science Interest</td>
<td>.039</td>
<td>.794</td>
<td>2.590^b</td>
</tr>
</tbody>
</table>

^b .05 level of significance.

There was no significant difference between the first and second year schools in difference in change in achievement in biology and agriculture interest.

Significance of difference in change in achievement between tenth grade students in first year pilot schools and second year pilot schools

There were seventy tenth grade students in the first year pilot schools and one hundred seven tenth grade students in the second year pilot schools. Even though seven of the fifteen pilot schools were participating in this project, the second year all students were first year participants so the only difference
would be in the experience of the teacher. The mean difference for both groups and the "t" values is presented in Table 6.

TABLE 6.—Mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest for tenth grade students in first year pilot schools and second year pilot schools

<table>
<thead>
<tr>
<th>Test</th>
<th>1st Year n = 70</th>
<th>2nd Year n = 107</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture Achievement</td>
<td>4.486</td>
<td>3.365</td>
<td>- .837</td>
</tr>
<tr>
<td>Biology Achievement</td>
<td>8.714</td>
<td>5.860</td>
<td>-2.219b</td>
</tr>
<tr>
<td>Agriculture Interest</td>
<td>-1.128</td>
<td>-.141</td>
<td>2.414b</td>
</tr>
<tr>
<td>Science Interest</td>
<td>-.364</td>
<td>.238</td>
<td>2.988a</td>
</tr>
</tbody>
</table>

Significant at .01 level.
Significant at .05 level.

Table 6 shows a significant difference at the .05 level in mean difference in change in achievement in biology between tenth grade students in first year pilot schools and tenth grade students in second year pilot schools. This difference was in favor of the first year schools. The mean difference in agriculture interest was -1.128 for the tenth grade students in the first year pilot schools and -.141 for tenth grade students in the second year pilot schools. This was a significant difference at the .05 confidence level in favor of the second year pilot schools.

The most significant was the difference in interest in biology between the first and second year pilot schools. The
tenth grade students in the first year pilot schools showed a decrease of -.364 interest in science while the students in the second year pilot schools showed an increase of .238. The calculated "t" value for this difference was 2.988, making a significant difference at the .01 level of confidence.

A comparison of Tables 5 and 6 shows that the only test on which there was consistent increase between first and second year students was science interest. Due to this inconsistency, the writer is of the opinion that it would be difficult to say that there is a significant advantage to the year of experience. Since there was some significance for both ninth and tenth grade students it was necessary to reject the hypothesis stated in Chapter I of this study that there would be no significant difference between first and second year pilot schools relative to change in achievement in agriculture, biology, and interest in agriculture and science.

Correlation between independent variables and change in achievement in agriculture and biology

In discussing the design for this study, the question as to what would be the relationship between certain independent variables and change in achievement in agriculture and biology was often presented. The independent variables frequently suggested were these:

Mental Maturity Score

Number of Principles Taught
Student Age
Grade Level of Students
Biology Status
Agriculture Interest
Science Interest

After the data were analyzed by the correlation coefficient (r), it was still difficult to determine which correlations were significant. In order to determine the significance of the various correlations, reference was made to Snedecor, Statistical Models, and the following formula was applied:\textsuperscript{28}

\[
t = r \sqrt{\frac{n - 2}{1 - r^2}}
\]

Using this formula, it was determined that an "r" value equal to or greater than .0955 was significant at the .05 confidence level and an "r" value equal to or greater than .1253 was significant at the .01 confidence level.

Table 7 shows the correlation between student age and change in achievement in agriculture to be significant at the .05 level of confidence. The older students showed slightly greater achievement in agriculture between the pre- and post-tests than younger students.

The opposite was the case between student age and change in achievement in biology in that the older students showed less change in achievement in biology between the pre- and post-test.

than the younger students. This negative correlation was significant at the .01 level of confidence.

TABLE 7.--Correlation between independent variables and change in achievement in agriculture and biology

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Change in Achievement in Agriculture</th>
<th>Change in Achievement in Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Maturity Score</td>
<td>-.0277</td>
<td>.0565</td>
</tr>
<tr>
<td>Number of Principles Taught (Pilot Schools Only)</td>
<td>.0497</td>
<td>.0347</td>
</tr>
<tr>
<td>Grade Level of Students</td>
<td>-.0269</td>
<td>-.1538a</td>
</tr>
<tr>
<td>Age of Student</td>
<td>.1100b</td>
<td>-.2289a</td>
</tr>
<tr>
<td>Agriculture Interest Score (Pre-test)</td>
<td>.0497</td>
<td>.0613</td>
</tr>
<tr>
<td>Science Interest Score (Pre-test)</td>
<td>.0109</td>
<td>.0791</td>
</tr>
</tbody>
</table>

\(^a\)Significant at .01 level.
\(^b\)Significant at .05 level.

There was also negative correlation which was significant at the .01 confidence level between grade level and change in achievement in biology. The students in the upper high school grades showed less change in achievement in biology between pre- and post-test than students in the lower high school grades.

There was no significant correlation between the other independent variables and change in achievement in agriculture or biology.

Based on the results of this study, it appears that younger students achieve more than older students. Perhaps it
could be implied that younger students try harder or that the biological principles approach is more adapted for younger students.

In Chapter I of this study, the hypothesis was stated that there would be no relationship between any of the independent variables and the dependent variables change in achievement in agriculture and biology. Since there was some correlation it was necessary to reject this hypothesis and accept the fact that there was correlation between the independent variables, grade level, student age, and the dependent variables.

Significance of the independent variables in predicting the dependent variables change in achievement in agriculture and biology

Since there was little correlation between the independent and dependent variables it seemed advisable to further analyze the data to determine which independent variables were the best predictors of the dependent variables change in achievement in agriculture and biology. The "F" test was the statistic employed for this purpose.

After the "F" test was used to analyze the data, it was apparent that there was no significance between any of the independent variables and change in achievement in agriculture so these results are not presented in the following table. The results relative to achievement in biology are presented in Table 8.
TABLE 8.—Significance of independent variables in determining the dependent variable, change in achievement in biology

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression Coefficient</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year in project</td>
<td>.032</td>
<td>.0019</td>
</tr>
<tr>
<td>Number of principles taught</td>
<td>.265</td>
<td>7.78a</td>
</tr>
<tr>
<td>Student age</td>
<td>.864</td>
<td>-15.547a</td>
</tr>
<tr>
<td>Year in high school</td>
<td>.616</td>
<td>2.47</td>
</tr>
<tr>
<td>Biology status</td>
<td>-2.363b</td>
<td>9.831a</td>
</tr>
<tr>
<td></td>
<td>2.040c</td>
<td></td>
</tr>
<tr>
<td>California Mental Maturity</td>
<td>.013</td>
<td>.542</td>
</tr>
<tr>
<td>Agriculture interest</td>
<td>.029</td>
<td>.0756</td>
</tr>
<tr>
<td>Science interest</td>
<td>.247</td>
<td>2.396</td>
</tr>
</tbody>
</table>

\(a\) Significant at .01 level.
\(b\) Student had biology a previous year.
\(c\) Student taking biology concurrently.
\(d\) Student has not had biology.

Table 8 shows that the two variables most significant in predicting change in achievement in biology were the number of principles taught and biology status. These factors were significant at the .01 confidence level. It should also be noted that students who were taking biology concurrently achieved the best while the students having had biology previously achieved the least and the students who had not had biology were in between. The age of students was significant at the .01 level; however, this was of negative value as can be seen by the "F" value of -15.547 in Table 8.
Based on the analysis presented in this table, if a study similar to this were conducted the two most reliable factors in predicting achievement in biology would be the number of principles taught and status in biology.

In Chapter I, the hypothesis was presented that none of the independent variables would be significant in predicting the dependent variables. Since the number of principles taught and status in biology were significant, it was necessary to reject this hypothesis.

The writer is of the opinion that the best predictor is the number of principles taught. This is particularly true since it would be difficult to have all students taking biology concurrently with the biological principles approach in vocational agriculture. The writer would recommend that, if a similar study were conducted, a greater effort should be made to teach more of the principles.
CHAPTER IV

TEACHER'S EVALUATION OF THE BIOLOGICAL PRINCIPLES APPROACH

As reported earlier in this study, the teacher's evaluation of the biological principles approach was secured through the use of a three-page evaluation instrument. A meeting of all the teachers in the pilot schools was held the second week in May, 1964, at which time the teachers reacted to all items on the evaluation instrument. In the cases of multiple teacher departments, the two teachers conferred with each other in answering questions and only one evaluation per school was obtained. The experience of the teachers in the fifteen pilot schools placed them in an excellent position to express their opinions on the questions on the evaluation instrument. This subjective analysis provides a valuable addition to the objective analysis included in the previous chapter of this study.

Summary of principles taught

At the outset of this study, the writer was hopeful that an average of ten of the twenty-two biological principles per school would be taught. Actually, the average number of principles taught per school was 7.1.

Table 9 is a summary of the number of schools teaching each of the twenty-two principles and the number of schools
TABLE 9.—Number of schools teaching each principle and number of schools teaching each principle inductively

<table>
<thead>
<tr>
<th>Principle</th>
<th>Number of Schools Teaching this Principle</th>
<th>Number of Schools Teaching this Principle Inductively</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproduction</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Plant Nutrition</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Animal Nutrition</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Germination of Seeds</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Transpiration</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Genetics</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Growth</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Diffusion</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Matter and Energy</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Respiration</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Living Matter</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Regulators of Plant Growth</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Movement of Substances in Living Organisms</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Ecology</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Non-living Matter</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Pathology</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Classification</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Organic Cycles</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Nervous System</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Endocrine System</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Irritability</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Teaching each of the principles inductively, or incorporating them into the solving of an agricultural problem. "Reproduction" was taught by all fifteen of the pilot schools while "Irritability" was taught by only one school. A comparison of Columns 2 and 3 in
Table 9 shows there was close correlation between the schools teaching a principle and the schools teaching a principle inductively.

The principles of reproduction, photosynthesis, plant nutrition, animal nutrition, germination of seeds, transpiration, genetics, and growth were taught by more than 50 percent of the schools. Table 9 also shows that the principles of diffusion, matter and energy, respiration, living matter, regulators of plant growth, and movement of substances in living organisms were taught by more than 30 percent of the schools. The remaining eight principles were taught by less than 30 percent of the schools.

Reasons for not teaching other principles

In answer to this question, all fifteen teachers gave "a lack of time to prepare" as their reason for not teaching some of the principles. Nine of the fifteen teachers said, "the principles didn't fit into my course of study" or "they didn't apply to the subject areas I was teaching." One teacher stated, "My students were too slow to comprehend some of the principles," and one teacher stated, "I could teach all of the principles if they were spread out over a four-year period."

The writer would doubt the validity of the reason, "My students were too slow to comprehend some of the principles," because in Chapter III it was shown that there was no correlation between student I.Q. and change in achievement in agriculture and
biology. The results of the California study also showed that lower I.Q. students were able to achieve when the biological principles approach was used.

It is the opinion of the writer that teachers need to be equally as concerned for the slower as for the better students. This is supported by the following statement:

To attain the objective of science competence, the slow learner requires a high quality science program as do all our youth. Basically, it should encompass the fundamental concepts of science that every other citizen needs to live effectively in our highly scientific and technological age.29

Teachers of vocational agriculture have an excellent opportunity to use living materials which should make the biological principles more meaningful to slow students. This is a good technique in any teaching program as is indicated by this statement:

One of our goals as teachers should be to help the students learn directly from living material. The knowledge gained in this way has a vividness and force not gained from books and lectures.30

Extent to which students were able to transfer their understanding of the principles to the study of other agricultural problems

A four-point rating scale was used to secure teachers' opinions as to the extent of transfer of understanding. The teachers checked "very well," "some," "very little," or "none."

30 Ibid., p. 89.
Twelve of the fifteen teachers checked "some" for the extent to which students were able to transfer their understanding of the principles in the study of other agricultural problems while the other three checked "very well."

The teachers gave some specific examples of transfer of understanding of the principles which were as follows:

1. "When students understood the principles of reproduction relative to one species of farm animals, they were able to transfer this understanding to other species."

2. "Students were able to see the reason for careful selection of livestock when they understood the principle of genetics."

3. "Students were able to associate the principle of photosynthesis with the rate of planting corn."

4. "In studying plant nutrition, students could see that the principle of nutrition was dependent on other principles such as: photosynthesis, transpiration, and diffusion."

5. "When we were discussing chemical weed control, the students associated regulators of plant growth as interfering with the growth process."

6. "In studying animal nutrition, students had a better understanding of the interdependence of plants and animals since we had previously studied photosynthesis and plant nutrition."
7. "Students could associate the principle of ecology with environment control in swine."

8. "The placement of fertilizer on corn made sense to students when they understood the principles of diffusion and plant nutrition."

The foregoing statements were based on observed behavior of students and is closely related to a study conducted by Howard William Crall, Teaching and Evaluation of Achievement in Applying Principles in High School Biology.

This study tested the hypothesis "that high school students would show more growth in certain desired abilities when the class experiences were based on the applications of biological principles, than when these experiences were not so based."\(^{31}\)

As a result of his study, the following conclusion was drawn:

In the two classes compared strong support is given this hypothesis, because the class whose experiences were based on the applications of principles did show greater average progress for the year in all the desired abilities except one. It is reasonable to assume, that high school students in general, under conditions similar to those of this study, would show more growth in such abilities.\(^{32}\)

In meetings with the teachers, emphasis was given to having the students state a principle after a problem was taught


\(^{32}\)Ibid., p. 255.
which included the application of a principle. Emphasis was also given to providing an opportunity for students to apply principles previously learned in solving other agricultural problems. This approach is supported by this statement:

"We must recognize that a given course should not be encyclopedic in scope; that skills (and here is included skill in the application of scientific modes of thought) are retained longer than facts and are more likely to be employed in new situations." 33

Ways in which the biological principles approach added to the effectiveness of teaching

The teachers were in general agreement that the biological principles approach added greatly to the effectiveness of their teaching. Six of the teachers said, "It caused me to study and do a more thorough job of preparing for my classes." Five teachers said, "This approach makes the vocational agriculture program more applicable to non-farm students" or "It provides students with a better background for non-farm agricultural jobs." Four teachers said, "It has stimulated more thinking and interest among students" and two teachers stated, "This approach has increased my interest in teaching." Two teachers stated, "This approach helps to gain respect for vocational agriculture" and one teacher said, "It coordinates agriculture with science courses and makes the total school program more meaningful to students."

All teachers expressed the opinion that the biological principles approach should be extended to more schools in order to upgrade the teaching in vocational agriculture.

It is the opinion of the writer that all good teachers spend more time in preparing to teach a class than in actually teaching the class. If the biological principles approach caused teachers to do a more thorough job of planning, it was worthwhile. In our complex society, it behoves every teacher to continue to study and grow in the profession. This is particularly true in this scientific age as is emphasized by this statement: "Scientific horizons are expanding so rapidly that 'once qualified' does not mean 'forever qualified'."[34]

Teachers' opinions about what assistance should be provided if other teachers are to use the biological principles approach

When we embark on any new educational approach we realize that if it is to be successful we must provide assistance to the teachers. The experience gained by the teachers in the fifteen pilot schools placed them in an excellent position to make suggestions about what assistance should be provided in the areas of: references for teachers, student references, demonstrations, special teaching aids, facilities, and a course of study. The suggestions most often made follow:

References for Teachers

1. "Biological Principles in Agriculture, which was used

[34] Ibid., p. 63.
in this program should be made available to all teachers." (12)

2. "Biological Principles in Agriculture should be revised for Ohio conditions." (3)

3. "Teachers should have good biology references to help them prepare for teaching." (4)

Student References

1. "A copy of Today's Biology by Alexander A. Fried, and available from College Entrance Book Company, should be available for each student." (14)

2. "In the selection of references on agricultural subjects, more attention should be given to references that include a discussion of principles." (2)

Note: Figures in parentheses indicate the number of teachers making the suggestions.

In working with the teachers in this project, the writer found that a set of references which is available from Prentice-Hall, Inc., Englewood Cliffs, New Jersey, was extremely helpful both as teacher and student references.

Animal Behavior by V. G. Dethier and Eliot Stellar.
The Cell by Carl P. Swanson.
The Life of the Green Plant by Arthur W. Galston.
Man in Nature by Marston Bates.
Animal Growth and Development by Maurice Sussman.
Animal Diversity by Earl D. Hanson.
Cellular Physiology and Biochemistry by William D. McElroy.
Heredity by David M. Bonner.
Adaptation by Bruce Wallace and Adrian M. Srb.

Animal Physiology by Knut, Schmidt, Nielsen.

Suggested Teaching Aids

During the small group meetings with the teachers in the pilot schools they suggested movies, film strips, and other teaching aids that had been helpful in teaching the biological principles. The teachers also gave further suggestions for teaching aids to improve the teaching of biological principles on the questionnaire to which they responded. Their suggestions were:

1. A list of movies and film strips that aid in teaching the principles should be made available to teachers. (4)

2. A land laboratory would be very helpful as an aid in teaching biological principles. (3)

3. Specimens such as those used in biology classes could be used in teaching vocational agriculture. (1)

4. Transparencies from the California reference material and other charts should be available to use with an overhead projector. (1)

Note: Figures in parentheses indicate the number of teachers making the suggestions.

The 16 mm films most used and recommended by the teachers were these:

The World Around Us from Encyclopedia Britannica Film Service.

Osmosis from Encyclopedia Britannica Film Service.
Lost Harvest from Motion Picture and Audio Visual Service, Wilmington, Delaware.

What's in the Bag from National Plant Food Institute, Washington, D. C.

The Science of Milk Production from Ralston Purina, St. Louis, Missouri.

Acres of Science from DeKalb Agricultural Association, DeKalb, Illinois.

The following strip films were also used and recommended as very helpful in teaching the principles:

Diseases of Livestock from National Agricultural Supply Company.

Principles of Animal Breeding from National Agricultural Supply Company.

A Trip Through a Pig Factory from Ralston Purina Company.

Nutrition from Ralston Purina Company.

Methods of Selfing and Crossing Corn from DeKalb Agricultural Association.

In some instances, farsighted school boards have been able to acquire undeveloped land for school sites and use it in the school's educational program. A land laboratory was suggested by five of the teachers and this suggestion is supported by the following statement:

School grounds are becoming increasingly valuable and recognized as important outdoor laboratories for school programs of study in science, agriculture, mathematics, and other subjects.35

Facilities

Suggestions regarding facilities were secured from teachers during the small group meetings and from the questionnaire to secure teacher opinions. Their suggestions were these:

1. Since growing plants are needed in this biological principles approach, a greenhouse would be a desirable addition to the vocational agriculture facilities. (8)

2. Some equipment used by biology classes, such as a microscope, should be available for vocational agriculture. (1)

3. A land laboratory for growing plants would be a definite aid in teaching some of the principles. (5)

Note: Figures in parentheses indicate the number of teachers making the suggestions.

The value of a greenhouse is also expressed in The Science Teacher by this statement: "A greenhouse for botanical experimentation provides year-round specimens for study."\(^{36}\)

Some teachers made use of equipment such as microscopes and charts that were available from their biology departments.

Suggested Course of Study

The teachers in the pilot schools gave the following suggestions regarding a course of study to make the biological principles approach more effective:

1. The course of study is perhaps the key to the success of the biological principles approach because it must include units that lend themselves to the teaching of principles. (9)

2. When teachers plan their program of instruction they should make plans to teach principles where they apply. (7)

3. Program of instruction should be developed to meet the needs of a local community and the biological principles should be integrated into this program of instruction. (5)

Note: Figures in parentheses indicate the number of teachers making the suggestions.

In Chapter III of this study, it was shown that the number of principles taught was one of the best predictors in determining the change in achievement in biology. It is the opinion of the writer that the best assurance to getting a high percentage of the principles taught is to plan for integrating the principles into the teaching of specific agricultural problems when the course of study is developed.
Since curriculum development is a dynamic process and must never be static, the curriculum should always be in the process of revision leading to modernization, refinement, and enrichment.37

Demonstrations

The use of appropriate demonstrations was considered a valuable aid in the inductive method of teaching principles. In order to improve the demonstrations the teachers presented the following suggestions:

1. In-service training programs for teachers should include demonstrations to be used in teaching biological principles. (6)

2. Teaching units that are prepared for teachers should include demonstrations to be used in teaching principles. (4)

3. The undergraduate program for preparing teachers of vocational agriculture should emphasize more demonstrations for teaching principles. (7)

Note: Figures in parentheses indicates the number of teachers making the suggestions.

The question might be asked concerning the preparation of teachers of vocational agriculture to teach scientific principles. Table 10 shows the number of quarter hours of science included in the pre-service training of the teachers in the pilot schools. It shows an average of 42.3 quarter hours of science

was taken in their pre-service training with a low of 33 quarter hours and a high of 51.5 quarter hours. The science courses taken included Bacteriology, Botany, Chemistry, Entomology, Genetics, Plant Pathology, and Zoology.

Some of the teachers indicated that even though they had several hours of science in their pre-service training, they needed refresher courses in science which would include demonstrations to be used in teaching biological principles.

**TABLE 10.---Number of quarter hours of science taken by the teachers in the pilot schools**

<table>
<thead>
<tr>
<th>School Number</th>
<th>Quarter Hours of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>51.5*</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>43</td>
</tr>
<tr>
<td>8</td>
<td>43</td>
</tr>
<tr>
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**Mean---All Schools 42.3**

*Average for two-teacher department.*
Teachers' opinions concerning the major advantages and disadvantages of the biological principles approach

During the final evaluation meeting the teachers were asked to list the major advantages and disadvantages of the biological principles approach. The following statements are a summary of their responses to this question:

Advantages

1. Principles don't become obsolete like production practices. (12)
2. The principles approach emphasizes why rather than so much how. (8)
3. This approach makes agriculture more scientific which appeals to better students. (5)
4. This scientific approach does a better job of preparing students for college. (4)
5. Better understanding is developed when principles are emphasized in the teaching. (7)
6. The vocational agriculture program was more challenging and the students were more interested. (6)
7. This approach removes the idea that agriculture isn't scientific. (1)
8. It causes the teacher to do a better job of preparation. (5)

Disadvantages

1. The slower students tend to get lost with this scientific approach. (3)
2. A lot more time is required for preparation. (13)

3. Many of the references required are not written on high school level. (2)

4. In order to develop understanding of a principle, more time was required which made it necessary to eliminate some units from the course of study. (4)

Note: Figures in parentheses indicates the number of teachers making the suggestions.

It is the opinion of the writer that S. S. Sutherland gives an excellent summary of the advantages and disadvantages of the inductive method of teaching biological principles in the following statements taken from a recent issue of Agricultural Education Magazine:

Teaching inductively has much to recommend it. True, it takes more time to cover a given subject; more teacher preparation is involved to set up the necessary problems, demonstrations, field trips, etc., but there are compensations which offset these disadvantages.

1. Discovery is an inherently interesting process and the inductive approach is the discovery approach.

2. Teachers using it may tend to cover fewer subjects and to teach them more thoroughly.

3. Centering teaching around broad principles which have wide application should result in students emerging with greater understanding of the practices which are based upon these generalizations.

4. Since the inductive process students are taught to think; given practice in thinking, especially if deduction is added to induction, and if students are required to apply what they have discovered.

5. Science teachers are being taught to use this improved teaching procedure. We can hardly afford to drop behind the parade.38

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The major purpose of this study was to determine the feasibility of integrating biological principles with instruction in vocational agriculture at the high school level in Ohio.

Specific Objectives

In an effort to attain the major purpose of the study the following specific objectives were studied:

1. To determine the significant difference between the pilot and control schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

2. To determine the significant difference between pilot schools that are first-year participants and those that are second-year participants relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

3. To determine the correlation between the dependent variables, change in achievement in agriculture and biology and the following independent variables:
   a. Year in the project.
   b. Number of principles taught.
c. Age of the student.
d. Status in biology.
e. California Mental Maturity score.
f. Agricultural interest score.
g. Science interest score.

4. To determine which independent variables were most important in influencing the dependent variables.

5. To determine the desirability of integrating the biological principles with instruction in vocational agriculture in Ohio.

6. To determine the changes needed to make the biological principles approach more effective.

Procedures Employed in the Study

In order to accomplish the objective evaluation in this study, the design involved pilot and control schools. Both groups were given a pre-test and a post-test. This study was patterned after a similar study conducted in California. However, this study went beyond the California study in that an Agricultural Achievement test and an Interest Inventory test were given in addition to the California Mental Maturity test and a Biological Principles test used in the California study. This study also made use of a more comprehensive statistical analysis.

The subjective evaluation was accomplished through the use of a questionnaire to secure opinions from the teachers of vocational agriculture in the pilot schools.
The major steps in the procedure employed in this study included (1) selecting the pilot and control schools, (2) developing and selecting evaluative tests, (3) administering evaluative tests, (4) developing and administering the questionnaire, and (5) summary and analysis of data.

In selecting the pilot schools, assistant state supervisors of vocational agriculture were asked to recommend schools that, in their opinion, would give the biological principles approach a fair trial. The supervisors considered such factors as: geographic location, size of school, administrator attitude and teacher competency. From the list of eighteen schools recommended by the supervisors, fifteen agreed to serve as pilot centers in which the teachers would integrate the biological principles into their course of study for high school students of vocational agriculture.

In order to have a benchmark to use in evaluating the biological principles approach, control schools were selected to serve as a means of comparison. The vocational agriculture staff decided that the control schools should be selected from the cooperating schools or schools used for the purpose of training teachers of vocational agriculture. Eight schools were selected for the control group in which a traditional program would be conducted. They were asked to participate only in the testing phase of the program with no attempt to integrate the principles into their course of study.
In developing the agricultural achievement test, a list of one hundred fifty multiple choice questions, based on the major areas of emphasis in the Ohio vocational agriculture program, was developed. This list of questions was rated by the vocational agriculture staff and one hundred questions were selected to make up the agricultural achievement test used in this study.

The biological principles test previously used in the California study was used as the instrument to evaluate understanding of biological principles. This test consisted of seventy-five multiple choice questions.

In the selection of the I.Q. and Interest Inventory tests to be used, the Division of Guidance and Testing, Ohio State Department of Education, was consulted. As a result of their recommendation, the California Short-Form Test of Mental Maturity and Educational Interest Inventory by James E. Oliver were the tests selected.

The pre-tests which included the agricultural achievement, biological achievement, California Mental Maturity, and Interest Inventory were administered the first week in October, 1963.

The post-tests were administered the first week in May, 1964. The California Mental Maturity was not included in the post-tests because the I.Q. scores were obtained from the pre-test.

All tests were scored and the results recorded by clerical assistants in the Department of Agricultural Education. After all
tests had been scored and the results recorded on master data sheets the data were transferred to code sheets. The coded data were punched into data processing cards and analyzed by the Statistical Laboratory of The Ohio State University.

The questionnaire used to secure the subjective evaluation was developed by the writer of this study. A list of questions to secure teachers opinions relative to their experience with the biological principles approach and implications for future programs was developed and submitted to the writer's graduate committee. Their suggestions were incorporated into the development of the questionnaire into its final form. The questionnaire was administered to the teachers in the pilot schools at a meeting with these teachers the second week of May, 1964.

The "t" test of significance was the statistical model used to determine the significance of the change in achievement between the pre- and post-tests for the pilot and control schools. The product-moment correlation or "r" test was used to determine the relationship between the independent variables and the dependent variables achievement in agriculture and biology. In order to determine which independent variables were the most important in determining the dependent variables, the "F" test of significance was employed. The mean was the statistic used as a measure of central tendency.

Major Findings

The following are the major findings as a result of the analyzed data collected for this study.
Mean difference between pre- and post-test achievement for pilot and control schools

Students in the pilot schools made significantly greater achievement in agriculture and biology between the pre- and post-test than students in the control schools.

The mean score in agriculture achievement for students in the pilot schools was 43.47 on the pre-test and 47.36 on the post-test making a net gain of 3.89. The mean score in agriculture achievement for students in the control schools was 47.6 on the pre-test and 49.76 on the post-test making a net gain of 2.16. The difference in net gain between the pilot and control schools was significant at the .05 level of confidence.

The greatest difference in student achievement between the pilot and control schools was on the biology achievement test. Students in the pilot schools had a mean score of 25.76 on the pre-test and 30.97 on the post-test making a net gain of 5.23. Students in the control schools had a mean score of 28.59 on the pre-test and 30.03 on the post-test making a net gain of 1.44. The difference between the two groups was significant at the .01 level of confidence.

Students in both the pilot and control schools showed a decrease in interest in agriculture from pre-test to post-test. The mean score in agriculture interest for students in the pilot schools was 13.02 on the pre-test and 12.92 on the post-test making a loss of .10. The mean score in agriculture interest for students in the control schools was 13.33 on the pre-test and
12.69 on the post-test making a loss of -.64. The difference between the two groups which was in favor of the pilot schools was significant at the .05 level of confidence.

Students in the pilot schools showed an increase in interest in science between pre- and post-test while students in the control schools showed a decrease. The mean score on science interest for students in the pilot schools on the pre-test was 10.88 and 11.08 on the post-test making a gain of .2. In contrast the mean score on science interest for students in the control schools on the pre-test was 11.12 and 10.87 on the post-test making a decrease of -.25. This difference in favor of the pilot schools was significant at the .01 level of confidence.

The I.Q. score was taken from the pre-test and the mean score was 98.68 for students in the pilot schools and 98.87 for students in the control schools.

**Mean difference between pre- and post-test achievement for ninth grade students in first year pilot schools and second year pilot schools**

Ninth grade students in the second year pilot schools showed significantly greater change in achievement in agriculture than ninth grade students in the first year pilot schools. There was a mean difference of 3.066 between pre- and post-test in agricultural achievement for students in the pilot schools who were first year participants and this difference was 6.208 for students in the pilot schools who were second year participants. This
difference between the two groups was significant at the .05 level of confidence.

Ninth grade students in the second year pilot schools also showed significantly greater change in interest in science than students in the first year pilot schools. The difference between pre- and post-test science interest was .039 for the first year pilot schools and .794 for the second year pilot schools. This difference in favor of the second year pilot schools was significant at the .05 confidence level.

There was no significant difference between the first and second year pilot schools in change in achievement in biology or interest in agriculture.

Mean difference between pre- and post-test achievement for tenth grade students in first year pilot schools and second year pilot schools

There was no significant difference between tenth grade students in first year pilot schools and tenth grade students in second year pilot schools in change in achievement in agriculture.

Tenth grade students in the second year pilot schools showed less change in achievement in biology between pre- and post-test than tenth grade students in the first year pilot schools. The mean difference between pre- and post-test in biology achievement was 8.714 for students in the first year pilot schools while the difference was only 5.86 for students in the second year pilot schools. The difference between the two groups was in favor of the first year participants and significant at the .05 level of confidence.
Tenth grade students in the second year pilot schools showed less decrease in interest in agriculture between pre- and post-test than tenth grade students in first year pilot schools. The students in the first year pilot schools showed a decrease of -.128 on interest in agriculture between pre- and post-test while students in second year pilot schools decreased -.141. This difference between the two groups was in favor of the second year pilot schools and was significant at the .05 level of confidence.

Tenth grade students in the second year pilot schools showed a slight increase in interest in science between pre- and post-test while the students in the first year pilot schools showed a slight decrease. On the science interest test, the students in the first year pilot schools showed a decrease of -.364 from pre-test to post-test while students in the second year pilot schools showed an increase of .238. The difference between the two groups was significant at the .01 level of confidence.

Correlation between independent variables and change in achievement in agriculture and biology

The independent variables studied to determine their relationship with change in achievement in agriculture and biology included: Mental Maturity score, number of principles taught, student age, grade level of students, agriculture interest, science interest, and biology status. In order to identify biology status students were placed in three groups: (1) those taking biology concurrently, (2) those having had biology a
previous year, and (3) those not having biology a previous year
nor taking it this year.

The older students showed slightly greater achievement in
agriculture between pre- and post-test. This correlation was
significant at the .05 level of confidence.

There was negative correlation which was significant at
the .01 confidence level between the grade level of the student
and achievement in biology. This same significant level of cor­
relation existed between student age and achievement in biology.
The older students in the upper high school grades showed less
achievement in biology than younger students.

**Significance of the independent variables in determining the dependent variables change in achievement in agriculture and biology**

Even though there was very little correlation between the
independent variables and change in achievement in agriculture and
biology further study was made to determine if some independent
variables were better predictors than others. It was found that
none of the independent variables were significant in determining
change in achievement in agriculture.

The two independent variables most significant in de­
terminating change in achievement in biology were the number of
principles taught and biology status. These variables were sig­
nificant at the .01 level of confidence. Students who were taking
biology concurrently achieved the best while students having had
biology previously achieved the least and students who had not had biology were in between.

The age of the student was significant at the .01 level; however, this was of negative value because the older students showed less change in achievement in biology than younger students.

**Teachers' evaluation of the biological principles approach**

The mean number of principles taught by each pilot school was 7.1. The principle of reproduction was taught by all fifteen of the pilot schools while irritability was taught by only one school. The principles of reproduction, photosynthesis, plant nutrition, animal nutrition, germination of seeds, transpiration, genetics, and growth were taught by more than 50 percent of the schools. More than 30 percent of the schools taught the principles of diffusion, matter and energy, respiration, living matter, regulators of plant growth, and movement of substances in living organisms. The remaining eight principles were taught by less than 30 percent of the schools.

There was close correlation between the principles taught and the principles taught inductively. Eighty-three percent of the principles taught were taught inductively.

All fifteen teachers in the pilot schools gave, "A lack of time to prepare" as their reason for not teaching some of the principles. Nine of the fifteen teachers stated, "the principles didn't fit into my course of study" or "the principles didn't apply to the subject areas I was teaching."
The teachers checked a four-point rating scale concerning the extent to which students were able to transfer understanding of the principles. The rating scale included, "very well," "some," "very little," or "none." Twelve of the fifteen teachers checked "some" as to the extent to which students were able to transfer their understanding of the principles in the study of other agricultural problems while the other three checked "very well." Substituting the numbers 3 for very well, 2 for some, 1 for very little, and 0 for none the mean rating was 2.2.

Some of the teachers' opinions concerning the value of the biological principles approach were:

1. "It caused me to study and do a more thorough job of preparing for my classes."
2. "This approach makes vocational agriculture more applicable to non-farm students."
3. "This approach provides students with a better background for non-farm agricultural jobs."
4. "It has stimulated more thinking and interest among students."
5. "This approach has increased my interest in teaching."

All teachers expressed the opinion that more student and teacher references should be provided as an aid in teaching biological principles. They suggested that when agricultural references were selected more attention should be given to selecting those which include a discussion of the principles involved. They also suggested that more emphasis should be given
to the application of principles in the pre-service agricultural courses and in-service training programs for teachers of vocational agriculture should include more demonstrations and teaching aids adapted to teaching biological principles. Since the availability of growing plants is a valuable aid in this approach, the teachers were of the opinion that a greenhouse and land laboratory should be a part of the vocational agriculture facilities. The teachers were also of the opinion that planning a program of instruction which included the principles was the most important factor in the success of this program.

Teachers' opinions concerning the major advantages and disadvantages of the biological principles approach were:

Advantages

1. Principles don't become obsolete like production practices.

2. The principles approach emphasizes why rather than so much how.

3. This approach makes agriculture more scientific which appeals to the better students.

4. This scientific approach does a better job of preparing students for college.

5. Better understanding is developed when principles are emphasized in teaching.

6. The vocational agriculture program was more challenging and the students were more interested.
7. This approach causes the teacher to do a better job of preparation.

Disadvantages

1. The slower students tend to get lost with this scientific approach.
2. A lot more time is required for preparation.
3. Many of the references required are not written on high school level.

Conclusions

Based on an interpretation of the data presented in this study, the writer has drawn the following conclusions:

1. When biological principles are integrated into the teaching of vocational agriculture, at the high school level, the students show greater achievement in agriculture and have a greater understanding of biological principles. The students are also more interested in agriculture and in science.

2. The teaching of biological principles integrated with instruction in vocational agriculture is desirable in Ohio high school vocational agriculture classes.

3. The difference in student achievement between first and second year pilot schools was not consistent on all tests.

4. Freshman and sophomore students showed greater achievement than junior and senior students when the biological principles approach was used in teaching vocational agriculture.
5. The number of principles taught was the most significant factor influencing achievement in biology.

6. Teachers believed that, when the biological principles approach was used in teaching high school students of vocational agriculture, their students were able to transfer their understanding of principles in the solving of other agricultural problems.

7. Classroom teaching which involved integrating biological principles with instruction in vocational agriculture required more teacher time but caused teachers to do a more thorough job of planning for their classes.

8. Teachers believed that in-service education programs should place more emphasis on the development of related teaching aids and demonstrations in order to improve the teaching of biological principles.

Recommendations

As a result of the findings of this study and the experiences of the writer, the following recommendations are made:

1. That the biological principles approach be continued and extended into all of the Ohio vocational agriculture departments.

2. That the Ohio vocational agriculture staff provide more assistance to teachers in planning their course of study in order to include the teaching of a greater number of biological principles.
3. That in-service education programs for teachers of vocational agriculture give greater emphasis to demonstrations and teaching aids to be used in teaching biological principles.

4. That prospective teachers of vocational agriculture be given experience in integrating biological principles into their instruction during student teaching.

5. That all twenty-two of the biological principles be taught by integrating them into the teaching of agricultural problems beginning with the freshman year and continuing as the principles apply to areas of instruction in the four-year program of instruction.

6. That the principles be taught through an inductive method of solving agricultural problems.

7. That consideration be given to the development of principles in other areas of the vocational agriculture program such as farm mechanics and management.
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APPENDIX A

A list of the twenty-two biological principles basic to agriculture
BIOLOGICAL PRINCIPLES BASIC TO AGRICULTURE

1. **Matter and Energy**: All things living and non-living, are either matter, energy, or a combination of matter and energy.

2. **Living Matter**: All living things are composed of protoplasm and carry on the life processes of reproduction, nutrition, and irritability (response to stimuli).

3. **Non-living Matter**: A number of non-living systems carry on processes similar to those of living organisms making the dividing line between them very indistinct. However, living organisms are more complex and are capable of carrying on both constructive and destructive processes, while non-living systems may or may not carry on both processes.

4. **Classification**: The basis of classification of living organisms is the similarity of structure and function. The greater the similarity of any two organisms the closer the relationship.

5. **Ecology**: In a changing environment living organisms can survive only through adaptation and/or migration. Each species of living organisms has a maximum and minimum range for each physical condition below or beyond which it cannot survive.

6. **Diffusion**: All living organisms are dependent on the fact that, in general, materials tend to move from an area of high concentration to an area of low concentration.

7. **Photosynthesis**: Life on earth, both plant and animal, depends upon photosynthesis, the process by which plants incorporate the energy from the sun with the food which they manufacture.

8. **Organic Cycles**: All plant and animal life is dependent upon cycles in which quantities of certain essential elements are kept in constant circulation among plants, animals, soil, air, and water and are used over and over.

9. **Growth**: Growth takes place over extended periods of time only when the rate of synthesis of protoplasm exceeds the rate of protoplasmic degradation.

10. **Regulators of Plant Growth and Development**: All living things require specialized chemical substances to regulate the life processes necessary for growth and development.
11. **Pathology:** All living organisms are subject to malfunctions due to exterior or interior causes. If the malfunction is within the homeostatic limits of the organism, it maintains life in the diseased condition, or recovers. If the malfunction is beyond these limits, death occurs.

12. **Reproduction:** Living things, in order to survive, possess the ability to perpetuate their own kind from a part of themselves.

13. **Irritability:** All living organisms have the ability to respond in some fashion to stimuli.

14. **Germination of Seeds:** Viable seeds will germinate when environmental conditions are favorable and the conditions of dormancy are satisfied.

15. **Plant Nutrition:** A plant's ability to attain maximum growth, development, and maintenance is directly related to the availability of all the essential nutrients, provided other environmental factors are favorable.

16. **Transpiration:** All plants transpire. Whenever the uptake of water by the roots is lower than the rate of transpiration wilting will be initiated and the severity of damage, if any, will be dependent upon the kind of plant, the stage of growth, and the duration of time that the condition exists.

17. **Movement of Substances in Living Organisms:** All organisms depend in varying degree on a system by which nutrients, oxygen, and regulatory secretions are distributed in the organisms and the waste products of metabolism are removed. In higher organisms this same system is also utilized in the regulation of body temperature and in the prevention and control of disease.

18. **Animal Nutrition:** The benefit an organism derives from its food is dependent upon the composition, the nutritive value of the food, and the ability of an organism to utilize this food.

19. **Nervous System:** In higher animals the activities of the various body parts are coordinated with each other and are capable of responding to changes in the environment; sometimes with the benefit of being able to profit from previous experiences.

20. **Endocrine System:** All vertebrate animals have endocrine glands that secrete special chemical substances which are capable of regulating the life processes of the organism.
21. **Respiration**: All organisms derive the energy required for the activities from the oxidation of simple foods within their protoplasm.

The rate of energy release is dependent upon those internal and external factors which create the need for energy.

22. **Genetics**: All organisms resemble and differ from their parents with a degree of variation dependent upon the interaction and segregation of genes, the occurrence of mutations of genes, and environmental factors.
APPENDIX B

Results of pre- and post-tests for the California study and the 1962-63 Ohio study
Results of Pre and Post Tests

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Difference

Pilot over Control  | + 4.24 | +12.67 | + 8.43 | + 0.77
Mean scores on pre and post agriculture, biology, agriculture interest, science interest, and California Mental Maturity tests for pilot and control schools 1962-63 Ohio study

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<tr>
<td>Biology Achievement</td>
<td>28.35</td>
<td>32.3</td>
<td>29.26</td>
<td>29.30</td>
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<td></td>
<td></td>
<td>+ 3.95</td>
<td></td>
<td>+ 0.04</td>
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<td>12.75</td>
<td>12.6</td>
<td>12.8</td>
<td>12.25</td>
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<td>- 0.15</td>
<td></td>
<td>- 0.55</td>
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<tr>
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<td>10.57</td>
<td>10.8</td>
<td>10.63</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ 0.23</td>
<td></td>
<td>- 0.13</td>
</tr>
<tr>
<td>California Mental Maturity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>97.9</td>
<td></td>
<td>99.8</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

Letters to executive heads and teachers of vocational agriculture in pilot and control schools
TO: Executive Heads and Teachers of Vocational Agriculture in Selected Schools

FROM: Ralph E. Bender, Chairman, Department of Agricultural Education, and Warren G. Weiler, State Supervisor of Vocational Agriculture

The vocational agriculture service of the State Department of Education and the Department of Agricultural Education at The Ohio State University are conducting a Pilot Program on the application of Biological Principles to instruction in vocational agriculture.

Your school is one of 18 Ohio schools that has been selected to participate in this project. This does not involve any major change in the regular teaching program only including the teaching of Biological Principles in the vocational agriculture teaching program. It would entail, however, participation in a testing program. This would include California Mental Maturity (short form), Educational Interest Inventory, a test on the understanding of Biological Principles and a comprehensive agricultural subject matter test.

Approximately four to six hours would be needed to conduct this testing program. With the exception of the mental maturity test it is planned that the test would be administered at the beginning and end of the school year. In most instances the test would be only administered to one or two classes in vocational agriculture. We plan to conduct the testing program around October 1 and May 1. All tests and answer sheets would be furnished and the scoring would be done by our offices. We would, however, appreciate the teachers of vocational agriculture administering these tests. The result of these tests would be made available to you.

Would you kindly advise us on the enclosed card whether or not you would be interested in cooperating in this worthy educational project.

Enclosure
August 14, 1963

TO: Executive Heads and Teachers of Vocational Agriculture in Selected Schools

FROM: Ralph E. Bender, Chairman, Department of Agricultural Education, and Warren G. Weiler, State Supervisor of Vocational Agriculture

The Vocational Agriculture Service of the State Department of Education and the Department of Agricultural Education at The Ohio State University are conducting a pilot program on the application of biological principles to instruction in vocational agriculture.

Fifteen Ohio schools have been selected to participate in this project.

To adequately assess the merits of this instructional approach, it is necessary to identify some control schools to be used for comparison purposes. This would not involve any change in their regular teaching program. In fact, any modification would seriously disrupt the research design. It would entail, however, participation in the testing phase of the program. This would include California Mental Maturity (Short Form), Educational Interest Inventory, a test on the understanding of biological principles, and a comprehensive agricultural subject matter test. Approximately four to six hours would be needed to conduct this testing program. With the exception of the Mental Maturity Test, it is planned that the tests would be administered at the beginning and end of the school year. In most instances, the test would only be administered to one or two classes in vocational agriculture. We plan to conduct the testing program around October 1 and May 1. All tests and answer sheets would be furnished, and the scoring would be done by our offices. We would, however, appreciate the teacher of vocational agriculture administering these tests.

We would like to use your school as one of these control schools. The results of these tests would be made available to you. We again repeat that we would not expect nor want any other deviation from your traditional program than the above-mentioned testing procedure. Would you kindly advise us on the enclosed card whether or not you would be interested in cooperating in this worthwhile educational project.

/ch
Enc. to Executive Heads
APPENDIX D

Evaluation sheet used for securing teachers' opinions
RESEARCH PROJECT ON THE APPLICATION OF BIOLOGICAL PRINCIPLES TO INSTRUCTION IN VOCATIONAL AGRICULTURE

EVALUATION SHEET

1. Check the principles you have taught:

<table>
<thead>
<tr>
<th>Matter and Energy</th>
<th>Pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living Matter</td>
<td>Reproduction</td>
</tr>
<tr>
<td>Non-living Matter</td>
<td>Irritability</td>
</tr>
<tr>
<td>Classification</td>
<td>Germination of Seeds</td>
</tr>
<tr>
<td>Ecology</td>
<td>Plant Nutrition</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Transpiration</td>
</tr>
<tr>
<td>Genetics</td>
<td>Movement of Substances in Living Organisms</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>Animal Nutrition</td>
</tr>
<tr>
<td>Organic Cycles</td>
<td>Nervous System</td>
</tr>
<tr>
<td>Regulators of Plant Growth</td>
<td>Endocrine System</td>
</tr>
</tbody>
</table>

2. Check the principles you taught inductively or incorporated into the solving of an agricultural problem:

<table>
<thead>
<tr>
<th>Matter and Energy</th>
<th>Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living Matter</td>
<td>Irritability</td>
</tr>
<tr>
<td>Non-living Matter</td>
<td>Germination of Seeds</td>
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<tr>
<td>Classification</td>
<td>Plant Nutrition</td>
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<td>Nervous System</td>
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<tr>
<td>Organic Cycles</td>
<td>Endocrine System</td>
</tr>
<tr>
<td>Regulators of Plant Growth</td>
<td>Respiration</td>
</tr>
<tr>
<td>Pathology</td>
<td></td>
</tr>
</tbody>
</table>

3. What was your reason for not teaching the other principles?

4. After you taught a principle to what extent were students able to transfer their understanding of the principle in the study of other agricultural problems? (Circle one)

   Very Well       Some       Very Little        None
5. What were some specific examples of this transfer of understanding?

6. In what ways did this biological principles approach add to the effectiveness of your teaching?

7. If other teachers are going to use the biological principles approach what assistance should be provided in the following areas:
   
   Teacher References--
   
   Student References--
   
   Suggested Demonstrations--
   
   Suggested Teaching Aids--
   
   Facilities--
   
   Suggested Course of Study--
   
   Other--
8. In your opinion, what are the major advantages and disadvantages of the biological principles approach?

Advantages--

Disadvantages--

9. Indicate the number of quarter hours you have had in the following courses:

Bacteriology _______ Entomology _______
Botany and Plant Pathology _______ Zoology, including Genetics _______
Chemistry _______

10. Have you ever taught Biology or General Science: Yes _______
    No _______

11. If this biological principles approach was used in vocational agriculture should this serve as a substitute for Biology?
    Yes _______
    No _______
APPENDIX E

The testing program
Directions for Administering

1. Please explain to your students that this is a test of their general knowledge of the field of agriculture. It is a multiple-choice test consisting of a statement with four alternative answers. Please review the sample question with your students to be sure they understand the method of selecting and recording their answers.

2. There should be no time limit on this test.

3. We recognize that you can not avoid discussing some of these test items with your students following the test, however, we request that you avoid unnecessary or deliberate discussion of all test items. Please do not "prep" or discuss these areas with the students prior to the test beyond normal instruction.

Directions for Scoring

1. After completing the test, please have the students exchange tests and grade according to the key. The instructor should read the number of the question and the correct response.

2. If the answer is correct, the students should make no mark.

3. If the answer is incorrect, a check mark should be made in the margin to the left of the answer.

4. Following the checking of the test, each student should count the number of incorrect responses and record these in the upper right hand corner of the first page of the test.
GENERAL INSTRUCTIONS TO THE EXAMINER

This test has been carefully standardized, using the directions, time limits, and general procedures detailed below. The seven separate tests comprising this battery contribute to factor scores and are combined to give two major mental ages, a Non-Language mental age and a Language mental age, together with accompanying I.Q.'s. Familiarization with the general instructions that follow and careful adherence to recommended procedures is mandatory for most meaningful results. An excellent source of basic information for those who are unfamiliar with test administration is contained in Chapter 10 of EDUCATIONAL MEASUREMENT.

TIME LIMITS

This is a power rather than a speed test. However, the time limits should be accurately observed. They are ample for examinees to reach the effective limits of their abilities, and the test will be completed by most examinees in the time specified. If all examinees complete a test unit in less than the specified time, the examiner should proceed to administer the next test unit.

It should be remembered that the time limits include only actual working time. Thus, timing should not begin on any unit until examinees actually start to work. The total working time for the test, when answers are marked on test booklets, is 52 minutes; when using answer sheets, the time is 53 minutes. Presentation of the printed instructions for the seven test units will require additional time. Factors over which printed instructions have no control, such as time needed to answer procedural questions, fill in data, distribute and collect materials, etc., will vary in individual instances. Some time must be allowed for these factors.

CAUTION AGAINST COACHING

It is important that examinees understand clearly the manner in which they are expected to indicate their responses. However, the examiner should remember that he is giving a test and not directing a learning activity; therefore, the correct response should in no way be indicated for any item except the samples.

When examinees need help in recording identifying data, prepare a chalkboard model of the part on the answer sheet in which the data are to be written. Complete the name of school, grade, teacher or examiner, city, etc., as they apply to your group. Note the space set off by parentheses in the middle of
the second line for identifying data. This space is provided for teachers or examiners who wish examinees to indicate their section, class, home room, etc., in order to facilitate the handling of data and answer sheets after tests have been scored.

Check to see that all examinees have pencils, erasers, and scratch paper. When using Scoreze, warn examinees not to place scratch paper on the answer sheet when they are working problems.

From this point on, certain parts of these directions are preceded by SAY:. These parts are to be read by examinees.
EDUCATIONAL INTEREST INVENTORY

Directions for Administering

1. Please explain to your students that there are no right answers to this inventory. It is merely an attempt to determine their broad educational interests. It would be expected that no two students would have identical interests, therefore, they should make each selection in terms of their own personal preferences.

2. The Educational Interest Inventory is self-administering. Complete directions are provided on page one of each test booklet. The examiner will normally read this page carefully with the student group and determine that the method of recording responses is fully understood.

3. An occasional student will indicate he does not know enough about one or more of the statements presented to render a judgment relative to his preference. If this occurs, the student should be asked to give a response since he should be able to determine which of the two statements appears most attractive to him even though his specific knowledge is limited.

4. There is no time limit for this test.

Directions for Scoring

1. Take up the Interest Inventory manuals from the students.

2. Ask students to exchange answer sheets.

3. Have each student count the number of darkened circles in the vertical columns numbered 1 to 19. In counting, they should count down. If, for example, in counting down Column 1, there were 5 darkened circles, the student should record the number "5" in the blank after No. 1 at the bottom of the page, and so on for all 19 columns.

4. Before packaging the test materials and answer sheets for return to the Department of Agricultural Education, The Ohio State University, count to be sure that you have not lost any manuals or answer sheets.
AGRICULTURAL ACHIEVEMENT TEST

INSTRUCTIONS

Each test item includes a statement followed by several alternative answers labeled A, B, C, D. Select the answer which best completes the statement. Place the identifying letter in the blank in front of the item number.

Example: In the following question, alternative B is the best answer. Therefore, B is written in the blank in front of the number.

B 1. Small and irregular shaped fields are:

A. More efficient because work in each field can be finished in a shorter period of time
B. Inefficient because maneuvering of machinery is difficult and time is lost in turning
C. More efficient because a more adequate system of roads and lanes can be used to connect the different fields
D. Inefficient because it makes it harder to set up a crop rotation program

** ** ** **

1. All of the following are major divisions of the FFA chapter program of work except:

A. Earning and saving
B. State and national activities
C. Safety
D. Public relations

2. All of the following are degrees in the FFA except:

A. American Farmer
B. Chapter Farmer
C. Greenhand
D. Star Farmer
3. Each state association may elect a certain per cent of its membership to the State Farmer Degree each year. The maximum per cent is:

A. 10%
B. 25%
C. 2%
D. 15%

4. The third line of the FFA motto is:

A. Living to serve
B. Learning to do
C. None of these
D. Doing to learn

5. The Ohio FFA Foundation, Inc., is:

A. An independent organization of businessmen
B. A means whereby interested organizations and individuals may financially assist the FFA
C. A new group to be established next year
D. Solely concerned with providing awards to FFA members

6. All are good FFA chapter officer election procedures except:

A. Vote by written ballot
B. Use a nominating committee of seniors
C. Limit officers to seniors
D. Establish a minimum scholarship requirement for potential officers

7. All of the following are aims and purposes of the FFA except:

A. To create and nurture a love of country life
B. To encourage and practice thrift
C. To encourage improvement in scholarship
D. To develop skills and abilities needed in farming

8. During the year, the minimum number of times an FFA chapter executive committee should meet is:

A. 3 times
B. Prior to each chapter meeting
C. 3 times during the year and once during the summer
D. At the call of the adviser
9. All of the following are commonly used sources of long term farm credit except:

A. Federal Land Bank
B. Commercial banks
C. Insurance companies
D. Production Credit Associations

10. A group of hog producers who kept careful records averaged 5.29 pounds of feed per pound of pork produced, 7.5 pigs farrowed per litter, and 6.1 pigs weaned per litter. In terms of efficiency of production on good corn belt farms, these producers would be considered:

A. Highly efficient
B. Efficient in terms of pigs produced
C. Efficient in terms of feed conversion
D. Below average in efficiency

11. A method for a farmer to lower risks would be to:

A. Concentrate on one type of livestock enterprise
B. Concentrate on one type of crop enterprise
C. Have one type of livestock enterprise and grow feed for that enterprise
D. Have supplemental livestock and crops which best fit into the major system

12. When a farmer is short on capital, it is important that he:

A. Have a fast rate of turnover for his capital
B. Have his capital invested in low risk enterprises with a slow rate of turnover
C. Speculate on new crops or breeds of livestock in order to make large profits
D. Invest his money in long-time investments which are very secure

13. A farmer on a small acreage can best increase his volume of business through enterprises:

A. Where labor inputs are very low in utilizing forage produced
B. Which have high labor peaks at certain seasons of the year
C. That take a medium amount of labor throughout the year
D. Which are intensive in the use of labor throughout the year
14. The most suitable measuring stick for an efficient dairy enterprise would be:

A. Greatest production per animal in pounds of milk
B. Greatest production per animal in pounds of butterfat
C. Maximum profit from the enterprise
D. To have the highest quality livestock possible

15. If a conservation plan is adequate the farm will:

A. Probably have higher profits the first year
B. Make more profits over the longer period of time
C. Make less profits but conserve fertility for future use
D. Show very little difference in the profits made

16. Machinery should be substituted for labor when:

A. The value of labor saved is more than the increase in machine costs
B. There is a plentiful supply of labor
C. The machinery is first placed on the market
D. Farm prices are beginning to go downward

17. The time for a farmer to expand production is when:

A. Industrial wages and employment rise and before his farming costs catch up
B. Industrial wages and employment have risen and farming costs have caught up and leveled off
C. General employment seems to be going into a slump
D. His costs are going up faster than prices received for his products

18. When returns from capital are greater than the cost of borrowing money:

A. Profits can be increased still further by using credit
B. Profits can be maximized by using available capital and not more credit
C. It is more efficient to have enough money on hand to cover production costs
D. It is good policy to have reserve to protect credit
19. Which of the following is not an advantage of specialization

A. More labor-saving equipment is practical
B. Production knowledge can be concentrated
C. Marketing and purchasing may be carried on more effectively
D. Labor can usually be distributed more evenly over the year

20. Which of the following would be considered a liability for a farmer?

A. Cash on hand
B. Crops on hand to be sold
C. Bank note for operating expenses
D. Cash reserve in the bank

21. The most reliable measure of efficient economic management of a field crop is:

A. Total yield per acre
B. Plant population per acre
C. Net returns per acre
D. Value of crop sold per acre

22. The young farmer with limited cash:

A. Should invest his funds in a small farm
B. Should invest his funds in a small equity in a large farm and borrow the remainder
C. Should rent a full-sized farm and invest his funds in machinery and livestock
D. Put cash in savings account and work for wages until able to buy a farm

23. The price of any agricultural product is usually:

A. Not related to the distance from market
B. Lowest in the surplus area farthest from the market
C. Highest in the surplus area farthest from the market
D. Uniform throughout the market area

24. The individual farmer should:

A. Go in and out of an important enterprise to avoid the influence of a cycle
B. Keep rather constant acreages or number of animals
C. Increase and decrease numbers of animals when his neighbors do
D. Switch from one major enterprise to another to try to hit the best market for each
The firing order of a tractor is 1-3-4-2. Intake valve #1 opens after:

A. Intake valve 2  
B. Intake valve 3  
C. Intake valve 4  
D. Can't tell from information

If the same numbers on the blade and tongue of the framing square are used when setting the T bevel it will give an angle of:

A. 30 degrees  
B. 45 degrees  
C. 60 degrees  
D. 90 degrees

A number 4 stamped on the tang of an auger bit means it is:

A. 4 inches in length  
B. 4/3 inches in diameter  
C. 1/4 inches in diameter  
D. 1/16 inches in diameter

Which of the following is not a product of the partial and complete combustion of acetylene and oxygen?

A. CO  
B. CO_2  
C. H_2O  
D. H_2

Bronze welding is described as a process of:

A. Fusion  
B. Cohesion  
C. Adhesion  
D. None of the above

Which of the following is not a layout tool?

A. Combination square  
B. Level  
C. Divider  
D. Chamfer
31. You use a tachometer to check the cylinder speed on a combine and discover that it is too slow. To correct this trouble you would need:

A. A larger driven pulley  
B. A larger driving pulley  
C. A smaller driving pulley  
D. None of these

32. A field is 400 feet wide and 1306.8 feet long. How many acres are in it? (1 acre = 43,560 sq. ft.)

A. 10 acres  
B. 12 acres  
C. 15 acres  
D. 20 acres

33. Which of the following accounts for the greatest percentage of loss when combining a clean crop?

A. Shoe  
B. Rack  
C. Cylinder  
D. Cutter bar

34. The height of your eyes is 5.6 feet. Using a hand level you sight on a point 50 feet up the slope as being on the same level as your eyes. The slope of the land in front of you is:

A. 5.6 per cent  
B. 11.2 per cent  
C. 12.4 per cent  
D. 56.0 per cent

35. The main advantage of a diesel tractor compared to a gasoline tractor is:

A. More power in diesel  
B. Lower initial investment  
C. Lower fuel costs  
D. No particular advantage

36. One spark plug in an engine is not firing. Which of the following would you do to find the faulty spark plug?

A. Adjust the gap on each plug and start again  
B. Clean each spark plug and replace  
C. Use a wrench to short out each plug in order and listen for a change in engine operation  
D. Pull out in order the spark plug lead wires at the distributor and listen for a change in engine operation
37. A 5-inch V-pulley is turning at 1,750 revolutions per minute and driving a 9-inch pulley. At what rpm will the 9-inch pulley turn?

A. 176
B. 877
C. 974
D. 3,500

38. The primary purpose of cultivation is to:

A. Make a mulch to conserve moisture
B. Break up clods
C. Control weeds
D. Mix fertilizer with the soil

39. You have purchased a 13 x 7 drill. The width covered by the drill is:

A. 84 inches
B. 91 inches
C. 98 inches
D. 7 feet

40. When planting corn you have changed from a narrow seed to a very wide seed. What adjustment must be made to correct for the width of the seed?

A. Select a seed plate with the correct length cell
B. Increase the planting rate
C. Turn the filler ring groove up
D. Decrease the speed of forward travel

41. If one bushel of wheat were spread over one acre, there would be 18 to 20 kernels per square foot. A combine operating in wheat is found to leave 40 kernels per square foot. What is the loss in bushels per acre?

A. 1 bu.
B. 2 bu.
C. 4 bu.
D. 8 bu.

42. You find a large amount of shelled corn on the ground behind a corn picker. Which of the following adjustments would help correct this condition?

A. Increase rate of forward travel
B. Move snapping rolls closer together
C. Decrease the tension on the husking rolls
D. Add lugs to the snapping rolls
43. Where should the footing of a house be placed?
A. On top of the ground
B. Just below the top soil
C. Where the footing is placed makes very little difference
D. On firm soil below frost level

44. A mixture of concrete is too sloppy or wet for placing in a form. Which item listed below should be performed to make a stiffer mix and yet not change the strength?
A. Add more cement and gravel
B. Add more cement
C. Let it set a while before placing it in the form
D. Add more cement, gravel and sand as in original proportion

45. A bin on the second floor of a barn is 8 feet square and 6 feet high. One cubic foot of the bin holds \( \frac{4}{5} \) or four-fifths of a bushel. The bin is filled with wheat which weighs 60 pounds per bushel. How much weight is there on each square foot of the bin floor?
A. 288 lbs.
B. 384 lbs.
C. 480 lbs.
D. 2880 lbs.

46. The voltage of a circuit supplying a particular electric heating load is doubled, but the wattage of the load is kept constant. Power (watts) loss due to resistance in the circuit conductors will be:
A. Reduced to one-half its former value
B. Increased to double its former value
C. Increased to four times its former value
D. Reduced to one-fourth its former value

47. An electric hot water heater rated 5290 watts at 230 volts is mistakenly connected to 115 volt service. The resistance of the heater is now approximately:
A. 5 ohms
B. 10 ohms
C. 20 ohms
D. 25 ohms
48. 2000 watt hours is equivalent to:
   (A) 200 kilowatts consumed for a period of 6 minutes
   (B) 1 kilowatt consumed for a period of 30 minutes
   (C) 2 kilowatt hours consumed over a period of 30 minutes
   (D) 20 kilowatts consumed over a period of 10 minutes

49. All of the following are items of fixed cost in owning a farm tractor except:
   (A) Interest on investment
   (B) Insurance
   (C) Taxes
   (D) Labor

50. If a tractor is operated 800 hours per year instead of 400 hours per year, all of the following statements could be expected to be true except:
   (A) The total cost of operation per hour would increase
   (B) The total cost of operation would increase
   (C) The fixed costs per hour would be reduced
   (D) The depreciation cost per hour would be lower

51. The machines which a farmer can best afford to own are those:
   (A) Which are used most throughout the year and are efficient labor savers
   (B) Used only at peak season work loads and are available with custom operators
   (C) Which are high investments and used only during a short period of time
   (D) Which are older and cheaper to purchase although newer models may be more efficient

52. The cost of owning machinery, for a farmer who is limited in the amount of capital which he has for production purposes, can be determined by:
   (A) The rate he could earn on an outside loan or investment
   (B) The rate of return his money would yield when used for other investments on the farm
   (C) The rate of interest he would get if he put the money in a savings account
   (D) The rate of return he would get if the amount were invested in low risk investments such as government bonds
53. The number of bd. ft. in 16 pieces of 2" x 6" x 14' oak is:
   A. 224 bd. ft.
   B. 448 bd. ft.
   C. 112 bd. ft.
   D. 672 bd. ft.

54. Scaly and ulcerated skin, diarrhea and lameness are common visible symptoms in swine of:
   A. Hog Mange
   B. Rickets
   C. Vitamin B₂ deficiency (Riboflavin)
   D. Hog Flu

55. Hog cholera is:
   A. A highly contagious disease
   B. A non-contagious disease
   C. A rare disease among swine
   D. Usually non-fatal to swine

56. When a cow ovulates, the ova is:
   A. Being fertilized
   B. Being released
   C. Undergoing reduction division
   D. Being imbedded

57. When would be the best time to breed a cow?
   A. When you first notice her in estrus
   B. When she is no longer mounting
   C. 12 hours after you first notice her in estrus
   D. For fall freshening

58. Fertilization takes place when:
   A. A bull serves a cow
   B. A cow comes in estrus
   C. The egg and sperm unite
   D. The calf is born

59. All of the following are advantages of artificial breeding of dairy cattle except:
   A. The danger of cross bulls is eliminated
   B. The cash cost per service is lower
   C. The total cost per service is lower
   D. The danger of transmitting disease is lessened
60. Incomplete dominance in color means that when a red cow is crossed with a white bull, the off-spring will all be:
A. Red
B. White
C. Roan
D. Born dead

61. The practice of mating closely related animals is called:
A. Outcrossing
B. Inbreeding
C. Nicking
D. Artificial breeding

62. The dressing percentage for choice steers is ordinarily:
A. 52%
B. 60%
C. 68%
D. 80%

63. All of the following are protein supplements for beef cattle except:
A. Cottonseed cake
B. Linseed oil meal
C. Soybean oil meal
D. Molasses

64. All of the following terms describe corn as a feed for beef cattle except:
A. Palatable
B. High in Vitamin A
C. Low in total digestible nutrients
D. Low in fiber

65. The dressing percentage of beef cattle is most affected by:
A. Differences in sex
B. Differences between pregnant and open heifers
C. Differences in finish
D. Differences between breeds

66. Pelleting feeds for fattening beef cattle has all the advantages listed below except:
A. Less feed wasted
B. Less feed required per pound of gain
C. Faster gains
D. Lower cost per pound of gain
67. The gestation period for swine is:
   A. 124 days
   B. 3 months and 3 days
   C. 104 days
   D. 3 months, 3 weeks, and 3 days

68. The best source of calcium for feeding brood sows is from:
   A. Corn
   B. Iodized salt
   C. Soybean oil meal
   D. Ground limestone

69. The most critical time in feeding bred gilts or sows during gestation is:
   A. The last month
   B. The first month
   C. Two weeks after the pigs are born
   D. During the flushing period

70. Pigs farrowed by gilts which have received aureomycin are usually:
   A. Larger at birth
   B. Stronger at birth
   C. Stronger and more uniform at weaning time
   D. All of the above

71. Milk should be cooled quickly to a temperature of:
   A. 26°F
   B. 32°F
   C. 45°F
   D. 60°F

72. Name the disease of dairy cows that most commonly affects the quality of milk:
   A. Mastitis
   B. Pink eye
   C. Cholera
   D. Ketosis

73. To control feed flavor in milk, silage should be fed:
   A. Immediately before milking
   B. During milking
   C. After milking
   D. 3 hours before milking
74. The bacterial plate count of milk for fluid consumption as it is delivered from the farm should not exceed:
   A. 10,000
   B. 50,000
   C. 200,000
   D. 500,000 bacteria per milliliter

75. Antibiotics most likely to contaminate milk are those administered to the cow:
   A. By drenches through the mouth
   B. Through salves on the surface of the teats
   C. Through injections in the skin
   D. Through materials injected into the teats

76. The major function of pasteurization of milk is to:
   A. Kill bacteria
   B. Increase palatability
   C. Remove foreign matter
   D. Reduce the size of the fat globules

77. Dairymen are encouraged to pasteurize milk for home consumption because:
   A. The heat dissolves foreign material making the milk richer
   B. The heat destroys harmful microorganisms which may be present, making the milk safe for consumption
   C. Raw milk doesn't taste as good as pasteurized milk
   D. It improves the nutritional value of the milk

78. For a farmer just getting started in farming, to raise purebred stock for show purposes:
   A. Is a business with very little risk involved
   B. Is easy to get into and takes very little capital
   C. Requires large capital funds and involves large risks
   D. Will give him quick returns for the capital which he has invested

79. The units of heredity which are responsible for expressing a single characteristic are called:
   A. Chromosomes
   B. Genotypes
   C. Phenotypes
   D. Genes
80. Sand soil particles are smaller than:
   A. Silt
   B. Clay
   C. Gravel
   D. All answers correct

81. Corn should be planted:
   A. As deep as possible to get roots down to water (about 3-4 inches)
   B. As shallow as possible to get seed in warm soil (about ½-1 inch)
   C. Deep enough for moisture, yet shallow enough to be in the upper strata of warm soil (1½-3 inches)
   D. As shallow as possible to avoid insect damage (½-1 inch)

82. The earliest date that corn may be safely planted is determined primarily by:
   A. Soil moisture
   B. Soil temperature
   C. The length of day
   D. Farm work load

83. The soil temperature is best for planting when it reaches:
   A. 54 degrees
   B. 60 degrees
   C. 75 degrees
   D. 81 degrees

84. Planting more than three inches deep:
   A. May kill the sprout because it is too difficult to reach the surface
   B. May place the seed in too much moisture for germination
   C. Place the seed too far from the fertilizer
   D. Results in greatly increased supply of phosphorus for plant

85. Planting too shallow is harmful because:
   A. The seedling may lack moisture for germination
   B. The plant will suffer from drought in July
   C. Moles may damage the grain
   D. Late cold spells may stop germination
With heavier plant population should go:
A. A high fertility level
B. A smaller type corn plant
C. An early maturing hybrid
D. A mid-season hybrid strain

A good ear size to strive for is:
A. .25 to .50 # ear
B. .50 to .75 # ear
C. .75 to 1.00 # ear
D. 1.00 to 1.50 # ear

All of the following are important in deciding the most profitable rate of fertilizing corn except:
A. The price of corn
B. The expected yields from different amounts of fertilizer
C. The color of the soil
D. The cost of the fertilizer

A land use capability map includes all of the following information on each land area except:
A. Slope
B. Degree of past erosion
C. Dominant soil series
D. Per cent of run-off

Fertilizer should be used as long as:
A. It increases the crop yields
B. The added returns are more than the expenses over a reasonable length of time
C. The quality of the crop is increased
D. The original fertility of the soil is maintained

Nitrogen fixing bacteria are found in the soybean plant in the:
A. Leaf petioles
B. Stalks
C. Blossoms
D. Root nodules
92. The most important ingredient in an inoculant used on soybeans is:
   A. Bacteria
   B. Fertilizer
   C. Mineral
   D. None of these

93. Which of the following groups of inoculant can be used to inoculate soybeans?
   A. Clover group
   B. Bean group
   C. Pea and vetch group
   D. None of these

94. One bushel of soybeans will produce about how many pounds of soybean oil meal?
   A. 30
   B. 36
   C. 42
   D. 48

95. Chemical defoliation of soybeans is most important when:
   A. An early frost has occurred
   B. September and October are warm and wet
   C. Short season varieties are used
   D. Corn is to follow soybeans in the rotation

96. What is the highest moisture content at which you should try to store soybeans at home without a drier?
   A. 9%
   B. 11%
   C. 13%
   D. 15%

97. What is the minimum per cent germination necessary for seed to be certified?
   A. 70%
   B. 90%
   C. 99%
   D. 80%
98. Companion crops (such as oats and wheat) are often used by farmers to obtain a return while the slower developing seeding (alfalfa-brome) is becoming established. This procedure has resulted in poor stands of meadow. The basic reason for this is from competition between the companion crop and seeding for:

A. Lime
B. Inoculation
C. Light
D. Weeds

99. Which is the most economical fertilizer in terms of cost per pound of plant food?

A. 2-12-12 at 50.00 per ton
B. 5-10-10 at 55.00 per ton
C. 8-16-16 at 60.00 per ton
D. 12-12-12 at 72.00 per ton

100. The best control for loose smut of wheat is:

A. Crop rotations
B. Seed treatment of Ceresan M
C. Resistant varieties
D. Control of barberry (alternate host)
Department of Agricultural Education
The Ohio State University
and
Vocational Agriculture Service
State Department of Education

BIOLOGICAL SCIENCE--AGRICULTURE TEST
by
S. S. Sutherland
University of California, Davis, 1961

DIRECTIONS

This is a test of your knowledge of biology as applied to agriculture. For most questions there are five possible answers. You are to decide which is the best one. You should answer all questions even when you are not perfectly sure that your answer is correct. You may guess, but you should avoid wild guessing. Do not spend too much time on any one question.

Study the sample questions below, and notice how the answers are to be marked on the separate answer sheet.

Sample 1. Which of the following is the name of a breed of cattle?
A. Poland China D. Hereford
B. Percheron E. Leghorn
C. Southdown

For Sample 1 the correct answer, of course, is D (Hereford). In the five answer spaces after Sample 1 on your answer sheet, an "X" has been made through the letter D.

Sample 2. The name given to the scientific study of living things is--
A. Chemistry D. Geology
B. Physics E. Anthropology
C. Biology

The correct answer for Sample 2 is "Biology" which is answer C; so you would answer Sample 2 by making an "X" through C on your answer sheet. Do this now.

Read each question carefully and decide which one of the answers is best. Notice what letter your choice is. Then on the separate answer sheet, make an X through the letter. In marking your answers, always be sure that the question number in the test booklet is the same as the question number on the answer sheet.
Erase completely any answer you wish to change, and be careful not to make stray marks of any kind on your answer sheet or on your test booklet. When you finish a page go on to the next page. If you finish the entire test before the time is up go back and check your answers. Work as rapidly and as accurately as you can.

When you are told to do so, open your booklet to page 2 and begin. The working time for this test is 60 minutes.
1. The difference between living and non-living things is best described by one of the following statements--

   A. Only living things grow or change in size
   B. Non-living things do not grow or move about
   C. Living things can reproduce their own kind
   D. Non-living things can become living things if they produce growth
   E. There is no such thing as non-living matter

2. The science that deals with classification and naming of organisms is called--

   A. Botany
   B. Psychology
   C. Taxonomy
   D. Physiology
   E. Zoology

3. Latin names are assigned to plants and animals--

   A. To make it difficult for people not trained in scientific work to understand
   B. To help keep Latin a "live" language
   C. Because all early work was done in Latin and it is too late to change now
   D. To make one name universal for the same organism
   E. Because there are more descriptive words to use in Latin

4. The scientific name of barley is *Hordeum vulgare*. These two Latin words tell--

   A. The family and the order
   B. The order and the class
   C. The genus and the species
   D. The phylum and the kingdom
   E. The phylum and the class

5. Which one of the following does not belong in the following order?

   A. Deer
   B. Bison
   C. Horse
   D. Bear
   E. Zebra
6. The interrelationship between living organisms and their environment is called--
   A. Botany
   B. Zoology
   C. Taxonomy
   D. Ecology
   E. Physiology

7. One of the following would not change the environment of plants--
   A. Wind
   B. Heat
   C. Water
   D. Gravity
   E. Light

8. Plants compete for all but one of the following--
   A. Heat
   B. Light
   C. Oxygen
   D. Carbon dioxide
   E. Nutrients

9. In a changing environment, living organisms can survive only through adaptation and/or migration. One of the following is not related to the above principle--
   A. Migration
   B. Estivation
   C. Hibernation
   D. Winter sleep
   E. Solar rotation

10. The coyote, which is classified as a carnivore, has done considerable damage to the sheep and cattle industry throughout the U.S. He has an appetite for young lamb and calves, although he also eats a variety of other animals. His ultimate source of energy and food can be traced to--
    A. Plants
    B. Insects
    C. Lizards
    D. Rodents
    E. Jackrabbits
11. The U.S. Department of Agriculture has many restrictions on the importation of plants and animals into the United States from foreign lands, especially if the organism does not already exist in the United States. The reason for this is—

A. The organism may not be suited to our climate
B. The country of origin does not have the same political views as the U.S.
C. The organism may adapt so well it may become a pest
D. Competition may be so keen for the organism that it will not survive
E. The S.P.C.A. has gone on record opposing the import of foreign organisms

12. Living things can survive in a changing environment only through adaptation or migration. In which type of farming does the farmer do the most toward changing the environment of the crop or livestock he produces?

A. Range beef cattle
B. Growing dry land barley
C. Producing apricots on irrigated land
D. Producing grade A milk
E. Growing ornamentals in a greenhouse

13. Which of the following "Rules of Thumb" are not based directly upon the principle that plants and animals survive only by adapting to their environment or by migrating?

A. Warm season crops tend to have deeper roots than cool season crops
B. All biennial plants require long days and low temperature for optimum flowering
C. Annual plants endure unfavorable environmental conditions through seed dormancy
D. Where tomatoes produce maximum yields, potatoes produce minimum yields
E. Wind machines and orchard heaters should be used in many areas to reduce the danger of frost damage

14. The success of a farmer is directly dependent upon his ability to adjust the plants and animals he grows to their environment or to adjust the environment to his livestock and crops. Which of the following does not illustrate adapting plants or animals to their environment?

A. Dehorning cattle
B. Pruning fruit trees
C. Irrigating barley
D. Scarifying legume seed
E. Castrating pigs
15. All living organisms affect each other in some manner. Which of the following best illustrates a detrimental relationship in which one or both of the organisms suffer?

A. Cattle and other ruminants have microbes in their digestive systems which affect digestion
B. Nematodes in a soil on which sugar beets are grown
C. A number of cattle fattening in a feed lot
D. Grapefruit trees grown in a date garden
E. Nitrogen-fixing bacteria in soil where alfalfa is grown

16. Sometimes two organisms live in a close relationship which is beneficial to both of them. Such a situation is called—

A. Symbiosis
B. Adaptation
C. Parasitism
D. Autecology
E. Synecology

17. The movement of materials from an area of high concentration to one of low concentration is called—

A. Circulation
B. Diffusion
C. Mixing
D. Percolation
E. Evaporation

18. All living organisms depend upon the fact that, in general, materials tend to move from an area of high concentration to an area of low concentration. Which one of the following is not an application of this principle?

A. Some plants will not grow in an alkali soil
B. Fresh water is sprinkled over vegetables in the grocery store to keep them crisp.
C. Alkaline soils may be improved by leaching
D. Too heavy applications of fertilizer may kill a plant
E. Celery is blanched by excluding light from the lower stalks of the plant

19. The over-application of fertilizer will produce symptoms in the plants called fertilizer burns. This condition is brought about by the change in—

A. Nutrient requirement
B. Moisture requirement
C. Respiration requirement
D. Photosynthesis requirement
E. Osmotic relationship
20. The manufacture of simple sugar by green plants is accomplished by a process called—

A. Chlorophyll  
B. Transpiration  
C. Respiration  
D. Photosynthesis  
E. Food production

21. Green plants are capable of manufacturing their own food when light and essential elements are present because they contain—

A. Nucleolus  
B. Cytoplasm  
C. Protoplasm  
D. Vacuoles  
E. Chlorophyll

22. Which one of the following is not directly accomplished by the presence of organic matter in the soil?

A. Decreases water run-off  
B. Increases water holding capacity  
C. Improves aeration of soil  
D. Increases available plant food  
E. Produces a better soil structure

23. All plant and animal life is dependent upon cycles in which certain essential food elements are kept in constant circulation between plants, animals, soil, air, and water. Which one is not an example of this cycle?

A. Gypsum added to the soil to improve its structure  
B. The Pilgrims burying a fish beside each hill of corn planted  
C. The making and using of a compost heap  
D. The use of manure as a fertilizer  
E. Plowing under clover or alfalfa

24. When barley is planted on ground which grew barley the year before, there will be streaks across the field where the plants are lighter in color and rather yellowish. These lighter colored strips are where straw was left by the harvester when the preceding year's crop was harvested. The reason for this is—

A. Lack of moisture, since the straw kept the rain off these strips of soil
B. The straw kept the temperature of the soil too low during the summer.
C. Insufficient nitrogen in the soil to support both the barley and the soil bacteria which break down and decompose the straw.
D. Too much nitrogen in the soil so that the soil bacteria do not need to break down the straw to obtain nourishment.
E. The straw smothered out the new barley plants and prevented them from growing as rapidly as where the ground was bare.

25. The growth of an animal is influenced by all but one of the following—

A. Age of the organism
B. Health
C. Heredity
D. Color of the organism
E. Temperature

26. Grasses will recover after grazing or cutting because their growing points (meristematic tissue) are located in the—

A. Margins of the leaves
B. Tips of the leaves
C. Bases of the leaves
D. Roots
E. Tendrils

27. A farmer, fencing his pasture, has used a 13-foot tree as a post and nailed his woven wire fencing to this tree. The top of his fence is 4 feet high and the bottom is 6 inches above the ground. The following year he discovers his sheep are getting out and immediately remembers his live post. The farmer returns and finds to his amazement that the tree is now 20 feet tall and the bottom of his fence is now—

A. About ½ foot above the ground
B. About 1 foot above the ground
C. About 5½ feet above the ground
D. About 3½ feet above the ground
E. About 4 feet above the ground
28. All living things require specialized chemical substances to regulate the life processes necessary for growth and development. All but one of the following practices are applications of this principle—

A. Pruning roots when transplanting
B. Defoliating cotton by spraying with synthetic auxins
C. Pruning fruit trees
D. Harvesting barley
E. Thinning fruit by use of synthetic auxin to cause abscission

29. Synthetic growth regulators are used for all but one of the following—

A. Killing dandelions
B. Shortening dormancy of fruit trees
C. Rooting cuttings
D. Preventing fruit drop
E. Formation of fruit buds

30. "Heading back" trees by pruning the ends of branches promotes growth of new shoots because—

A. More sunlight is admitted to the other branches
B. Materials in the tips of the branches which prevent or slow down growth are removed
C. There is more plant food available to the parts of the tree which remain
D. Less moisture is lost from the leaves

31. Diseases or malfunctions that may occur on plants or animals are serious because they—

A. Generally affect some physiological process
B. Make the organism sick
C. Can ruin the appearance of the plant or animal
D. May affect humans if not controlled
E. Are infectious

32. Non-infectious diseases in animals may be caused by all but one of these—

A. Smog
B. Improper feeding
C. Viruses
D. Heredity
E. Poisons
33. Infectious diseases in plants are controlled by all but one of these—

A. Breeding disease resistant plants
B. Using sprays and dusts
C. Seed treatment
D. Injection of vaccines
E. Changing cultural practices

34. All living organisms have parasites which are capable of affecting their life processes to a degree which depends upon the susceptibility of the host, the environment, and the nature of the parasite. Which of the following is not an application of this principle?

A. Pigs in certain areas are born hairless and have goiters
B. Cattle grubs cause an estimated loss of 100 million dollars annually
C. Reduction of aphid damage to alfalfa has been obtained by introducing a fungus which attacks the aphids
D. Lice and mites on chickens may reduce egg production
E. The "lady bug" or Australian lady beetle feeds upon and is used in the control of cottony cushion scale

35. In order to survive, living things possess the ability to perpetuate their own kind from a part of themselves. All but one of the following terms are related to this statement—

A. Asexual reproduction
B. Sexual reproduction
C. Alternation of generations
D. Crop rotation
E. Fission

36. Fruit trees are usually propagated asexually by cuttings or by grafting and budding because—

A. They do not produce viable seeds
B. The seed produced by fruit trees is usually not true to variety
C. It is easier and quicker
D. It is cheaper
E. It is too difficult to harvest and store the seeds

37. Our domestic animals reproduce sexually because—

A. They are one of the lower forms of life
B. They are one of the higher forms of life
C. They have been domesticated
D. Sexual reproduction is a less complicated process
E. All forms of animal life reproduce only in this way
38. Which of the following normally reproduce both sexually and asexually?
   A. Corn
   B. Johnson grass (Bermuda grass)
   C. Swine
   D. Barley
   E. Sunflowers

39. All living organisms respond in some fashion to stimuli. One of the following would not necessarily stimulate an organism--
   A. Soil type
   B. Light
   C. Heat
   D. Cold
   E. Darkness

40. Beehives are placed in alfalfa fields which are grown to produce seed because the alfalfa flower reacts to a bee entering the flower by releasing pollen, thereby making a larger yield of seed possible. This is an example of--
   A. Photosynthesis
   B. Diffusion
   C. Irritability
   D. Pathology
   E. Transpiration

41. Which one of the following conditions is essential to the germination of seeds?
   A. The seeds have gone through a period of dormancy
   B. The seeds have been treated for fungus diseases
   C. The soil in which the seed is planted is free from weeds
   D. The soil in which the seed is planted is fertile
   E. The seed is planted in the "dark of the moon"

42. Which one of the following environmental factors does not affect the germination of seeds?
   A. Moisture
   B. Temperature
   C. Type of soil
   D. Oxygen
   E. Light
43. A plant will attain optimum growth, provided other environmental factors are favorable, when all essential nutrients for growth are available--

A. In adequate amounts
B. In much more than adequate amounts
C. In much less than adequate amounts
D. In slightly less than adequate amounts
E. But some in adequate amounts and others in inadequate amounts

44. In fertilizing plants, which of the following is unimportant?

A. The time of day when the fertilizer is applied
B. The location of the fertilizer with respect to the plant
C. The nutrients contained in the fertilizer
D. The pH of the soil
E. The method of applying the fertilizer

45. The letters "C HOPKNS Cafe Mg Cu Zn Mo Cl"--

A. Are a code used by the fertilizer dealers
B. Are the symbols for all of the nutrients essential for plant growth
C. Are the symbols for the micronutrients needed by plants
D. Is the trade name for a commercial fertilizer

46. Plants require certain available essential nutrients to attain maximum growth, if all other factors are favorable. Which group of minerals or elements are all essential nutrients?

A. Nitrogen, hydrogen, oxygen, sulfur, humus
B. Phosphorus, potassium, sulfur, calcium, uranium
C. Magnesium, carbon, iron, zinc, lead
D. Nitrogen, carbon, iron, zinc, oxygen
E. Nitrogen, carbon, potassium, lead, magnesium

47. All plants transpire. Whenever the uptake of water by the roots is lower than the rate of transpiration, wilting will be initiated and the severity of damage, if any, will be dependent upon the kind of plant, the stage of growth, and the duration of time that the condition exists. Transpiration means--

A. The loss of water vapor by the aerial portion of the plant to the atmosphere
B. A distension or pressure created by the protoplasm against the cell wall caused by the accumulation of fluids
C. The time at which the available soil moisture is less than what is required by the plant
D. Difference in atmospheric pressure
E. The amount of water a soil will hold against gravity when allowed to drain freely

48. In the same environment, which plant will transpire most rapidly?
   A. Cactus
   B. Sunflower
   C. Bamboo
   D. Pine tree
   E. Apricot tree

49. Which of the following does not influence the rate of transpiration in plants?
   A. Temperature
   B. Humidity
   C. Wind velocity
   D. Availability of nutrients
   E. Size and shape of leaves (number of stomata)

50. When transplanting crop plants it is important to remember that there will be some wilting by transpiration losses. This deficit can best be controlled at planting time by—
   A. Reducing the root area
   B. Good soil moisture
   C. Reducing the leaf area
   D. Irrigating after planting
   E. Irrigating before planting

51. All organisms depend in varying degrees on a system by which nutrients, oxygen, and regulatory secretions are distributed in the organisms, and the waste products of metabolism are removed. This indicates that plants and animals—
   A. Are related
   B. Have similar organs
   C. Transport food in a fluid
   D. Have hearts to pump these secretions
   E. Have "blood"
52. Which of the following is not a part of the circulatory system in higher animals, such as farm animals?

A. Intestines
B. Heart
C. Veins
D. Capillaries
E. Arteries

53. In the circulatory system of plants the xylem and phloem correspond to which parts of the circulatory system in animals?

A. Heart and blood
B. Capillaries and blood
C. Veins and arteries
D. Blood and arteries
E. Lungs and heart

54. The benefit which livestock derive from their food depends upon the composition of the food, its nutritive value and the ability of the animal to utilize the food. Which of the following is not based upon this principle?

A. The nutritional content of a feed increases with an increase in the % of dry matter
B. The higher the % of lignin in a feed, the lower its digestibility
C. The higher the % of protein in a feed, the lower its nutritional value
D. It takes more pounds of roughage than of concentrates to produce the same amount of nutrients
E. As a feed crop matures the % of moisture and protein decreases

55. Which of the following best defines a balanced ration?

A. It is always palatable
B. It needs no further adjustment
C. It is available and economically practical
D. It supplies all the essential nutrients in the right amounts and proportions for a twenty-four hour period
E. It supplies all the essential nutrients in the right amounts and proportions for a month
56. The type of nutrient which is highest in energy value is—

A. Protein  
B. Carbohydrates  
C. Minerals  
D. Fats  
E. Lignin

57. Which of the following is not a good "rule of thumb" for the feeding of farm animals?

A. As an animal matures, the required protein decreases; the required carbohydrate increases  
B. The feed requirement for the maintenance of an animal depends upon the size of the animal, its activity, and its environment  
C. Approximately three-fourths of the feed eaten by an average dairy cow is used for milk production

58. Animals perceive changes in their environment by way of their nervous systems. Which of the following is not an application of this principle?

A. Strangers present in a barn at milking time may cause dairy cattle to hold up milk  
B. A period of extremely hot weather may cut down egg production of a poultry flock  
C. A nervous herdsman may make cattle nervous  
D. Cattle coming in contact with an electric fence and receiving a shock will avoid it in the future  
E. The appearance of a healthy animal is quite different from that of a diseased animal

59. The endocrine glands regulate or control four of the following life processes of animals. Which one is not directly regulated by these glands?

A. Rate of metabolism  
B. Amount of blood sugar  
C. Blood pressure  
D. Activity of ovaries or testes  
E. Digestion

60. The livestock breeder is most concerned with the function of which one of the following endocrine glands in his animals?

A. Gonads  
B. Thyroid  
C. Parathyroid  
D. Pancreas  
E. Adrenal
61. All organisms derive the energy required for the activities from the oxidation of simple foods within their protoplasm. The rate of energy release is dependent upon those internal and external factors which create the need for energy. This being a true principle, all organisms—

A. Respire
B. Breathe
C. Transpire
D. Inhale
E. Exhale

62. The rate at which energy is released as plants and animals respire is dependent upon factors which create the need for energy. Which of the following is not an agricultural application of this principle?

A. The respiration rate of a vegetable determines the length of time which it can be stored
B. Livestock being fattened should be kept quiet
C. Compacted soil hinders growth of plants
D. Livestock should be protected from extreme cold
E. Salt is used in preserving ham

63. Chemically, the process of respiration is—

A. The same as photosynthesis
B. The reverse of photosynthesis
C. The same as transpiration
D. The reverse of transpiration

64. The branch of biology dealing with the study of heredity is called—

A. Geriatrics
B. Genetics
C. Physiology
D. Ecology
E. Taxonomy

65. On the basis of the genes which they possess, which of the following cattle would be most closely related?

A. Sire and daughter
B. Identical twin calves
C. Dam and daughter
D. Dam and sire
E. A bull calf and a heifer calf not twins
66. A farmer has a valuable and highly productive cow which lost the sight of one eye as a result of an accident.

A. It is all right to continue raising calves from her
B. The unsoundness is likely to be transmitted to her offspring
C. The calves will probably have a tendency to have weak eyes
D. There will be a tendency toward moonblindness in the offspring
E. It is impossible to tell ahead of time what would be the effect on the offspring

In the crossing of breeds of cattle the traits for some characteristics are dominant and some are recessive. In the following crosses of Aberdeen Angus and white Shorthorns the black color of the Angus is dominant over white and the polled characteristic of this breed is dominant over horns of the Shorthorns.

Let B stand for Black color
   b stand for White color
   P stand for polled
   p stand for horned

Listed below are 5 possible crosses that involve the listed traits. For each question 67 to 75 determine which cross in the Key applies. Then mark on your answer sheet for each question the letter that is the same letter as that cross.

A. BBPP x BBPP
B. BbPp x BbPp
C. bbpp x bbpp
D. bbPP x bbPP
E. BBpp x BBpp

67. Which cross would give you only pure white horned calves?
68. Which cross would give only pure black polled calves?
69. Which cross would give only pure white polled calves?
70. Which cross would give a ratio of three black polled calves and one white horned calf?
71. Which cross would be used if you were interested in breeding for the dominant traits?
72. Which cross would be used if you were interested in only the recessive traits?
73. Which cross would be used if you wanted dominant color and recessive horned characteristics?

74. Which cross would give only recessive color and dominant polled characteristics?

75. Which cross would produce the genotype bbPP?
APPENDIX F

Data processing
<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Year in the project—1st, 2nd</td>
</tr>
<tr>
<td>2</td>
<td>Group—1-pilot; 2-control</td>
</tr>
<tr>
<td>3, 4</td>
<td>School number</td>
</tr>
<tr>
<td>5, 6</td>
<td>Number of principles taught to this class</td>
</tr>
<tr>
<td>7, 8</td>
<td>Student number within the school</td>
</tr>
<tr>
<td>9, 10</td>
<td>Age of student</td>
</tr>
<tr>
<td>11</td>
<td>Year in high school (1=9th grade, 2=10th grade, 3=11th grade, 4=12th grade)</td>
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<tr>
<td>12</td>
<td>1=student has had biology; 2=taking biology concurrently; 3=has not had biology or taking it at the present time</td>
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<tr>
<td>13, 14, 15, 16</td>
<td>Score on California Mental Maturity Test</td>
</tr>
<tr>
<td>17, 18</td>
<td>Agricultural Achievement Test Score Pre.</td>
</tr>
<tr>
<td>19, 20</td>
<td>Agricultural Achievement Test Score Post</td>
</tr>
<tr>
<td>21, 22</td>
<td>Biological Principles Test Score Pre.</td>
</tr>
<tr>
<td>23, 24</td>
<td>Biological Principles Test Score Post</td>
</tr>
<tr>
<td>25, 26</td>
<td>Agricultural Interest Test Score Pre.</td>
</tr>
<tr>
<td>27, 28</td>
<td>Agricultural Interest Test Score Post</td>
</tr>
<tr>
<td>29, 30, 31</td>
<td>Science Interest Test Score Pre.</td>
</tr>
<tr>
<td>32, 33, 34</td>
<td>Science Interest Test Score Post</td>
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CODING SHEET FOR
A STUDY ON INTEGRATING
BIOLOGICAL PRINCIPLES
WITH INSTRUCTION IN
VOCATIONAL AGRICULTURE

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AUTOBIOGRAPHY

I, John Tull Starling, was born in Pennsville, Morgan County, Ohio, on May 31, 1918. I received my elementary and secondary education at Pennsville Local School.

Following graduation from high school in May, 1936, I worked part-time on the home farm of 130 acres and worked on highway construction jobs.

In January, 1940, I enrolled in the College of Agriculture at The Ohio State University.

In June, 1942, I entered the United States Army Air Force and served in the Air Force Technical Command as an instructor in technical schools at Lincoln, Nebraska, Albuquerque, New Mexico, Las Vegas, Nevada, and Elgin Field, Florida. In January, 1946, I was honorably discharged and returned to The Ohio State University in March, 1946.

I received my Bachelor of Science degree with a major in Agricultural Education from The Ohio State University in December, 1947.

I was employed as a teacher of vocational agriculture at Shawnee High School, Allen County, Ohio, January, 1948, and remained in this position until I joined the Ohio vocational agriculture staff as an assistant supervisor January 1, 1962.
I began a graduate program at The Ohio State University in the summer of 1949 and received the degree Master of Science in December, 1955.

As a teacher of vocational agriculture at Shawnee High School, I served as a cooperating instructor for the Department of Agricultural Education, The Ohio State University, training teachers of vocational agriculture. I also served as president of the Ohio Vocational Agriculture Teachers Association in 1958 and president of the Ohio Vocational Association in 1959.

In January, 1962, I enrolled in the Graduate School, The Ohio State University, to fulfill the requirements for the degree Doctor of Philosophy.