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EFFECTIVENESS OF PRIOR EXPOSURE TO PERFORMANCE OBJECTIVES AS A TECHNIQUE FOR IMPROVEMENT OF STUDENT RECALL AND RETENTION

DISSERTATION

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

By

Douglas D. Bishop, B.S., M.E.

* * * * * *

The Ohio State University 1969

Approved by

[Signature]
Adviser
Department of Agricultural Education
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VITA

September 24, 1933  Born - Dodge City, Kansas

1951 ............... Graduated, Stratton Public High
                  School, Stratton, Colorado

1951-1955 .......... B.S., in Agricultural Education,
                  Colorado State University, Fort
                  Collins, Colorado

1955-1957 .......... Military Service

1957-1962 .......... Teacher of Vocational Agriculture,
                  Wiley Public High School, Wiley,
                  Colorado

1960-1962 .......... High School Principal, Wiley Public
                  High School, Wiley, Colorado

1962-1967 .......... Teacher of Vocational Agriculture,
                  Sterling High School, Sterling,
                  Colorado

1963 .............. M.E., in Education, Colorado State
                  University, Fort Collins, Colorado

                  Vocational and Technical Education,
                  The Ohio State University, Columbus,
                  Ohio

PUBLICATIONS

"Resource Personnel in the Sterling Community of Value to
the Local Vocational Agriculture Program," (Unpublished
Master's Professional Paper), Colorado State University,
1963.

iii
FIELDS OF STUDY

Major Field: Agricultural Education

Studies in Agricultural Education.
Professor James W. Hensel

Studies in Vocational Education.
Professor William E. Jennings

Studies in Teacher Education.
Professor Richard H. Wilson

Studies in Research and Evaluation.
Professor J. Robert Warmbrod
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CHAPTER I

THE PROBLEM AND ITS SETTING

Introduction

At no time in history has so much emphasis been placed on curriculum revision and curriculum development. A myriad of commissions, agencies and individuals have worked feverishly attempting to find a "breakthrough" in curriculum planning and development which will unequivocally improve the effectiveness of the teaching-learning process.

The task of identifying goals in education has been a continuous one. Each attempt to define educational goals has been purported to bring us nearer to the ultimate goal of education which is to develop each individual to his full potential. However, Lindvall pointed out that, "... despite this widespread attention to the matter and despite the rather general availability of statements of the goals of education, the impact of such statements on the curriculum or on what actually takes place in classrooms is generally much less than it might be." ¹

Louise Tyler, speaking on the subject of current trends in curriculum development and what is involved in curriculum development, suggested that decisions must be made about the commonplaces of (1) objectives, (2) learning opportunities, (3) organization, (4) evaluation, and (5) staff. Referring to the formulation and use of behavioral objectives, Tyler posed three questions which are significant to curriculum development and, also, illustrate the need for additional research:

1. What procedure should be utilized in the process of formulating valid objectives?
2. How should objectives (behavioral) be stated?
3. Are objectives (behavioral) needed?

The present research study was envisioned as an initial step in providing a base for further research relative to the effectiveness of performance objectives in agricultural education. "There is no more important contribution being made by modern learning theorists and educational technologists than the development of a sound body of knowledge related to the conceptualization, development, and implementation of learning objectives."4

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3 Tyler, Ibid., p. 27.

The concept of formulating explicit performance objectives as a first step in curriculum development has received much attention from educators in all disciplines. Such concern appears to have resulted from the emphasis on meeting students' individual needs and by the demand that education be held responsible for the quality of its product, the student. Lindvall, writing on the subject of educational goals said:

If goals are defined only in broad general terms the possibility that such curriculum development efforts will have much effect on what actually goes on in classrooms will be relatively small. Objectives must be specified in such concrete and specific terms that they will have a clear meaning to all persons involved. It would be a tragic waste of effort if much of the current widespread work in curriculum development should prove to be relatively useless because of a lack of specific goals.5

Agricultural educators are among those faced with the problem of identifying plausible goals for curriculum development and revision. In order for agricultural educators to fulfill their ultimate objective for the individual, it seems apparent that attention must be focused not only on the general goals but on the more specific objectives of instruction.

The major goals of agricultural education provide a

5Lindvall, op. cit., p. 5.
parameter within which curriculum development can take place. But how can agricultural educators measure the extent to which the broad goals have been attained?

Gagne concluded that educators should examine those statements that seem to represent goals in education:

In other words, we need to be able to inform ourselves how we can tell when these things have been achieved by individuals. And, second, we need to analyze, or break down into smaller components and stages, the progression toward these goals. 6

This seemed to imply that one of today's major concerns should be that of identifying teaching-learning variables which can be utilized in moving agricultural education toward the attainment of its goals.

**Background of the Study**

The use of explicitly stated objectives in education has received unprecedented support from teachers, educational psychologists, and researchers during the past decade. A great amount of material has been written on the subject; many meetings have been held in which learning theorists have discussed the merits of explicitly stated objectives; and untold hours have been spent by

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curriculum committees in developing lists of objectives for particular disciplines. The formulation and use of educational objectives as a means of bringing about effective student learning have been advocated from the beginning of our educational system. As early as 1934, Tyler expounded the value of stating objectives in explicit behavioral terms in order that the objectives might be used to guide students and educational practitioners in selecting appropriate learning experiences.

Even though the use of carefully stated student performance objectives has gained much support, only a limited amount of research has been designed to provide empirical evidence to assess their effectiveness. A perusal of the curriculum research which has focused on performance objectives disclosed that most recent research efforts have been directed toward studying the effectiveness of teacher-centered objectives rather than student-centered performance objectives.

Performance objectives and contemporary curriculum development are so inextricably associated that each complements the other. Performance objectives are cited

7Ralph W. Tyler, Constructing Achievement Tests, (Columbus, Ohio: The Ohio State University, 1934) p. 18.
by Tyler\textsuperscript{8} and Lindvall\textsuperscript{9} as a component of curriculum. The writings of these authors indicated a need to give greater attention to the matter of specifying the standard of performance the student is expected to achieve.

A recently initiated, highly publicized national curriculum project focused attention on performance objectives as they relate to an organic curriculum. The project, An Educational System For The 1970's, more commonly known as ES'70,\textsuperscript{10} called for the establishment of behavioral objectives and the utilization of individualized instruction. The project design, as outlined by Morgan and Bushnell, described the steps of the curriculum project:

The first step in the design of this model (organic curriculum) is the development of the course content. Following this, all the behavioral objectives that are associated with the course content will be specified. Using the sequences of behavioral objectives, instructional strategies will be designed...\textsuperscript{11}


\textsuperscript{9}Lindvall, op. cit., p. 10.


Bushnell described the kind of curriculum ES'70 would, it was hoped, demonstrate:

... a kind of educational program which incorporates the idea of a continuous progress curriculum with instructional techniques that emphasize the active development, the positive achievement and self-direction of students.12

The 1968 Advisory Council Report on vocational education identified a number of broad goals for program planning. Each goal has implications for curriculum development and revision. In general, each goal implied a need for emphasis on evaluation of performance as an appropriate technique to insure the most efficient and effective learning for the individual student. Future activities, according to the advisory council report, should account for and support the following:

1. A curriculum plan that embodies and stresses methods of inquiry, techniques of learning, and educational procedures that will maximize learning opportunities for students at all educational levels.

2. A flexible, varied program that recognizes the individualized selection of applied fields of knowledge and provides for guidance to realistic career choice involving local resources and institutional philosophy as the context of school learning experiences.

3. Emphasis in the design of integrated curriculum directed toward enabling the student to derive beneficial intellectual concept experiences, productive behavioral attitudes, and attendant psychomotor outcomes.

4. Identification of the goals of education in terms of specific student behavior in a developmental program.

5. The opportunity to identify specific objectives for education in terms of curriculum, personnel, and facilities.

6. Provisions that foster maximum teacher flexibility, innovation, and experimentation in the development of instructional procedures and instructional materials commensurate with expressed educational aims.13

The problems encountered by vocational educators in training students to maintain employment in a complex urban environment calls for curricular change. The demand for more advanced job skills indicated a need for the utilization of performance objectives to specify educational intents. Flanagan, referring to the systematic approaches to education, stated, "The specific factors which have prevented effective use of these approaches in education are a lack of well-defined objectives and inadequate measuring procedures to determine whether the student has achieved the objectives set for him."14


In the past many educators have been content to define objectives in general terms; thus, they have encountered difficulty in determining if these objectives have been attained either in whole or in part by the students. Tyler suggested that defining objectives for the student is an inadequately exploited educational technique.

Unless the exercises in the work books and the textbook assignments clearly reflect the desired objectives, the student is likely to resort to memorization and mechanical completion of exercises rather than to carry on the activities which are really relevant to the desired goals.15

More recently, McClelland, Chairman of the Social Relations Department of Harvard University, after studying the psychological effects of different kinds of educational techniques wrote:

So little attention was being paid to measuring the effects of different kinds of education that it was impossible to arrive at any systematic conclusions as to what educational inputs produced what effects. No one was following the experimental model in which an input is varied experimentally to see what the yield in pupil learning would be.16

Educators, including those in agricultural education,

15 Tyler, op. cit., p. 77.

are discussing the use of performance objectives as a technique to improve the effectiveness of the teaching-learning process. Generally it is felt that the application of the concept will add meaning, function, and utility to the subject matter taught. However, in agricultural education, little research has been conducted to determine if students' prior exposure to carefully worded performance objectives will influence the teaching-learning process.

Purpose of the Study

The purpose of this research was to measure the influence of clearly stated performance objectives upon immediate recall of knowledge and upon the retention of knowledge when students are made aware of the performance objectives and of the inherent value of these objectives prior to the instructional unit being taught.

Specific Objectives of the Study

Two specific objectives were identified as being essential to the development and conduct of this study:

1. To determine the influence of prior exposure to explicitly stated performance objectives on immediate recall of knowledge among ninth grade students of vocational agriculture.
2. To determine the influence of prior exposure to explicitly stated performance objectives on the retention of knowledge after an interval of thirty days among ninth grade students of vocational agriculture.

**Need for the Study**

Several factors or combinations of factors gave rise to the need to study the effectiveness of prior exposure to performance objectives as a technique to increase learning among students in agricultural education. First, the changing nature of agricultural employment has resulted in a need for a more integrated curriculum designed to meet the needs of the individual student. Second, there is a growing concern over the number of employees who lack the high level of technical competency demanded by today's agricultural industry. Third, there is an apparent lack of experimental research designed to test the hypothesis that student performance objectives, as an educational input, result in more efficient and more effective student learning. Finally, it is believed that data obtained will serve as a base for additional research efforts to improve programs of agricultural education.
Changes in Agricultural Employment

In an unpublished report of the Commission on Education in Agriculture and Natural Resources for the National Academy of Sciences, three contemporary trends were cited which affect agriculture and, subsequently, education in agriculture. The writers of the report pointed out that in the maelstrom of change in society:

1. We are witnessing an expanding and migratory population. By the year 2000 the majority of the 250-300 million people will live in huge urbanized areas and work in mammoth organizations . . . Many young men in rural areas will continue to migrate toward the urban centers to seek employment . . .

2. Technological advances in agriculture will continue. With increasing technological sophistication, society and its problems are becoming more complex . . . In a word, society is becoming complex and more dependent on sophisticated problem solving skills.

3. There will be a demand for education in agriculture. The agriculture industry will require many people with varying amounts of education beyond high school. The educational minimums for agricultural employment will continue to be increased especially as agriculture moves toward a higher degree of specialization in all areas.  

There is little doubt but what these trends have brought about change and will continue to cause change in agricultural occupations. However, it would appear that three additional factors make the task of preparing employees for those occupations that supplement and complement production agriculture more critical:

1. Technological change has taken place in American agriculture, but accompanying change in agricultural education has not been so dynamic.

2. Attention being focused on agricultural education will call for continuous change in instructional techniques to insure program effectiveness.

3. Potential employment opportunity still exists in American agriculture but for a more highly skilled individual.

The interaction of the aforementioned factors of change has given rise to a very complicated question with which agricultural educators must deal. What techniques can we use in designing curriculum to meet the individual differences of agriculture students while developing within each student those skills deemed essential by a complex agricultural industry?
The Need for Competency

Before a curriculum planner can tell whether a proposed curriculum will meet the need of the students, he must know what the needs of the students are. Industry is calling upon vocational education to deliver a higher quality product. This product must be in the form of an employee who possesses the level of competency demanded by the occupation for which he has been trained. Present output specifications are so global in nature that they provide little basis for determining performance criteria.

The use of performance objectives established through a logical, analytical approach should provide a means whereby agricultural educators can move students through a sequence of instruction on an ever increasing level of difficulty.

A Research Gap in Agricultural Education

The importance of clearly defined objectives to the success of an educational venture has been emphasized by many educational leaders including Tyler and Bloom. Many of the objectives used in the development of agricultural education have been based on general educational objectives, such as the ability to analyze, evaluate, and synthesize information. These general objectives are not specific enough to measure the performance of students in agricultural education. Therefore, a research gap exists in agricultural education, where specific objectives are needed to measure the performance of students.

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18 Ralph W. Tyler, op. cit., p. 77.

tural instructional materials provided a typical example of objectives centered on content rather than the student. To assist present and prospective workers in non-farm agricultural jobs to improve their efficiency, to promote creative activities of students, and to participate in rural leadership activities are representative of the broad global objectives in common usage. Lindvall concluded that despite widespread interest in objectives:

... an outside observer may have difficulty in relating what he sees taking place in the day-to-day instruction in a classroom to the schools' philosophy of education because objectives are stated in such general form that any teacher can look at them and no matter what he does with his class, can convince himself that these are the purposes that guide his teaching.20

In general, agricultural educators agree that performance objectives are essential to sound curriculum development and effective teaching. However, little research has been conducted to determine the overall effect of utilizing objectives carefully worded in behavioral terms. Additional research is needed to

1. Demonstrate the applicability of performance objectives in agricultural education.

2. Determine if student understanding of performance objectives increases student achievement.

3. Determine the usefulness of performance objectives in providing instruction that accounts for individual differences in ability, interest, and prior learning.

Theoretical Framework of the Study

The basic theoretical framework of this study evolved from the discernible merits of stating objectives as measurable learner behaviors. These recognized merits gave rise to several postulates formulated by the investigator.

The soundness of the postulates and the effectiveness of the approach can best be illustrated by considering the relationship between those postulates formulated by the investigator and some of the more commonly accepted general principles of learning.

Burton, when discussing the basic principles of a good teaching-learning situation, reported that approximately a dozen learning theories are available. Although no one has formulated a single theory of learning that satisfies all educators, there are many facts about learning that are known and accepted by most theorists.

Principles of Learning and Postulates About Performance

Objectives

Burton pointed out the difficulty of summarizing the principles of learning due to the differences in basic viewpoints and to the accepted premises of educational theorists. However, he did formulate a group of reasonable consistent statements of principles useful in everyday teaching. Selected principles of learning, summarized by Burton from the many learning theories, served as the basis for the formulation of postulates which in turn comprised a theoretical framework. The general postulates were considered essential to the development of exact and testable hypotheses for the study.

Learning Principle 1. - Learning situations are meaningful to the learner when they are realistic and take place in a rich environment.

Postulate 1. - Explicitly stated objectives make it easier for students to focus on the important instructional outcomes.

Learning Principle 2. - Learning situations are dominated by a goal or goals accepted by the learner.

Postulate 2. - Explicitly stated objectives provide

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22 Burton, Ibid., p. 9.
a basis for the formulation of goals essential to the maintenance of a high degree of attention to the learning task.

Learning Principle 3. - The learning process is materially affected by the level of expectation established for the learner.

Postulate 3. - Explicitly stated objectives place before the student an expectation of attainment which becomes a motivating factor.

Learning Principle 4. - The learning process becomes more meaningful to the student when the elements of learning are made discernible.

Postulate 4. - Explicitly stated objectives provide a basis for self-evaluation which is essential to the development of desirable learner behavior.

Learning Principle 5. - The learning process is enhanced when students are alerted to the conditions under which learning takes place.

Postulate 5. - Explicitly stated objectives direct the students' attention to the most efficient way to acquire learning.

Learning Principle 6. - Student motivation to learn is enhanced when expectations and demands are clearly stated in terms familiar to the student.
Postulate 6. - Explicitly stated objectives serve to alert the student, thus, creating a motivating factor.

**Hypotheses for the Study**

Two general hypotheses were formulated from the theoretical bases for the study. For each general hypothesis, two null hypotheses \((H_0)\) were established to test the significance of the main effect of the independent variables. A third null hypothesis was formulated to test the significance of interaction of the two independent variables.

**Hypothesis 1**

Exposing students to explicitly worded performance objectives prior to the presentation of any instructional unit will have a positive influence on the recall of knowledge when measured by a criterion test administered immediately after the instructional period.

\[ H_{01}: \text{There is no significant difference in recall of knowledge between groups receiving prior exposure to performance objectives when compared with treatment groups receiving no prior exposure to performance objectives.} \ (e.g., \mu_{T_1} = \mu_{T_2}) \]
H_{02}: There is no significant difference in recall of knowledge between groups receiving separate instructional units with or without prior exposure to performance objectives.

\( (e.g., H_0: \mu_{U_1} = \mu_{U_2}) \)

H_{03}: There is no significant difference in recall of knowledge due to interaction between prior exposure to performance objectives and separate instructional units.

\( (e.g., H_0: \mu_{T_1U_1} - \mu_{T_2U_1} = \mu_{T_1U_2} - \mu_{T_2U_2}) \)

**Hypothesis 2**

Exposing students to explicitly worded performance objectives prior to the presentation of any instructional unit will have a positive influence on the retention of knowledge when measured by a criterion test administered thirty days after the instructional period.

H_{04}: There is no significant difference in retention of knowledge between groups receiving prior exposure to performance objectives when compared with treatment groups receiving no prior exposure to performance objectives.

\( (e.g., \mu_{T_1} = \mu_{T_2}) \)
H_{05}^*:\ \text{There is no significant difference in retention of knowledge between groups receiving separate instructional units with or without prior exposure to performance objectives.} \\
(\text{e.g., } H_0: \mu_{U_1} = \mu_{U_2})

H_{06}^*:\ \text{There is no significant difference in retention of knowledge due to interaction between prior exposure to performance objectives and separate instructional units.} \\
(\text{e.g., } H_0: \mu_{T_1 U_1 - T_2 U_1} = \mu_{T_1 U_2 - T_2 U_2})

\textbf{Basic Assumptions}

Three basic assumptions were accepted by the investigator at the outset of this study:

1. Student teachers assigned to each of the selected schools were capable of teaching satisfactorily the lessons prepared for the study.

2. Student performance objectives could be written in precise and measurable terms.

3. Student performance objectives could be stated at several different levels of understanding.
Delimitations of the Study

The study was delimited within the following parameters:

1. The study was delimited to eleven schools in which student teachers from The Ohio State University Agricultural Education Department were assigned during the 1969 spring quarter.

3. The study was delimited to ninth grade students enrolled in agricultural education classes.

3. The study was delimited to a measure of the influence of the independent variable under classroom conditions and for only one unit of instruction.

Definition of Terms

The following terms are defined in order to minimize misunderstandings and provide a basis for understanding their use in the conduct of the study.

Area of Instruction.—A major subdivision of an agricultural course of study.

Lesson. —A short period of instruction in agricultural education devoted to a specific limited topic, skill or idea.

Unit of Instruction.—A part of the area of instruction that can be considered as complete in itself or can be taught as a whole.
Student Performance Objective.—A clear and precise statement of a single meaningful unit of behavior that will satisfy an instructor that a student can perform a task which is a desired outcome of a specific lesson.

Development of the Study

The study was developed to determine the influence of prior exposure to performance objectives upon immediate learning and upon retention of knowledge when students are made aware of performance objectives and the inherent value of these objectives prior to the instructional unit being taught. The primary objective was to develop a series of lessons, presenting them to some students with performance objectives and to some students without performance objectives, thereby testing the hypothesis that explicitly stated performance objectives will effect student learning.

The investigator became interested in curriculum development while working as a research associate at The Center for Vocational and Technical Education, The Ohio State University, Columbus, Ohio. While serving in that capacity the investigator assisted with the develop-
ment of a project proposal entitled "project agriculture."²³ The proposal was extensive in scope, designed to determine the nature and extent of educational needs uniquely associated with agricultural employment and to develop appropriate curricular programs for agricultural education. The broad design for the curriculum development project called for the application of the concepts of task analysis and performance competence.

Interest continued to develop from additional reading and investigation into the field. However, it was as a result of assisting in the preparation of a second research proposal, "Individualized Instruction and Performance Goals in Agricultural Education," that the investigator's interest was directed toward the use of performance objectives in curriculum development. Discussion with James W. Hensel, Agricultural Specialist at The Center for Vocational and Technical Education and major adviser to the investigator, resulted in a decision to prepare a research proposal to study the influence of performance objectives on student recall and retention of learning.

The preliminary outline and procedures to be used were critiqued in a course in research methodology in agricultural education and in a seminar in research design in which the investigator was enrolled. After further refinement, the proposal and its accompanying instruments were presented to other research associates at The Center for Vocational and Technical Education for critical review. Additional suggestions were given by the investigator's doctoral committee.

After considering all factors associated with the study and, especially, the factors of student involvement and the testing of a teaching technique, the investigator concluded that an experimental design would be most appropriate.

A conference with Richard H. Wilson, the coordinator of student teaching, Agricultural Education Department, The Ohio State University, resulted in the investigator's decision to request the assistance of student teachers to teach the lessons which were to be a part of the study. The investigator was given an opportunity to meet with the student teachers, explain the research, and request their help. Each pledged his assistance.

The population was defined as the ninth grade students enrolled in vocational agricultural in eleven
schools in central Ohio in which student teachers were teaching during the spring quarter of 1969. It was decided to include only ninth grade students in the experiment and randomly assign intact class groups to treatments.

Each cooperating teacher responsible for the ninth grade agricultural classes was contacted; the research project was explained; and their cooperation was requested. Each teacher agreed to cooperate.
CHAPTER II

REVIEW OF RELATED LITERATURE AND RESEARCH

A review of related literature and research was conducted to establish and support a theoretical base which focused on the use of student performance objectives as a means of improving the effectiveness of individual learning.

The literature revealed an increased interest on the part of educators in performance objectives as a means of effecting the fundamental processes of learning. Academicians in all fields have pointed out that the success of any educational venture is quite dependent upon clearly defined objectives. Lindvall\(^1\) supported such a philosophy and outlined a number of reasons why the educational world should look closely at the problem of defining specific instructional objectives. He concluded that (2) improved practice is especially important in view of the widespread efforts in curriculum development, (b) identifying goals is essential to

insure that curriculum development efforts will have an
effect on what goes in the classroom, and (c) specifying
goals that students are to be expected to achieve is
important in light of the current emphasis on giving
students a more rigorous educational experience.

Referring to the gap between theory and practice,
Burns stated: "There is no more important contribution
being made by modern learning theorists and educational
technologists than the development of a sound body of
knowledge related to the conceptualization, development,
and implementation of learning objectives." \(^2\) Speaking
as a practical educational technologist, Burns\(^3\) felt
that most objectives being used today are either "general­
izations" or a "mish-mash of educational gobbledygook."
Trow concluded that objectives have been neglected in
the history of educational theory and practice:

Behavioural objectives should have first priority
in the development of educational technology.
Without them all else is meaningless—curriculum
methods, media (hard or software), appraisals, and
administration procedure. .. \(^4\)

\(^2\)Richard W. Burns, "Objectives and Classroom Instruc­
\(^3\)Burns, Ibid., p. 1.
\(^4\)Clark Trow, "Behavioral Objectives in Education,"
According to Mager, behaviorally stated objectives will (1) tell the student what he will have to be able to do when he is evaluated, (2) tell the student the important conditions under which he will have to perform, and (3) tell the student the lower limit of quality of performance expected of him. Harmon concluded that a behavioral objective should be,

... a clear and precise statement of a single meaningful unit of behavior that will satisfy an instructor that a student can perform a task which is a desired outcome of a course of instruction.\(^5\)

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**Performance Objectives in the Teaching-Learning Process**

Current literature on behavioral technology revealed a close relationship between performance objectives and the efficiency of education. Slack alluded to such a relationship between educational objectives and efficiency of technology:

Where learning is inefficient, educational objectives tend to be "broad" and unclean. For learning to be efficient, objectives must be stated with a behavioral precision. This makes them appear less broad. However, the greater the efficiency, the greater the accomplishment within the same period.

---

of time. This means that absolute numbers of things taught can be much greater and the list of (limited sounding) objectives much longer.\textsuperscript{6}

In a proposal prepared by the American Institute of Research (AIR), Gagne stated that, "The importance to the success of an educational venture of clearly defined objectives has been emphasized by various investigators of educational problems. . . "\textsuperscript{7} According to Gagne, college teachers who specified objectives reported to have achieved greater clarification in the content and method of the course presentation which resulted in improved student achievement. Gagne concluded, "When such objectives are made clear to the student, his interest and motivation is likely to increase."\textsuperscript{8}

Doty\textsuperscript{9} conducted a study to investigate and to provide evidence relative to the effectiveness of behavioral objectives in increasing student learning. He attempted


\textsuperscript{8}Gagne, \textit{Ibid.}, p. 3.

to measure the effectiveness of behavioral objectives as an independent variable and in combination with actual and simulated practice. Doty was unable to show a significant increase in student learning because of the objectives, but he did report a slight increase of efficiency in student learning due to the fact that the students had prior possession of educational objectives.

Another study, although not designed to study the effectiveness of performance objectives as an independent variable, did generate findings that had implications for the use of performance objectives. Locke examined the way in which intentions affect level of performance. Specifically, he demonstrated that the level of intended achievement was related to the actual level of achievement. In a series of three experiments, Locke gathered data which indicated that a higher level of intended achievement would result in a higher level of performance exhibited by the student. If achievement and/or level of performance are inseparable components in an explicitly stated performance objective, Locke's research would support the theory that performance objectives motivate students toward higher achievement.

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The value of stating student tasks in clear, understandable form was supported by research conducted by Locke and Bryan.\textsuperscript{11} The investigators illustrated, through the use of complex psychomotor coordination task, that the difficulty of reaching the intended level of performance has a significant effect on performance. During the experiment, half of a group of students was given specific performance goals and told to attempt to beat the goal or standard on each subsequent trial. The other half of the group was given no goals and simply told to "do your best." From the data gathered the researchers concluded that performance goals did influence significantly the intensity of the effort per unit of time spent at the task.

Locke and Bryan\textsuperscript{12} explored the effects of qualitatively different goals of performance and examined the effects of qualitative goals on degree of boredom and on interest in a task. As a result of their research, it was concluded that student interest in the task was enhanced when given specific performance goals.


Gagne, writing on learning and the educational process, said, "Human performance is the fundamental class of data one must have in order to infer learning."\(^{13}\) Later, when relating human performance to objectives, Gagne stated, "Since observable human performances form the basis on which the inference of learning is made, it would seem to be a corollary that these same performances should constitute objectives of education."\(^{14}\)

Kapfer and Swenson reported, "Good teachers have always told their students what performance and achievement levels were expected of them at evaluation time. . . ."\(^{15}\) Lung, Picton, and Ward in a report to the American Educational Research Association, told curriculum researchers:

... clarity of purpose is critical for learning. Learners must be helped to develop skills essential for defining their learning goals. Learning is enhanced when the learner understands and accepts the learning goals and is involved in planning how to reach them . . . ."\(^{16}\)

The three researchers concluded their discussion on

\(^{13}\)Gagne, op. cit., p. 5.  
\(^{14}\)Gagne, op. cit., p. 5.  
learning by making four predictions for those with good learning experiences.

1. The learner will perceive himself more clearly as a learner.

2. He will increase his cognitive incorporation, retention, and recall of content.

3. He will enlarge the application of what he has learned to an insightful awareness of his environment and to integration of what he has learned.

4. He will be more capable of exercising purposeful control over his environment and adapting to it in ways that enhance human purpose and dignity.¹⁷

Utilization of Performance Objectives

Haberman¹⁸ and Dyers¹⁹ alluded to the fact that students and teachers alike benefit from performance objectives. Both authors agreed that student goals are made much clearer, that students know what they are doing, and that students have a much clearer picture of what they want to achieve. The teachers, on the other hand, are in a much better position to utilize more appropriate

¹⁷Lung, Picton, and Ward, Ibid., p. 11


teaching methods because pre-planning is involved in the development of performance objectives.

Popham,20 Haberman,21 and Mager22 considered performance objectives to be helpful in dividing the broad general concepts into more manageable, meaningful pieces. Popham refuted the argument that performance objectives are used to operationalize only trivial learning behaviors, thus, underestimating the really important outcomes of education. He stated, "Contrary to the objection raised . . . the truth is that explicit objectives make it easier for educators to attend to important instructional outcomes."23 Popham concluded his argument by pointing out that explicit performance objectives help identify and, subsequently, eliminate useless educational efforts.

The American Institute of Research (AIR) in cooperation with the Quincy Public Schools, Quincy, Mass., initiated a curriculum development effort in 1964 which

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21 Haberman, op. cit., p. 91.


23 Popham, op. cit., p. 2.
centered around the use of explicitly stated objectives. The major purpose was to develop an entire curriculum around objectives, "... defined in terms utterly plain to the student. ..." The logic was that objectives stated in the vernacular of the student would encourage the students to accept them as their own goals. The desire on the part of the researchers to have the students accept the objectives as their own goals implied that they intended for the students to have access to the objectives.

A second curriculum project initiated by the American Institute of Research involved fourteen school districts throughout several states. Project PLAN (Program for Learning in Accordance With Needs) represented an effort to develop a functional model of a comprehensive system of education to meet current educational requirements. Explicitly stated objectives were given to the students and the teachers indicating what the student was to learn over a two week time period. The objectives were given to the students in somewhat less specific terms than multiple-choice test items so as to require learning on a 

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24 Gagne, op. cit., p. 21.

more general level.

Criterion tests were prepared with each test item relating to the behavioral objectives. Multiple-choice test items were used to measure learning. Teaching units were prepared to tell the students and teachers (1) what the objectives are, (2) what instructional material will be used, (3) what the student should do with the material, and (4) how to check whether or not the student had learned the material.

Mager conducted a number of experiments related to the use of explicitly stated performance objectives. A number of inferences can be drawn from the reports of this research presented to the first performance criteria conference at Palo Alto, California, and to the Aerospace Education Foundation seminar. From the reports, the following was inferred:

1. The use of performance objectives substantially reduced instructional time.

2. The use of performance objectives tended to help students achieve higher levels of performance.

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3. The use of performance objectives in organizing an individualized student curricular program tends to keep the students from wasting time.

4. The use of performance objectives increased student motivation.

To be effective course content should be arranged into appropriate sequences and hierarchies. In this regard, Haberman\(^2\) suggested that performance objectives will prove useful in two ways: first, in determining what comprises the components of a particular piece of knowledge and second, by determining what a student needs to know before performing the task. These two considerations will, without doubt, become more critical as content knowledge in agriculture education begins to overlap more and more with content knowledge in other vocational education disciplines.

Gagne\(^3\) considered performance objectives necessary to guide teacher behavior. He implied that while many teachers are able to recognize educational goals and to translate them into effective conditions for learning some teachers have not carried their thinking beyond the

\(^2\)Haberman, op. cit., p. 91.

stage of selecting the content to be presented. Although Popham was answering the argument that explicit goals prevent the teacher from taking advantage of instructional opportunities in the classroom, his statement supported Gagne's philosophy:

Serendipity in the classroom is always welcome but, and here is an important point, it should always be justified in terms of its contribution to the learner's attainment of worthwhile objectives. Too often teachers believe they are capitalizing on unexpected instructional opportunities in the classroom, whereas measurement of pupil growth toward any defensible criterion would demonstrate that what has happened is merely ephemeral entertainment for the pupils, temporary diversion, or some other irrelevant classroom event.30

Popham31 concluded his defense by suggesting that the use of explicitly stated objectives in the classroom will actually help the teacher justify spontaneous learning activities in terms of worthwhile instructional ends.

Writing Performance Objectives

Even though there seemed to be much agreement on the value of clearly stated performance objectives, a further review of contemporary writing by behavioral technologists revealed that educators are often guilty

30 Popham, op. cit., p. 2.
31 Popham, Ibid., p. 2.
of expressing objectives in terms of abstract concepts. Thus, the salutary effects of these objectives are greatly reduced. To utilize objectives effectively, Gagne\(^3^2\) pointed out that it is necessary to break broadly stated objectives into smaller pieces so that they can be dealt with more readily. Esbensen,\(^3^3\) Dyers,\(^3^4\) Lindvall,\(^3^5\) and Mager\(^3^6\) reiterated that if objectives are to be meaningful to students, they must be written in understandable terms. It can be concluded from the writings of these authors that the use of broad, ambiguous terms such as understand, appreciate, and comprehend magnify vagueness. These terms are confusing to the student, and according to Gagne provide little or no direction toward purposeful activity:

> When educational objectives are stated as tasks, and the level of greater generality is avoided we can expect communication about education, its goals, and its procedures, to be most effective. There will be little remaining obscurity about what is to be learned.\(^3^7\)

\(^3^2\)Gagne, op. cit., p. 12.


\(^3^4\)Dyers, op. cit., p. 108.

\(^3^5\)Lindvall, op. cit., p. 2.


\(^3^7\)Gagne, op. cit., p. 13.
The arduous task of stating performance objectives was the basis for innumerable articles and a limited number of books. Current literature revealed two commonly accepted ways of stating performance objectives. According to Tyler,

The most useful form for stating objectives is to express them in terms which identify both the kind of behavior to be developed in the student and the content or area of life which this behavior is to operate. If you consider a number of statements of objectives that seem to be clear and to provide guidance in the development of instructional programs, you will note that each of these statements really includes both the behavior and the content aspects of the objective.38

Mager presented a second and widely accepted format for stating objectives:

1. Each objective should identify the terminal behavior by name; you can specify the kind of behavior that will be accepted as evidence that learning has achieved the objective.

2. Each objective should try to define the desired behavior further by describing the important conditions under which the behavior will be expected to occur.

3. Each objective should specify the criteria of acceptable performances by describing how well the learner must perform to be considered acceptable.39


Trow summed up the present situation relative to writing performance objectives that affect learning:

Some objectives seem to be implicit in the content, and students infer or guess at what they are expected to know to do. Others are more or less explicit. Only the assignments and examinations can be called behavioral objectives; and they are likely to be too late, too restricted, or too sporadic, or ill-adapted to the pupils or to the instruction they have received....

**Conclusion**

Numerous maxims were suggested in the literature to bring about maximum effectiveness in the use of performance objectives:

1. Objectives must be defined in terms of pupil behavior.41

2. Each objective should include a minimum standard of achievement.42

3. Each objective should give the student a clear idea of what he is to achieve.43

4. Each objective should specify the conditions under which the student needs to perform.44

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40 Trow, op. cit., p. 7.


42 Esbensen, op. cit., p. 6.

43 Dyers, op. cit., p. 469.

5. Each objective should be written within the capacity of the learner.\textsuperscript{45}

Performance objectives are, with greater frequency, becoming a part of curriculum research designed to discover new ways to engage students in worthwhile learning opportunities. Tyler\textsuperscript{46} defined a learning opportunity as a situation arranged to give the student an opportunity to engage in desired behavior. Although there is limited empirical evidence to prove the validity of providing students with performance objectives, the basis for their inclusion seemed both logical and compatible with current educational philosophy.

On the basis of the review of research, the deluge of literature on the use of performance objectives has failed to generate the type of experimental research needed to test the influence of performance objectives on the teaching-learning process.

The use of student performance objectives as a technique to support the basic principles of learning became the context for the study. The writings of learning theorists and behavioral technologists served to guide the investigator's effort to conceptualize the relationship of performance objectives to student learning.

\textsuperscript{45}\textsuperscript{Trow, op. cit., p. 7.}

\textsuperscript{46}\textsuperscript{Tyler, op. cit., p. 33.}
CHAPTER III

DESIGN AND CONDUCT OF THE STUDY

The design and conduct of the study were determined by the central purpose and the nature of the specific objectives outlined in Chapter I. Therefore, it was necessary to accomplish the following before data pertaining to this study could be collected and analyzed:

1. Define the population from which the data would be obtained.
2. Select an area of instruction appropriate for all ninth grade students enrolled in agricultural classes in those schools from which the sample would be selected.
3. Select two units of instruction in which the ninth grade students had had little or no prior formal instruction.
4. Develop one lesson for each instructional unit selected which could be taught in approximately one hour.
5. Develop student performance objectives for each lesson.
6. Prepare visual aids, worksheets, and reference material appropriate for each lesson based on the performance objectives.

7. Develop criterion tests to measure prior knowledge of the subject, immediate recall of the subject matter following the presentation of the lesson, and the retention of subject matter after an interval of thirty days.

8. Field test the criterion tests with a group of ninth grade students to study response patterns, identify weaknesses and discover misinterpretations of test questions.

9. Develop a procedure for securing personal data on all students.

10. Select the experimental design appropriate to test the hypotheses of the study.

11. Select a statistical treatment which would be appropriate to the design of the study.

Data were obtained from ninth grade students enrolled in vocational agriculture classes in eight high schools in central Ohio. The students' prior knowledge of the subject matter, immediate recall of the subject matter, and retention of the subject matter were determined by use of a nonstandardized test developed by the
researcher. A two-digit score represented the individual's prior knowledge of the subject. The permanent records of each student included in the study were used as a secondary source of data. The IQ score and cumulative grade point average for the first semester of the 1968-1969 school year were taken directly from the permanent records of each student.

Agricultural teachers in each of the eight schools were contacted and requested to grant permission to conduct the study. Permission was granted and it was agreed to allow the student teacher to participate. All materials needed to conduct the study were delivered directly to the teacher by the investigator.

The Design

The experimental study evolved around three components: the experimental design, the research design, and the statistical design. Each component served a separate and distinct function, but together they form an inseparable whole. Each component was selected or designed to assure the investigator that adequate data would be collected and that the data could be treated with appropriate statistical procedure in order to meet the objectives of the study.
The Experimental Design

Design for this experiment is defined by Campbell and Stanley\(^1\) as Design 10, **Nonequivalent Control Group Design**. Intact classes of ninth grade students were assigned randomly to treatment groups. The design requires that the researcher administer a pretest to all subjects and administer a posttest to the same subjects. The design is presented diagramically in Figure 1.

\[
\begin{array}{cccc}
0_1 & \cdots & X_1 & \cdots & 0_2 \\
0_3 & \cdots & \cdots & \cdots & 0_4 \\
\end{array}
\]

Figure 1.—Paradigm of Non-Equivalent Control Group Design

The basic design was expanded by adding two additional elements, a measure on three covariates and a re-test for retention. The covariates were IQ scores, pretest scores on the criterion test, and cumulative grade point averages for the first semester of the 1968-69 school year. The basic design was replicated by using two separate units of instruction. A complete diagram of the design is shown in Figure 2.

### Populations

<table>
<thead>
<tr>
<th>Population</th>
<th>Covariates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth grade students in beginning Ag. classes in 8 schools</td>
<td>IQ score</td>
</tr>
</tbody>
</table>

### Groups and Treatment

<table>
<thead>
<tr>
<th>Groups</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Students received instruction on &quot;Insect Identification&quot; with performance objectives</td>
</tr>
<tr>
<td>1.2</td>
<td>Students received instruction on &quot;Insect Identification&quot; without performance objectives</td>
</tr>
<tr>
<td>2.1</td>
<td>Students received instruction on &quot;Insect Life Cycles&quot; with performance objectives</td>
</tr>
<tr>
<td>2.2</td>
<td>Students received instruction on &quot;Insect Life Cycles&quot; without performance objectives</td>
</tr>
</tbody>
</table>

<sup>a</sup>Grade Point Average

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**Figure 2.--The Experimental Design**
The independent variables of the study were (1) prior exposure to student performance objectives and (2) the units of instruction on insect identification and insect life cycles. The dependent variables included (1) the test scores on the posttest and (2) the test scores on the re-test for retention given to the students during the conduct of the experiment.

To increase the internal validity, measures were taken to control a number of extraneous variables. Efforts made to account for (1) random assignment of classes to treatments; (2) selection of classes, (3) selection of teachers, (4) selection of schools, (5) prior knowledge of the subject, (6) the instructional unit, (7) the lesson length, and (8) classroom and physical setting assured the investigator that all subjects were treated in a similar manner.

Experimental Control

Experimental control provided a means whereby the investigator was assured that a measurable change was, in fact, due to an independent variable or variables and not due to uncontrolled extraneous variables. Aside from statistical control, the investigator imposed selective manipulation controls:
1. Random assignment of intact classes to treatments.

2. Random assignment of teachers to lessons.

3. Reducing teacher influence by preparing detailed lesson plans complete with time schedule, operating procedure and reference material.

4. Assigning all students in one school to only one lesson and one independent variable, thus preventing student collaboration.

5. Determining the students' prior knowledge of the instructional unit by administering a pretest.

6. The use of student teachers to reduce the possible influence of teacher ability because of prior teaching experience.

The physical manipulation controls were as follows:

1. Designing all lessons in such a way that they could be taught under normal classroom conditions.

2. The administration of all pretests within a period of one week (prior to the lesson being taught).

3. The administration of all posttests one day after the lesson was taught to reduce the effects of history and maturation.

4. Designing each lesson to be taught in one class session.

5. Use of two persons to check all tests, thus reducing possible grading error.

6. Use of two persons to transfer all data to computer cards to reduce transfer error.
Research Design

The research design enables the investigator to answer research questions about the experiment. The function of the research design differs from that of the experimental design presented earlier. Kerlinger explained the difference when he explained that:

Research design sets up the framework for "adequate" tests of the relations among variables. Design tells us, in a sense, what observations to make, how to make them, and how to analyze the quantitative representations of the observations. Strictly speaking design does not "tell" us precisely what to do, but rather "suggests". . . A design tells us what type of statistical analysis to use . . .

This study involved two independent variables, each variable having two levels. Thus, the investigator was able to consider the singular effect of the variable and the interaction of these variables under normal conditions. Lindquist pointed out that "... if the second variable is introduced primarily in order to study and evaluate its effect along with that of the first factor, and/or to study the interaction between the two factors, then the design is clearly of the factorial type." Figure 3 illustrates the 2 x 2 factorial design used in this study.

---


Unit of Instruction

Statistical Design

Campbell and Stanley stated, "Good experimental design is separable from the use of statistical tests of significance." They continued by pointing out that experimental design provides for comparisons that are interpretable, "... then statistical tests of significance come on for the decision as to whether or not the obtained difference rises above the fluctuations to be expected in cases of no true difference for samples of that size."

In their discussion of the statistical treatment for Design 10, Campbell and Stanley stated:

It becomes predictably certain that the two groups will differ on their posttest scores altogether independently of any effect of X, and that this difference will vary directly with the difference between the total populations from which the

\[
\begin{array}{c|c|c}
\text{Unit of Instruction} & T_1 & T_2 \\
\hline
U_1 & 1.1 & 1.2 \\
U_2 & 2.1 & 2.2 \\
\end{array}
\]

Figure 3.—2 x 2 Factorial Design

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4 Campbell and Stanley, op. cit., p. 22.
5 Campbell and Stanley, Ibid., p. 22.
selection was made and inversely with the test-re-test correlation . . .

Using simple gain scores to test the effect of the experimental variables with the procedures of matching is also applicable but usually less desirable than analysis of covariance.

Further examination revealed that the analysis of covariance test of significance could be used to study differences due to predetermined quantitative covariance that are purported to affect learning. Finally, it was determined that the data fit the assumptions of analysis of covariance and would be an appropriate statistical design.

The Covariates

Because of the nature of the experiment, direct control of variability due to chance error was not feasible. Thus, to increase the accuracy of the measurements, steps were taken to use statistical control to increase the precision of the experiment and remove the major potential sources of bias. The researcher attempted to achieve statistical control by measuring the effect of three quantitative covariates. The selection of the three

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6 Campbell and Stanley, Ibid., p. 49.
covariates was influenced by the researcher's desire to control for scholastic aptitude, concurrent achievement, and prior achievement.

Scholastic aptitude was accounted for through the use of standardized IQ scores. General IQ scores were taken from the permanent files for each student. It was discovered that it would be impossible to obtain an IQ score on all students that was a result of a single standardized test. When the IQ scores were collected the name of the test and its publisher were recorded. With the exception of a small percentage of the scores, all IQ tests used had means of approximately 100 and standard deviations of 16. Those scores which were not comparable on this basis were equated to a mean of 100 and a standard deviation of 16 by using the following linear transformation equation:

\[
W_i = \left( \frac{S_w}{S_x} \right) S_i + M_w = \left( \frac{S_w}{S_x} \right) M_x
\]

\[Wi\] linear derived score

\[Sw\] arbitrarily specified standard deviation of linear derived score

---


Concurrent achievement for each experimental group was established through a pretest given in advance of the actual starting date for the treatment. Thus, the investigator was able to detect student's prior knowledge of the instructional unit in order to adjust the posttest scores. The test was administered in the standard manner by the student teachers in the respective schools. Instructions for administering the pretest were provided for each teacher.

Prior achievement was established by determining the grade-point average for each student for the first semester of the 1968-1969 school year. The grade point average was calculated on the basis of a 4-point scale (e.g., A = 4.0, B = 3.0, C = 2.0, D = 1.0, F = 0) and included grades received in English, mathematics, science, and vocational agriculture.

The Sample

The inability of the investigator to manipulate the
students enrolled in beginning vocational agriculture classes resulted in the decision to assign intact classes to the various treatment groups. Winer pointed out that when, "The experimenter is not at liberty to assign the subjects at random to the different methods of training; he is required to use groups that are already formed."  

If these intact groups were not selected on the basis of variables directly relevant to the study then, according to Winer, . . . . for most practical purposes the groups can be considered as random samples from a common population."

The original population was defined as those ninth grade students enrolled in vocational agriculture classes in the eleven Ohio schools in which student teachers were teaching during the period of March 25 through May 12, 1969. Permission was obtained to examine the annual reports submitted to the Ohio State Department of Agricultural Education by each of the eleven schools selected for the population. The annual reports provided information concerning the (1) ninth grade agricultural enrollment for each school; (2) daily and weekly schedules for all ninth grade agricultural classes; (3) types of classes offered;

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10 Winer, Ibid., p. 588.
and (4) instructors in charge of each of the ninth grade classes.

A purusal of the annual reports revealed that three of the eleven schools in which student teachers were assigned either did not conduct agricultural classes for ninth grade students or the class was not designed specifically for ninth grade students. Thus, a decision was made to include only eight schools in the final population. All ninth grade agricultural students in the eight schools were included in the experiment.

Each of the teachers in charge of the ninth grade students in the eight schools was contacted by phone. The investigator explained the purpose of the study, stated the criteria for the sample, explained the content of the instructional units, and asked permission to conduct the study using one of the two student teachers as the instructor. Permission was granted to conduct the research in the eight schools selected. A follow-up letter was prepared and sent to each of the cooperating teachers confirming the phone conversation. (Appendix A)

Assignment of Treatment Groups

Each class was assigned randomly to one of four treatment groups using a random draw-replacement technique. After being assigned to a treatment group, each
school was given a number to facilitate the coding of data and to assure the promised anonymity.

Several uncontrollable factors made it necessary to reject data from certain students. All data were rejected from students who (1) were enrolled in special education classes; (2) lacked an IQ score; (3) failed to complete either the pretest and/or the posttest; or (4) were not present when the lesson was taught. Programming specialists from The Ohio State University Computer Center pointed out that the computer program selected for the analysis of the data required an equal number of subjects in each treatment group. An inspection of the sample revealed that the smallest treatment group contained twenty-two subjects. Through a random selection process each group was reduced to twenty-two students. Table 1 is a summary of the number of students in each treatment group for the analysis of posttest scores.
<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Initial Treatment Group Size Less Experimental Mortality</th>
<th>Adjusted Treatment Group Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>26</td>
<td>22</td>
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<tr>
<td>1.2</td>
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<tr>
<td>2.1</td>
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<td>22</td>
</tr>
<tr>
<td>2.2</td>
<td>23</td>
<td>22</td>
</tr>
</tbody>
</table>

**Instructional Units**

The divergency commonly observed among vocational agricultural departments relative to course content resulted in the establishment of a number of criteria for selecting appropriate instructional units. The selection of an appropriate area of instruction, unit of instruction, and specific lessons was guided by criteria established on the basis of local departmental and student needs. The criteria used in the selection of instructional units were as follows:

1. The instructional unit must be in an area of instruction normally taught in vocational agricultural classes to ninth or tenth grade students.
2. The instructional unit selected must not have been taught previously to the ninth grade agricultural classes.

3. The specific lesson or lessons selected must be of such length that they could be taught in approximately sixty minutes of class time.

4. The subject knowledge gained by the students as the result of the lesson must be of such nature that it could be objectively evaluated.

5. The performance objectives for the instructional unit could be stated in behavioral terms which could be readily understood by the students.

6. Sufficient reference material could be assembled so that each student would have individual access to the material.

7. The lessons could be taught in a manner familiar to the students and in a manner which would tend to reduce individual teacher influence.

8. The cost of preparing and administering the lessons was within the capability of the investigator.

9. The lessons would be considered appropriate by the cooperating teacher.
A review of the criteria, following telephone conversations with cooperating teachers, resulted in a decision to prepare two lessons, one lesson on identification of insects, and one lesson on insect life cycles.

The researcher contacted Billie Blair, Extension Entomologist, specialist in field crop production, The Ohio State University. Blair was asked to identify those insects most likely to cause damage to corn and alfalfa in Ohio. He was also asked to rank the insects in order of greatest economic importance in the areas within which the eight selected schools were located.

After reviewing draft copies of each lesson plan and each set of student performance objectives which had been established, minor changes were suggested relative to lesson content. It was suggested that Metcalf and Flint's *Destructive and Useful Insects*¹¹ be used as the basic text for the lessons being prepared by the researcher.

Preparing the Instructional Unit

The rationale upon which each lesson was prepared evolved from the need for selective manipulation control.

Manipulation control was maintained through the preparation of uniform lesson plans which provided a greater opportunity to determine if the treatment variable had a significant effect on student learning. (Appendix C through I) A standard pattern was adopted which included the following:

1. A detailed procedural outline giving general directions for the teachers and a step-by-step procedure to assist the teacher in preparing to teach the lesson.
2. A suggested time schedule including the approximate number of minutes that a teacher should spend on each activity in the lesson.
3. A complete lesson plan which included
   a. A suggested introduction.
   b. Student learning activities and accompanying teacher activities.
   c. Overhead transparencies.
   d. Student worksheets.
   e. Student reference booklets.
   f. A glossary of terms.

The performance objectives, teaching plans, procedural outlines, and reference materials were compared against the criterion tests to assure that all pertinent information had been included. All materials were delivered to the teachers one week prior to the time the instruction was to begin.
Writing the Performance Objectives

Defining a performance objective appeared to be the initial step to be taken in preparing objectives for the selected instructional units.

A clear and precise statement of a single meaningful unit of behavior that will satisfy an instructor that a student can perform a task which is a desired outcome of a course of instruction. 12

The components of each performance objective included (1) a title, (2) a set of conditions, (3) desired student behavior, and (4) performance standard or the success criteria. Each set of performance objectives was perfaced by a brief statement of explanation written especially for the student. (Appendix C and F) The final write-up of the performance objectives followed a pattern similar to that used by those preparing training programs for the Job Corp.

A reading level index was applied to each performance objective to determine the reading difficulty. The index measured the combined effect of word and sentence length and produced a number roughly equivalent to the number of years of education that a person would need to grasp the written material. The investigator found the objectives were written at a level quite acceptable for ninth grade students.

Presenting Objectives to the Student

Performance objectives were prepared for each of the lessons being taught. The objectives included sufficient information so that the student would know what he would need to read, understand, and recall to meet the required standard of performance. The performance objectives were prefaced by a brief statement describing their purpose to the student. The investigator felt it was necessary to focus the students' attention on the objectives as students are not generally accustomed to having lesson objectives stated in explicit terms nor do they generally understand the purpose for having performance objectives.

To assure that all students in the experimental treatment groups were given equal exposure to the performance objectives at the outset of the lesson, the teacher was asked to read the objectives to the students. Each student was given a copy of the objectives to follow as the instructor was presenting the performance objectives. The students were at liberty to refer back to the objectives at any time during the presentation of the lesson.

Development of Criterion Tests

The criterion measures used to test the hypotheses of the study consisted of a pretest, posttest, and test
for retention of knowledge after an interval of 30 days. (Appendix B) One basic test was prepared for each lesson and three different forms of each basic test were prepared by reordering test items. Through random selection, one form of each basic test was designed as the pretest, one as the posttest and one as a test for retention.

The performance objectives prepared for each lesson were used to determine the nature of the questions included on the criterion test. Tentative drafts of the two basic criterion tests were duplicated for use in a field trial on April 17, 1969. The subjects included ninth grade students in four agricultural departments not included in the study. The instructors were asked to administer the test as a pretest. Students were asked to record the total amount of time needed to complete the test and to circle any test item that they could not interpret. Each teacher was asked to record his observation and impressions relative to the test length, level of difficulty, and appropriateness.

A total of forty students completed both criterion tests. The response patterns were studied carefully to identify weaknesses and discover misinterpretations of test items. The specific suggestions offered by participants in the field trial and an item count were utilized in
revising both criterion tests to make each test more discriminating and more easily interpreted. The test time for each test was standardized at fifteen minutes.

The questions included in the criterion tests were of a "multiple-choice" or "best-answer" type. Each criterion test developed by the investigator was original and prepared specifically to determine the learning that occurred during the experimental session. However, based on the judgment of the investigator, an effort was made to develop a valid instrument that would measure what it was supposed to measure. "The most efficient way of developing a test with content validity is to consider first the final objectives of the course."¹³

Content validity was taken into consideration in developing the criterion instruments. According to Kerlinger, "Content validation is guided by the question, 'Is the substance of content of this measure representative of the content or the universe of content of the property being measured?'" In order to assure a higher level of content validity, a tentative draft of each criterion test

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¹⁴ Kerlinger, op. cit., p. 447.
was evaluated by other research associates at The Center for Vocational and Technical Education. The associates were considered to be competent judges as their experience included teaching, supervision, and teacher education in agricultural education. Each suggestion and/or criticism was used to eliminate misinterpretations resulting from the wording of the questions or the method of recording individual responses.

Further effort was made to establish content validity by developing questions that would, in the judgment of the investigator, measure the terminal performance stated in each objective. Because each performance objective was stated in explicit behavioral terms, each question could be worded in such a way that the student could display this terminal behavior.

**Procedures Used in Collecting Data**

All lesson plans, reference materials, pretests and posttests were delivered to the participating schools by the investigator on April 23rd and 24th, 1969. A total of thirty minutes was spent with each student teacher, who taught the lesson, examining the material, reviewing the procedure to be followed, and answering questions related to the experiment. The pretests and posttests, contained in each of two sealed envelopes, were included in each packet.
During the discussion the teachers were instructed to conduct the experiment as they would a regular class and not tell their students that an experiment was being conducted. The teachers were not told whether the lesson they were teaching was experimental or control. Each teacher was instructed to call the investigator in the event special problems arose.

Each teacher was instructed to administer the pre-test on the 22nd, 23rd, or 24th of April. The selection of dates allowed each teacher to plan ahead in order to select a time when there would be the least number of interruptions. The criterion posttest for immediate recall was administered by the teacher during the first fifteen minutes of the regular class period the day following the presentation of the lesson. The students were not told that a test would be given on the day the lesson was taught.

On May 14 and 15, the investigator visited the participating schools for the second time. The purpose of the visit was twofold. A sealed envelope containing the appropriate number of retention tests with instructions for administering was given to each of the cooperating teachers. The teachers were asked to leave the tests in the sealed envelope until such time as they were ready
to administer them to the ninth grade students. While in each school the investigator was introduced to the head guidance counselor. Each counselor was given a descriptive summary of the nature of the experiment, told what student data were needed, told how the data would be used, and assured that anonymity would be maintained. In all cases, cumulative records were shown to the investigator without reservations. All information was recorded in the presence of the cooperating teacher or counselor to assure complete accuracy.

On May 19, a letter was sent to each cooperating teacher to remind them of the need to administer the re-test for retention during the last week of May. Explicit instructions for administering the re-test for retention were included in the letter.

Analysis of Data

To increase the speed with which statistical calculations could be made, the Biomedical Computer Program (BMD03V) for the IBM 7094 computer was selected.\textsuperscript{15} The program was specially designed for analysis of covariance

\textsuperscript{15}BMD: Biomedical Computer Program, ed. by W. J. Dixon, (Los Angeles: University of California, School of Medicine, 1965), p. 511.
and the factorial design. The program provided a total covariance matrix adjusted by residuals, regression coefficients, t-values, F-statistics, and residual mean squares. The output also included an analysis of variance table.

Detailed coding instructions were prepared to facilitate the task of transferring all data to IBM data cards. To insure consistency and accuracy all data were coded and placed on code sheets by the investigator. Data cards were punched directly from the code sheets.

A two-way analysis of covariance test was run, first on posttest criterion test scores adjusted for variations in student pretest scores, IQ scores, and cumulative grade point averages. A second analysis was run on retention test scores adjusted for student pretest scores, IQ scores, and cumulative grade point averages. The program provided the investigator with total sums of squares and mean squares from which the F values were computed. Throughout the experiment the .05 level of probability was used to determine significance.
CHAPTER IV

PRESENTATION OF DATA

The central purpose of the study was to measure the influence of student performance objectives upon immediate recall and upon retention of knowledge. The specific objectives of the study were (1) to determine the influence of prior exposure to explicitly stated performance objectives on immediate recall of knowledge among ninth grade students of vocational agriculture and (2) to determine the influence of prior exposure to explicitly stated performance objectives on retention of knowledge among ninth grade students of vocational agriculture. Two general hypotheses were formulated from the theoretical framework for the study. The first general hypothesis was developed to accomplish the first objective and the second general hypothesis was developed to accomplish the second objective. For each general hypothesis, three null hypotheses were established to test the significance of the main effect and to test the interaction effect of the independent variables. The general hypotheses and the statements of null ($H_0$) hypotheses are presented under the first major section of this chapter.
A discussion of the statistical procedure used to equate the four treatment groups comprising the study sample is presented in the second section of the chapter. Consideration was given to the students prior knowledge of the subject matter, his scholastic ability, and his desire to achieve as indicated by the cumulative grade point average.

The findings relative to the effect of performance objectives on the first dependent variable (i.e., immediate learning) are presented in tabular and discussion form in section three of this chapter. An analysis of posttest scores was conducted to measure the influence of performance objectives on immediate recall of knowledge.

The final phase of the research project was directed toward determining the influence of prior exposure to performance objectives on the second dependent variable (i.e., retention of knowledge). The influence of performance objectives on retention of knowledge was determined by analyzing the retention test scores of those students who participated in all phases of the experiment. The presentation of these findings appear in the last section of this chapter.
Hypotheses

Two general hypotheses were formulated from the theoretical bases for the study. For each general hypothesis, three null hypotheses were established to test the significance of the main effect and interaction effect of the independent variables.

Hypothesis 1

Exposing students to explicitly worded performance objectives prior to the presentation of an instructional unit will have a positive influence on the recall of knowledge when measured by a criterion test administered immediately after the instructional period.

\[ H_{01} : \text{There is no significant difference in recall of knowledge between groups receiving prior exposure to performance objectives when compared with treatment groups receiving no prior exposure to performance objectives.} \]
\[ (e.g., H_0: \mu_{T_1} = \mu_{T_2}) \]

\[ H_{02} : \text{There is no significant difference in recall of knowledge between groups receiving separate instructional units with or without prior exposure to} \]
performance objectives.

(e.g., \( H_0: \mu_{U_1} = \mu_{U_2} \))

\( H_{03}: \) There is no significant difference in recall of knowledge due to interaction between prior exposure to performance objectives and separate instructional units.

(e.g., \( H_0: \mu_{T_1 U_1} - \mu_{T_2 U_1} = \mu_{T_1 U_2} - \mu_{T_2 U_2} \))

Hypotheses 2

Exposing students to explicitly worded performance objectives prior to the presentation of an instructional unit will have a positive influence on the retention of knowledge when measured by a criterion test administered thirty days after the instructional period.

\( H_{04}: \) There is no significant difference in retention of knowledge between groups receiving prior exposure to performance objectives when compared with treatment groups receiving no prior exposure to performance objectives.

(e.g., \( H_0: \mu_{T_1} = \mu_{U_2} \))
There is no significant difference in retention of knowledge between groups receiving separate instructional units with or without prior exposure to performance objectives.

(e.g., \( H_0: \mu_{U_1} = \mu_{U_2} \))

There is no significant difference in retention of knowledge due to interaction between prior exposure to performance objectives and separate instructional units.

(e.g., \( H_0: \mu_{T_1 U_1} - \mu_{T_2 U_1} = \mu_{T_1 U_2} - \mu_{T_2 U_2} \))

**Equating Treatment Groups**

The use of students in an actual school setting presented a problem relative to the analysis of data. Students normally differ in ability and aptitude. Thus, it was necessary to equate each student on the basis of certain measurable indices of ability and aptitude to reduce the possibility of obtaining a biased measure of the effect of the independent variables. The multiple classification of analysis of covariance was used to equate statistically all students on the basis of three selected covariates. Each covariate was selected to control for a specific source of variation which the investigator felt would have an unbalanced influence on the criterion measures. Pretest scores provided a measure of con-
current achievement, IQ scores were used to equate on the basis of scholastic ability, and the first semester grade point average was used to equate for prior achievement. The composition of the four treatment groups relative to the covariates adjusted for in the study are shown in Table 2.

**TABLE 2**

COVARIATE MEANS FOR TREATMENT GROUPS

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Pretest Score</th>
<th>I. Q. Score</th>
<th>G.P.A. a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>14.18</td>
<td>105.55</td>
<td>2.31</td>
</tr>
<tr>
<td>1.2</td>
<td>14.00</td>
<td>108.63</td>
<td>2.07</td>
</tr>
<tr>
<td>2.1</td>
<td>10.23</td>
<td>99.59</td>
<td>2.22</td>
</tr>
<tr>
<td>2.2</td>
<td>9.73</td>
<td>104.09</td>
<td>2.09</td>
</tr>
</tbody>
</table>

^aGrade Point Average

Analysis of Relationships Between Immediate Learning and Prior Exposure to Performance Objectives

The primary purpose of this experiment was to determine the influence of prior exposure to performance objectives on recall and on retention of knowledge. Two research hypotheses, each with three contributory null
hypotheses were developed to test the main effect of and interaction effect of the independent variable, (i.e., prior exposure to performance objectives and separate units of instruction) on immediate recall of knowledge and retention of knowledge after a thirty day interval of time.

Comparisons were made between performance scores received on a posttest for recall of knowledge administered following the instructional period and a test for retention of knowledge administered thirty days after the instructional period. Pretest scores, IQ scores, and cumulative grade point averages were used to control for individual differences that might have an unbalanced influence on the mean test score of the groups.

Multiple classification of analysis of covariance was used to test the six null hypotheses, three related to immediate recall of knowledge and three related to retention of knowledge. It seemed appropriate and meaningful to present the results of the tests for each set of three null hypotheses in a single summary table. The investigator was unable to report significance at the .05 level of probability. However, a table of adjusted means is presented for the convenience of the reader following each table of test for significance.
An examination of the tables of adjusted means will give the reader an opportunity to examine the extent to which group means are affected by adjustments due to the three covariates. The procedure used to calculate the adjusted means is presented in Appendix I.

**Prior Exposure to Performance Objectives**

It was hypothesized that those students receiving prior exposure to performance objectives would, on the basis of a criterion test administered following the lesson, recall more of the unit content than those students not exposed to performance objectives. The null hypothesis predicted there would be no statistically significant difference in posttest criterion test scores due to the main effect of prior exposure to performance objectives. The F value of 0.15 with 1 and 81 degrees of freedom indicated a lack of significance and was interpreted to mean there was no greater variation between groups than within groups. On the basis of the analysis, the null hypothesis (i.e., $H_0: \mu_{T_1} = \mu_{T_2}$) was accepted.
TABLE 3
ANALYSIS OF COVARIANCE OF SCORES ON TESTS FOR LEARNING

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Objectives</td>
<td>1</td>
<td>1.69</td>
<td>1.69</td>
<td>0.15</td>
</tr>
<tr>
<td>Instructional Units</td>
<td>1</td>
<td>0.02</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Interaction of Objectives and Instructional Units</td>
<td>1</td>
<td>23.32</td>
<td>23.32</td>
<td>2.01</td>
</tr>
<tr>
<td>Within Groups</td>
<td>81</td>
<td>967.34</td>
<td>11.63</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>967.34</td>
<td>35.66</td>
<td></td>
</tr>
</tbody>
</table>

P.05 ≥ 3.96 (with 1 and 81 degrees of freedom)

Instructional Units

Two separate units of instruction were taught with prior exposure to performance objectives and without prior exposure to performance objectives. The general hypothesis stated that prior exposure to performance objectives would positively influence student recall of knowledge irrespective of the content of the instructional unit. The contributory null predicted there would be no significant difference among treatment groups receiving separate
instructional units with or without prior exposure to performance objectives. An examination of Table 3 revealed a nonsignificant F value between posttest criterion test scores among treatment groups on the two separate units of instruction. The F value of 0.00 was not significant, therefore, the null hypothesis (i.e., $H_{02}: \mu_{U_1} = \mu_{U_2}$) was accepted.

Interaction Effects Between Independent Variable Groups

Interaction is represented by a lack of uniformity among treatment groups. The use of multiple classification of analysis of covariance and the factorial design allowed for the determination of the interaction effects. When interaction occurred among various treatment groups it was interpreted to mean there was differences among the mean criterion test scores due to the main effects of the independent variables. The null hypothesis predicted there would be no significant interaction between prior exposure to performance objective and separate instructional units. The F value of 2.01 with 1 and 81 degrees of freedom shown in Table 3 is not significant, and on the basis of the analysis of covariance, the null hypothesis (i.e., $H_{03}: \mu_{T_1 U_1} - \mu_{T_2 U_1} = \mu_{T_1 U_2} - \mu_{T_2 U_2}$) was accepted.
TABLE 4

CRITERION AND CONTROL VARIABLE MEANS FOR POST-ACHIEVEMENT

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Criterion</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post-Achievement</td>
<td>Pre-test</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>Un-adjusted</td>
</tr>
<tr>
<td>Performance Objectives</td>
<td>44</td>
<td>19.52</td>
</tr>
<tr>
<td>No Performance Objectives</td>
<td>44</td>
<td>19.16</td>
</tr>
<tr>
<td>Unit on Insect Identification</td>
<td>44</td>
<td>19.52</td>
</tr>
<tr>
<td>Unit on Insect Life Cycles</td>
<td>44</td>
<td>18.76</td>
</tr>
</tbody>
</table>

a Grade Point Average

Analysis of Relationships Between Retention of Knowledge and prior Exposure to Performance Objectives.

The final phase of the research project was an analysis of covariance to test the second general hypothesis and its three contributory null hypotheses relative to the retention of knowledge after a thirty-day interval of time. The covariates for the analysis of performance scores on the re-test for retention of knowledge were the same as those used for the analysis of posttest scores. Each subject in each treatment group was equated
on the basis of his pretest score, IQ score, and a cumulative grade point average.

Because of experimental mortality within treatment groups it was necessary to reduce each treatment group to twenty-two subjects. This was accomplished through a random selection process which assured each student an equal chance of remaining in the sample.

**Prior Exposure to Performance Objectives**

A re-test for retention of knowledge was administered thirty days after the instructional period. It was hypothesized that those treatment groups receiving prior exposure to performance objectives would retain more knowledge of the subject over a thirty-day interval of time than students receiving no prior exposure to performance objectives. The null hypothesis predicted no difference in retention of knowledge among treatment groups receiving prior exposure to performance objectives when compared with treatment groups receiving no prior exposure to performance objectives. An examination of the data presented in Table 4 revealed no statistically significant difference in retention test scores as the result of being exposed to performance objectives. The resulting F value of 2.40 with 1 and 77 degrees of freedom was interpreted to mean there was no greater variation between
groups than within groups. On the basis of the calculated F ratio the null hypothesis (i.e., \( H_{04}: \mu_{T_1} = \mu_{T_2} \)) was accepted.

**TABLE 5**

ANALYSIS OF COVARIANCE OF Scores ON Tests FOR RETENTION

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Objectives</td>
<td>1</td>
<td>31.71</td>
<td>31.71</td>
<td>2.40</td>
</tr>
<tr>
<td>Levels of Units</td>
<td>1</td>
<td>20.11</td>
<td>20.11</td>
<td>1.52</td>
</tr>
<tr>
<td>Interaction of Objective X Instructional Units</td>
<td>1</td>
<td>11.65</td>
<td>11.65</td>
<td>0.88</td>
</tr>
<tr>
<td>Within Groups</td>
<td>77</td>
<td>1018.58</td>
<td>13.23</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
<td><strong>1082.05</strong></td>
<td><strong>76.60</strong></td>
<td></td>
</tr>
</tbody>
</table>

\( P .05 \geq 3.98 \) (with 1 and 77 degrees of freedom)

**Instructional Units**

The research hypothesis stated that prior exposure to performance objectives would positively influence student retention of knowledge irrespective of the content of the instructional unit being taught. The contributory null predicted that there would be no significant difference between the retention of test scores among treatment
groups receiving separate instructional units with or without prior exposure to performance objectives. The F value of 1.52 with 1 and 77 degrees of freedom shown in Table 5 was not statistically significant, therefore, the null hypotheses (i.e., $H_{05}: \mu_{U_1} = \mu_{U_2}$) was accepted.

**Interaction Effects Between Independent Variable Groups**

Table 5 provided the researcher with data to determine the interaction effect of performance objectives, no performance objectives, and separate instructional units. The null hypothesis stated there is no difference in retention of knowledge among treatment groups caused by interaction between prior exposure to performance objectives and instructional units. Further inspection of Table 5 revealed an F value of .88 with 1 and 77 degrees of freedom which is non significant at the .05 level of probability. On the basis of the two-way analysis of covariance, the null hypothesis (i.e., $H_{06}$: $\mu_{T_1 U_1} - \mu_{T_2 U_1} = \mu_{T_1 U_2} - \mu_{T_2 U_2}$) was accepted.
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Criterion Post-Achievement</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted</td>
<td>Unadjusted</td>
</tr>
<tr>
<td>Performance Objective</td>
<td>42</td>
<td>15.51</td>
</tr>
<tr>
<td>No Performance Objectives</td>
<td>42</td>
<td>17.68</td>
</tr>
<tr>
<td>Unit on Insect Identification</td>
<td>42</td>
<td>16.62</td>
</tr>
<tr>
<td>Unit on Insect Life Cycles</td>
<td>42</td>
<td>16.54</td>
</tr>
</tbody>
</table>

<sup>a</sup>Group Point Average

**Summary**

To the extent that pretest performance scores have controlled for concurrent ability, IQ scores controlled for scholastic ability, and cumulative grade point averages controlled for prior achievement the effect of prior exposure to performance objectives with different separate instructional units was not proven unequal in this experiment. The data failed to indicate that difference in criterion test scores, due to the effect of the treatments, were significant enough to reject any of the null hypotheses at the .05 level of significance. The independent
variable chosen for this study (i.e., prior exposure to performance objectives) produced only limited variations among the sample. The conclusions, implications, and recommendations were formulated from these findings and appear in Chapter V.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A brief review of the study and the major findings are presented in this chapter. Also included are the major conclusions and their attendant recommendations. It should be pointed out that the conclusions were drawn from within the parameters of this study and should not be interpreted or generalized outside the population of the study.

Summary

Purpose of the Study

The purpose of this research was to measure the influence of clearly stated performance objectives upon immediate learning and upon the retention of knowledge when students are made aware of performance objectives prior to the instructional unit being taught.

Specific Objectives of the Study

Two specific objectives were identified as being essential to the development and conduct of the study:
1. To determine the influence of prior exposure to explicitly stated performance objectives on immediate learning among ninth grade students of vocational agriculture.

2. To determine the influence of prior exposure to explicitly stated performance objectives on the retention of knowledge among ninth grade students of vocational agriculture after an interval of thirty days.

Need for the Study

During the past decade, technological advance in agricultural industry has brought new demands on agricultural education. Subsequently, curriculum planners have been asked to prepare curriculum material of a more effective format. Using explicitly stated performance objectives as a technique to bring about more effective learning appeared to hold promise. Behavioral technologists suggested that such a technique would provide a means whereby a more systematic, scientific approach to instructional design could be developed.

Although there appeared to be much interest in the concept of presenting explicitly stated performance objectives to students, there has been little experimental research conducted to test the contention that student exposure to objectives written in behavioral terms will
result in a significant increase in student learning and retention of knowledge.

Methodology

The study was based on data gathered from ninth grade students enrolled in vocational agriculture in eight central Ohio schools and from secondary sources. Intact class groups were assigned at random to one of four treatment groups. Manipulation control was maintained by preparing two complete lesson plans which were distributed to each cooperating teacher. The lessons were taught to the various treatment groups by one of two student teachers assigned to the agricultural education department in the eight schools comprising the study sample. Eight of the sixteen student teachers were assigned at random to teach the appropriate instructional unit to all ninth grade students enrolled in the beginning vocational agricultural classes in the selected schools.

All classes were assigned to one of four treatment groups which included: Group 1.1 - students receiving a unit of instruction on identification of insects with prior exposure to performance objectives; Group 1.2 - students receiving a unit of instruction on identification of insects without prior exposure to performance
objectives; Group 2.1 - students receiving a unit on life cycles of insects with prior exposure to performance objectives; and Group 2.2 - students receiving a unit on life cycles of insects without prior exposure to performance objectives.

The Nonequivalent Control Group Design was selected as the experimental design for the study. A 2 x 2 factorial design was used to enable the investigator to answer research questions related to the experiment. The multiple classification of analysis of covariance was utilized as the statistical design with which all data were analyzed.

The measurement of the dependent variables (i.e., criterion test scores and retention test scores) was by means of objective type test instruments prepared by the investigator. The questions included in each test instrument grew out of the specific performance objectives developed for the two units of instruction. Tentative drafts of the two basic criterion tests were duplicated and field tested using ninth grade students not included in the study population. Students were allowed a maximum of fifteen minutes to complete all criterion tests both in the field tests and the actual experiment.
Each treatment group received a pretest one week prior to the presentation of the instructional unit. Two treatment groups received an identical pretest for the unit on insect life cycles, and two treatment groups received an identical pretest for the unit on identification of insects. Posttests were given on the day following the presentation of the instructional units and a re-test for retention of knowledge was administered thirty days after the completion of the lesson.

The student's cumulative record maintained by the school counselor constituted the secondary source of data. Personal data on each encumbent in the experiment was gathered from the records with the permission of the school administration and the school counselor. A complete set of data for each student included a pretest score, a posttest score, IQ score, and cumulative grade point average. These data were coded for electronic data processing through The Ohio State University Computer Center. The Biomedical Computer Program (BMD03V) for the IBM 7094 computer was selected. The program was specially designed for analysis of covariance, factorial designs.

Six null hypotheses were tested to determine the influence of two independent variables (i.e., prior exposure to performance objectives and two separate instructional units) on two dependent variables (i.e., immediate
learning and retention of knowledge). The decision was made to test all null hypotheses at the .05 level of significance.

Summary of Findings

Two general hypotheses were formulated from the theoretical framework for the study. For each general hypothesis, three contributory null hypotheses were established to test the significance of the main effect and the significance of the interaction effect of the independent variables. The first general hypothesis was developed to accomplish the first objective and the second general hypothesis was developed to accomplish the second objective. Two two-way analysis of covariance tests were run to test each null hypothesis at the .05 level of significance:

1. Based on the analysis of posttest performance scores among treatment groups with prior exposure to performance objectives and the posttest performance scores for treatment without performance objectives, no statistically significant difference was found due to prior exposure to performance objectives.
2. Comparisons of posttest performance scores between groups receiving separate instructional units with prior exposure to performance and without prior exposure to performance objectives resulted in an F value of less than one indicating there was no statistically significant difference in recall of knowledge between groups receiving separate units of instruction.

3. The use of multiple classification of analysis of covariance and the factorial design allowed for the determination of interaction. The analysis resulted in an F value of .88 which was less than the table value for the predetermined level of probability. Thus, there was no statistically significant difference in recall of knowledge caused by interaction due to the main effect of the two independent variables.

4. Based on the re-test for retention of knowledge which was administered to each treatment group thirty days after the presentation of the lessons, no statistically significant difference in retention test scores was found due to having had prior exposure to performance objectives.

5. The analysis of retention test scores between groups receiving separate instructional units with performance objectives and without performance objectives
failed to indicate that separate instructional units caused a significant difference in retention of knowledge.

6. Interaction is represented by a lack of uniformity among treatment groups. An analysis of retention performance scores revealed no statistically significant interaction due to the main effect of the two independent variables.

Conclusions

The tests conducted on the data collected during the conduct of the study resulted in the specific findings from which the conclusions are drawn.

Conclusion 1: Performance Objectives

The major independent variable chosen for this study (i.e., prior exposure to performance objectives) proved largely insignificant as a causal factor associated with increasing student recall of knowledge and student retention of knowledge. As utilized in this experiment, it appears that giving students prior exposure to performance objectives through the introduction immediately preceding a teacher-taught instructional unit did not result in a significant increase in immediate learning or retention of knowledge.
Conclusion 2: Instructional Units

The second independent variable of the study (i.e., separate instructional units) proved largely insignificant as a causal factor directly associated with increasing student recall of knowledge and student retention of knowledge when presented with and without prior exposure to performance objectives.

Conclusion 3: Interaction Effects

From the test for the interaction of prior exposure to performance objectives and separate instructional units, there appeared to be no significant difference in recall of knowledge or retention of knowledge due to the differential effect of prior knowledge of performance objectives with separate instructional units.

Doty,\(^1\) in a study involving educational objectives concluded that prior exposure to educational objectives did increase the efficiency of student learning. The analysis of data collected in the current experiment did not support the aforementioned conclusion. However, it should be pointed out that the present experiment involved different learning skills and was presented as

a teacher-taught lesson rather than as an individualized instructional unit.

**Recommendations**

The recommendations for further research are drawn from the conclusions, theoretical framework for the study, observations, and impressions gained while conducting the study. Much emphasis has been placed on the use of student performance objectives as a technique to improve student learning. A considerable amount of verbal support but no widespread practical support for the technique is evident among agricultural educators. The dearth of experimental research to investigate empirically whether prior exposure to performance objectives, as an independent educational input, will significantly increase learning and retention of knowledge resulted in the current experiment. The lack of significant test results, observations, and impressions resulting from the conduct of the current study lead the investigator to recommend that additional research be conducted. The investigator recommends:

1. Research be conducted to test the validity of the various techniques of writing and presenting performance objectives and to determine if the techniques now being used are consistent
with the theory under consideration. Research efforts should attempt to measure further the feasibility of the contention that greater efficiency and more extensive mastery of curriculum material will result from utilizing objectives stated in behavioral terms.

2. Research studies, similar to the current study, should be conducted over an extended period of time, include a larger population and make use of complete units of instruction in several appropriate areas. Such research would give students time to become familiar, not only with performance objectives, but with the concept itself, thereby enabling researchers to conduct curriculum research projects to determine the most effective use of performance objectives. Implementation of the recommendation would call for longitudinal curriculum studies with more emphasis on the analysis of course content in terms of relevant performance objectives, conveying performance objectives to students in the most advantageous way, and evaluation of student learning in terms of explicitly stated objectives.
3. Because the current research effort dealt with only one age group and because it is suspected that there is an effect due to individual differences, it is recommended that additional research be conducted to measure the extent to which age and mental maturity determines the effectiveness of prior exposure to performance objectives.

4. Research, similar to the current research, should be conducted to measure the effect that performance objectives might have on student learning and retention of knowledge when instructional units involve all learning domains, cognitive, affective, and psychomotor. A part of such research should be the development and testing of more techniques for more appropriate and reliable measurement of performance in agricultural education.

5. Further research efforts should seek to determine the value of performance objectives when used in conjunction with "prescription programs" in agricultural education (e.g., individualized instruction and programmed instruction). The current research concerned
itself with performance objectives as an independent variable in a teacher-taught lesson.
Dear

You have already learned of our need for your help with a research study of the Agricultural Education Department. Mr. Douglas Bishop is attempting to measure the influence of performance objectives on student learning.

He has sought your willingness to cooperate by allowing one of your student teachers to teach two lessons to your Ag. I class(es) during the week of April 28 through May 2, 1969. The student teacher assigned to the class(es) during that week would be requested to teach the class. Approximately 60 to 80 minutes of one day's class period will be required to complete each lesson and its posttest. A total of two days of class time will be required for the Ag. I class(es) to complete the two lessons. The lessons will not necessarily have to be taught on consecutive days.

Here is a review of the plan as it was related to you by phone.

1. Two complete lesson plans, including appropriate reference material and tests will be prepared by Mr. Bishop for use by the student teacher. One lesson will concern "Identification of Insects" and the other lesson will concern "Life Cycles of Insects".

2. A pretest will be given all students in the Ag. I class(es) prior to the lessons. The test and directions for its use will be supplied at the proper time.

3. The student teacher will teach the lesson to the entire beginning class according to the directions given. Immediately following the lesson, and in the same period, a posttest will be given all students. Upon completion of the second lesson all tests will be returned to the University for evaluation. It is intended that you keep all other teaching materials to use as you see fit.
A rather comprehensive package of teaching materials is being provided. The materials are being prepared and will be complete and in your hands in time for the student teacher to properly prepare to present the lesson. Every effort is being made to prepare the instructional material in such a way that the student teacher and your students will benefit from being a part of the research effort. It is imperative that your students not be told in advance of the pretest the nature of the lessons which will be taught. Neither should students be aware that the lessons are a part of a research project. Such knowledge could influence their learning.

Your willingness to cooperate in this effort is much appreciated. You will receive additional information as the project continues to develop. Again, let us point out that we are making every effort to develop the project in such a way that it compliments rather than interferes with ongoing activities. In the event problems develop that might affect the conduct of this project please contact us immediately.

Sincerely,

Richard H. Wilson,  
Associate Professor  
Agricultural Education  
The Ohio State University  
Columbus, Ohio 43210

Douglas Bishop  
Research Associate  
617 Stinchcomb Dr.  
Columbus, Ohio  
Ph. 268-7177
QUIZ

"Identification of Insects"

Name: ____________________ Age: ____ Name of School ______
Grade in School: ________ Date: __________________________

Answer questions 1 through 4 by placing the letter of the correct response in the blank provided.

1. Which statement best defines the insect exoskeleton?
   - a. A hard outer covering that protects the fleshy internal organs.
   - b. A hard outer covering that protects the wings of the insect.
   - c. A hard outer covering that protects the internal skeleton of the insect.
   - d. A hard outer covering over the insect's body that keeps the body parts from drying out.

2. Which statement best describes the characteristics of the leg of the true insect?
   - a. Consists of six segments all about the same length.
   - b. Consists of five segments all about the same length.
   - c. Consists of six segments connected by joints.
   - d. Consists of five segments connected by joints.

3. Which statement best describes the location of the insect spiracles?
   - a. Located on the bottom side of the insect.
   - b. Located on the side, abdomen and thorax.
   - c. Located on the very end of the abdomen.
   - d. Located on the head of the insect.

4. Which statement best describes the characteristics of the compound eye?
   - a. Special eyes through which the insect can distinguish color.
   - b. Large eyes composed of hundreds of lenses.
   - c. Large eyes which magnify the size of the object.
   - d. Special eyes which help the insect detect danger.
On the following diagram, the location of the principle body parts are indicated. In the numbered spaces, fill in the correct names of these parts.

5. __________________________ 8. __________________________
6. __________________________ 9. __________________________
7. __________________________ 10. __________________________

Observe the two diagrams below and identify, based on function, the type of mouthparts represented by each diagram.

11. __________________________

12. __________________________
The following statements describe the characteristics of specific life stages of the Potato Leafhopper and the European Corn Borer. In the space provided write the appropriate letter to indicate the insect life stage being described: A) Corn Borer Adult, B) Corn Borer Larva, C) Leafhopper Adult, D) Leafhopper Nymph.

13. Worm-like body, head dark brown to black, and rows of brown spots extending along the side of the body.
15. Pale yellow to light brown moth-like insect.

The following statements describe the characteristics of certain insect body parts. In the space provided write the letter to indicate the appropriate body part: A) leg, B) antennae, C) compound eye, D) exoskeleton, E) wings, and F) spiracles.

17. A body part found only on adult insects.
18. The region of the body on which the legs are attached.
19. A body part that many adult insects do not have.
20. A many segmented body part attached to the insect head.
21. Openings through which the insect breathes.

A number of statements are given below. Place an X in front of those that apply to insects and O in front of those that do not apply to insects.

22. A segmented body.
23. An exoskeleton resistant to chemicals.
24. Four pairs of legs only in the adult stage.
25. A body divided into the head, thorax, and abdomen.
26. Two pairs of wings in the adult stage.
QUIZ
"Life Cycles of Insects"

Name: ___________________ Age: _______ Name of School: ______________

Grade in School: ___________________ Date: ______________

Answer questions 1 through 9 by writing the appropriate letter in the space provided.

1. Which statement describes the incomplete life cycle of an insect?
   a. The young insect develops by going through a total of three stages during which the insect resembles the adult insect.
   b. The young insect develops by going through a total of three stages during which it is distinctly different from the adult insect.
   c. The young insect develops by going through a total of four life stages, none of which resemble the adult insect.
   d. The young insect develops by going through a total of four life stages with each stage resembling the adult insect.

2. Which statement describes the complete life cycle of an insect?
   a. The insect develops by going through a total of three distinctly different life stages.
   b. The insect develops by going through a total of three life stages each of which looks like the adult.
   c. The insect develops by going through a total of four distinctly different stages.
   d. The insect develops by going through a total of four life stages, each of which looks like the adult.

3. Which statement best describes an insect life stage?
   a. A life stage is a period of development in the complete and incomplete insect life cycle.
   b. A life stage is a period in the life of an insect in which they reproduce live young.
   c. A life stage is a period in the insect's life when they change from one form to another.
   d. A life stage refers to periods of radical change in body structure and appearance.
4. The stage during which the insect causes no injury to the plant.
   a. The adult.
   b. The larva.
   c. The pupa.
   d. The nymph.

5. The insect life stage that develops from the pupa is:
   a. The nymph.
   b. The adult.
   c. The egg.
   d. The larva.

6. The life stage in which there is no increase in size is:
   a. The nymph.
   b. The adult.
   c. The larva.
   d. The pupa.

7. The dormant or semi-dormant life stage of an insect with a complete life cycle is:
   a. The larva.
   b. The pupa.
   c. The nymph.
   d. The adult.

8. The insect life stage which occurs only in the incomplete life cycle is:
   a. The nymph.
   b. The pupa.
   c. The adult.
   d. The larva.

9. The mature stage in the insect life cycle of all insects is:
   a. The larva.
   b. The pupa.
   c. The adult.
   d. The nymph.
The following statements describe specific activities or functions performed by certain insect life stages. In the space provided write the appropriate letter to indicate the life stage: A) Adult, B) Egg, C) Larva, D) Nymph, or E) Pupa.

10. The feeding and growing stage for those insects with an incomplete life cycle.

11. The life stage in which the greatest amount of growth takes place in insects with a complete life cycle.

12. The life stage that develops from the larva.

13. The life stage in which the general body shape is the same as the adult.

14. The life stage that develops from the egg in the incomplete life cycle.

15. The life stage that develops from the egg in the incomplete life cycle.

16. The only life stage in which growth takes place for insects with an incomplete life cycle.

Answer questions 17 through 19 by writing the appropriate letter in the space provided.

17. Certain types of insects develop by going through a total of four life stages which are distinctly different. Which statement best describes this condition?
   a. Life stages.
   b. Instars.
   c. Complete life cycle.
   d. Incomplete life cycle.

18. When insects go through a total of three stages in their development from birth to maturity they have:
   a. A complete life cycle.
   b. An incomplete life cycle.
   c. A partial life cycle.
   d. A full life cycle.
19. The stage during which the insect changes in size but not in appearance is called:
   a. The life stage.
   b. The egg stage.
   c. The adult stage.
   d. The nymph stage.

The following statements describe specific activities or functions performed by certain insect life stages. In the space provided write the appropriate letter to indicate the life stage: A) Adult, B) Egg, C) Larva, D) Nymph, or E) Pupa.

20. The feeding and growing stage for those insects with a complete life cycle.

21. The life stage during which the insect is most mobile.

22. The life stage in the complete life cycle during which the greatest amount of growth takes place.

23. The life stage in which the body is worm-like and strikingly different from the adult.

24. The life cycle stage which develops from the nymph.

25. The life stage that develops from the egg in the complete life cycle.
TO THE TEACHER

Procedural Outline for Teaching the Lesson on
"IDENTIFICATION OF INSECTS"

READ CAREFULLY
IN PREPARATION FOR
THE LESSON
PROCEDURAL OUTLINE

To The Teacher:

This lesson has been designed to test the influence of prior knowledge of student performance objectives on student learning. Therefore, it is necessary that:

1. The students not be made aware of the performance objectives until immediately before the lesson is to be taught.

2. The students will not be told they are a part of an experiment.

3. The lessons will be taught as though it is part of the regular vocational agriculture curriculum.

4. The tests will be considered as being part of the course and administered in such context.

5. You, as the teacher, use your initiative but stay within the parameters of the lesson plan.

The instructional unit on insect life cycles is designed to be taught in 55 minutes. Fifteen additional minutes will be needed to administer the posttest. As you teach the unit you should use your own style of presenting yourself and the lesson to the students and you should follow the outline as closely as possible. Even though you may not be in agreement with the way the plan has been prepared, you are being asked to follow this general plan to help maintain uniformity for research purposes. A time schedule has been prepared and attached to this outline which, if followed, should help you complete the lesson on time.

Sufficient copies of work sheets and reference materials have been prepared so that each student will have an
individual copy.

All materials to be distributed to the students should be assembled in advance of the class session in order to conserve time. The procedure and timing of the procedures should be practiced several times before meeting the class.

Step 1: Meet the class, check the roll. Mention to the students that for this particular lesson, the class will continue until the lesson is complete. Do not indicate to the students that the lesson is a part of a research project.

Step 2: Distribute copies of the performance objectives to each student. Ask the students to follow along as you carefully read the material. (Note: This procedure is not being advocated as a good teaching technique. It is being used here to insure that each student in the class has an equal opportunity of being exposed to the performance objectives.)

Step 3: Introduce the lesson. A suggested approach has been included in the lesson plan. You may vary it if you feel you have an introduction that is more appropriate for your class.

Step 4: After introducing the lesson, move directly into those teaching activities which have been suggested to help the students accomplish the learning activities. Learning experiences 1 and 2 are the
least difficult. You should be able to complete them in a short time. The procedure suggested has been designed to promote student learning in the shortest possible time. Should you have extra time, apply it to the next set of student learning activities. It is important that you plan to have all material ready to distribute and/or use with the least possible delay.

Step 5: Develop, with your students, those questions that are included in student learning activities 3 and 4 of the lesson plan. Before class begins, place the worksheets and pictures that the students will use to answer these questions in the front of the reference booklet number 1. The booklet and the answer sheet should be passed out immediately after you have written the question(s) on the board.

Step 6: After students have been given approximately 20 minutes of supervised study, discuss the answers with them. Because of time limitation, make certain you cover the major points first. You may fill in as time permits.

Step 7: Give posttest. You should have these tests handy, but keep them out of the sight of the students. In order to keep the results of the test more accurate, make certain that each boy does his own work.
Step 8: Collect posttests. As you are collecting their tests, ask the students to make certain the name, date, class, and school have been filled in properly.

Step 9: Collect reference booklet number 2. In some cases these may be used in a second class.

**TIME SCHEDULE**

<table>
<thead>
<tr>
<th>Minutes of Class Time</th>
<th>Student Learning Experiences</th>
<th>Teacher Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes</td>
<td>Assemble</td>
<td>Role Call -- Announcements</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Listening to Introduction and Performance Objectives</td>
<td>Read performance objectives</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Students display prior knowledge</td>
<td>Develop rapport and introduce the lesson</td>
</tr>
<tr>
<td>10 minutes</td>
<td>Complete student learning experiences 1 and 2 (see lesson plan)</td>
<td>Present prepared material and direct discussion</td>
</tr>
<tr>
<td>30 minutes</td>
<td>Complete student learning experiences 3, 4, and 5. (See lesson plan)</td>
<td>Present prepared material--Assist students in supervised study period</td>
</tr>
<tr>
<td>15 minutes</td>
<td>Complete Posttest</td>
<td>Distribute tests--Give students directions for taking test</td>
</tr>
<tr>
<td>2 minutes</td>
<td></td>
<td>Collect posttests</td>
</tr>
</tbody>
</table>

72 minutes total
INTRODUCTION AND STUDENT PERFORMANCE OBJECTIVES

For The Lesson

"IDENTIFICATION OF INSECTS"

This material is not to
be shown to the students until
immediately before the
lesson is to be taught.
PERFORMANCE OBJECTIVES

lesson for
"Identification of Insects"

The lesson you are about to study, "Identification of Insects," is an introductory lesson in entomology—the science that deals with insects. It is designed to acquaint you with the external characteristics of the insect that will be helpful in identifying common insects.

To guide your study activities, performance objectives have been developed. The performance objectives will tell you several things about the lesson you are about to study. If you read them carefully you will know:

1. What you must learn from the lesson.
2. What kind of study material and reference you will be using when studying the lesson.
3. What you will have to do to show that you understand the lesson material you have been studying.

Follow along as these objectives are read to you. They will point out to you the most important parts of the lesson on insect life cycles.

Objective 1: Reviewing Insect Body Parts

You will review the body parts of insects. The lesson will help you to recall those parts of the insect which are used to identify insects. After you have studied and discussed diagrams, pictures and/or actual specimens which are representative of the insect family, you will be able to identify the: (1) leg, (2) head, (3) abdomen, (4) thorax,
(5) antennae, (6) compound eye, and (7) wings. When the lesson is completed, you will be able to locate all of these body parts on the diagrams and/or specimens.

**Objective 2: Identifying the Characteristics of Insect Body Parts**

Many animals have body parts similar to those found on insects. However, the body parts are often quite different in structure and appearance. Often the number of body parts differ. Through discussion, the use of diagrams, and other materials provided, you will study the specific characteristics of the insect: (1) leg, (2) antennae, (3) compound eye, (4) exoskeleton, and (5) wings. When the lesson is complete, you will be able to select appropriate written explanations that describe those characteristics unique to the external body parts of insects.

**Objective 3: Identifying Insect Mouth Parts**

Different insects have different types of mouth parts in the adult stage. Most of the insects you will be attempting to control will have either chewing or piercing-sucking mouth parts. Upon completion of the lesson you will be able to look at enlarged diagrams of adult insects or at actual adult insect specimens using a magnifying glass and distinguish between chewing and piercing-sucking mouth parts.

**Objective 4: Recognizing the European Corn Borer and the Potato Leafhopper**
The European Corn Borer and the Potato Leafhopper are destructive insects in Ohio. To effectively control these two insects you should be able to recognize the adult and larva stage of the European Corn Borer and the adult and nymph stage of the Potato Leafhopper. As a part of this lesson you will read the description of these insects and study colored photographs of them. Study the size, color, and shape of these insect stages. When you have completed the lesson, you will be able to recognize the Corn Borer and Leafhopper in the adult and larva stage or select statements that describe the identifying characteristics of them.
TO THE TEACHER

Vocational Agriculture I
Teaching Plan
IDENTIFICATION OF INSECTS
Vocational Agriculture I
Teaching Plan
IDENTIFICATION OF INSECTS

Objectives

Student performance objectives have been prepared for this lesson. The objectives are part of an introduction to the lesson. Sufficient copies have been prepared in order that each student may have a copy of the objectives. As a part of the introduction to the lesson, read these objectives to the students according to the directions given.

Introduction (Suggested approach)

1. Students will display knowledge of the insect family.
   a. Place transparency one showing a tick on the projector.
      Ask the students to indicate what they think it might be. Allow several members of the class to express their opinion.
      Ask, "On what basis do you make such a judgment?"
   b. Place transparency two on the projector.
      Ask, "What do you think this animal is?" How does it differ from the first animal you were shown?
      By this time the class has probably suggested bug or insect for the pictures shown. Let the class indicate which is which.
      Identify the pictures for the students.

Student Learning Experiences

1. Students review the external body structure of the insect.
   a. Place transparency three showing the segmented body and external body parts of the grasshopper.
Review the transparency with your students.

Make certain the class understands the term segment. If time permits point out the advantages of the segmented body for the insect.

Point out that all insects have the same segments and same body parts even though they may appear different.

b. Using transparency three, review the location of the body parts with the students.

Ask if there are any questions about the external body parts of the insect.

2. Students will note the differences in appearance of the two major types of insect mouth parts.

Place transparency four showing the chewing and piercing-sucking mouth parts on the projector.

Ask the students to suggest some insects with each type of mouthpart. Write a few of these insects on the transparency.

Point out some of the characteristics of each type of mouthpart.

Point out that it will be necessary to use a magnifying glass to see the mouthparts on most insects.

3. Students will become aware of the characteristics of the external body parts of the insect.

a. Point out that many of the animals in the lower classes have external body parts similar to those found in insects.

b. Ask, "Can we conclude that there is value in knowing the specific characteristics of the external body parts of insects?"

Many people are unable to distinguish between insects, ticks, spiders, etc.

Ask, "How can we select proper control measures, unless we can identify the insects?"
c. Ask, "What are the important characteristics of each of body parts?" (Note: Include only those on the student worksheet)

Distribute reference booklet No. 2 and student worksheet No. 1.

4. Students will learn to identify the European Corn Borer and the Potato Leafhopper.

a. Distribute colored photographs of the two insects.

Tell the students that the adult corn borer and the adult leafhopper will be showing up soon in Ohio.

Moths of the overwintering borers emerge from May to early July.

Adult leafhoppers usually arrive about the time the first alfalfa crop is harvested.

b. Emphasize that the damaging stages are the adult and larva stage of the European Corn Borer and the adult and nymph stage of the Potato Leafhopper.

c. Suggest to the students that the quickest way to identify common insects is by size, color, and shape.

d. Distribute the student worksheet No. 2. Give the student time to read page 6 of the reference booklet No. 1 and record what he finds.

5. Students will discuss the characteristics of the corn borer and the leafhopper.

a. After about 5 minutes place transparency number five on the projector.

Discuss the two insects with the students.

Note: If time permits it would be well to summarize the material which has been discussed.

6. Students will complete posttest.
References:

1. Booklet number 2, External Characteristics of Insects. (Student References)
2. The World of Insects Handbook. (Student Reference)
3. Destructive and Useful Insects. (Metcalf & Flint) (Teacher Ref.)
4. Supplemental material supplied with the lesson. (Teacher Ref.)

Equipment:

1. Overhead projector.
2. Transparencies 1, 2, 3, 4, and 5.
3. Screen.
SPECIFIC CHARACTERISTICS OF INSECT BODY PARTS

<table>
<thead>
<tr>
<th>Insect Body Part</th>
<th>General Characteristics</th>
<th>Number Found on an Insect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antennae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exoskeleton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compound Eye</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Worksheet No. 1
### SPECIFIC CHARACTERISTICS OF INSECT BODY PARTS

<table>
<thead>
<tr>
<th>Insect Body Parts</th>
<th>General Characteristics</th>
<th>Number Found On An Insect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leg</strong></td>
<td></td>
<td>Three Pair</td>
</tr>
<tr>
<td>A.</td>
<td>The legs are jointed.</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Each leg has six moveable segments.</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>The segments are not equal in length.</td>
<td></td>
</tr>
<tr>
<td>D.</td>
<td>The legs are attached to the thorax.</td>
<td></td>
</tr>
<tr>
<td><strong>Antennae</strong></td>
<td></td>
<td>One Pair</td>
</tr>
<tr>
<td>A.</td>
<td>A segmented appendage</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Attached to the insect's head</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Vary greatly in size and form.</td>
<td></td>
</tr>
<tr>
<td><strong>Wings</strong></td>
<td></td>
<td>Generally 2 Pair--Some pair only one pair some insects have none</td>
</tr>
<tr>
<td>A.</td>
<td>Found only on the mature</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Attached to the thorax</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Wings have no bone, muscles or joints.</td>
<td></td>
</tr>
<tr>
<td><strong>Exoskeleton</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>A light hard shell which protects the internal organs of the insect</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>It is not a boney structure</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Very resistant to all chemicals.</td>
<td></td>
</tr>
<tr>
<td><strong>Compound Eye</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Very conspicuous on the side one pair of the head</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Convex, round, oval or kidney shaped</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Usually appears shiny.</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet No. 1
<table>
<thead>
<tr>
<th>Insect and Life Stage</th>
<th>Color</th>
<th>Shape</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Corn Borer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
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<tr>
<td>Potato Leaf Hopper</td>
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<tr>
<td>Adult</td>
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Worksheet No. 2
# Identification of the European Corn Borer and the Potato Leaf Hopper

## Insect and Life Stage | Color | Shape | Size
---|---|---|---
**European Corn Borer**  
**Adult**  
FEMALE: PALE YELLOW TO LIGHT BROWN, TWO DARK ZIGZAG LINES ON THE OUTER 1/3 OF WING.  
MALE: DARKER THAN THE FEMALE, ZIGZAG LINES ON OUTER 1/3 OF WING.  
**Larva**  
HEAD DARK BROWN TO BLACK.  
UPPER PART OF BODY GRAY TO PINK.  
ROWS OF BROWN SPOTS AND PINK LINES EXTENDING LENGTHWISE ALONG SIDE OF LARVA.  
UNDERNEATH SIDE IS WHITE.  
**Potato Leaf Hopper**  
**Adult**  
PALE GREEN IN COLOR  
**Larva**  
WHITE WHEN THEY FIRST HATCH. THEY TURN PALE GREEN IN A FEW DAYS  
**Worksheet No. 2**  
FEMALE HAS A 1 INCH WINGSPAN  
SLIGHTLY SMALLER THAN FEMALE.  
WORMLIKE  
WINGED—WEDGE SHAPED INSECT,  
WINGLESS—WEDGE SHAPED INSECT.  
UP TO 1 AND 1/8 INCH LONG.
TO THE TEACHER

Procedural Outline for Teaching the Lesson On
"IDENTIFICATION OF INSECTS"

READ CAREFULLY
IN PREPARATION FOR
THE LESSON
PROCEDURAL OUTLINE

To The Teacher:

In order to maintain uniformity in the lessons being taught as part of this research project, it is necessary that:

1. The student be given no prior exposure to lesson objectives.

2. The students will not be told they are a part of a research project.

3. The lessons be taught as though they are part of the regular vocational agriculture curriculum.

4. The tests be considered part of the course and administered in this context.

5. You, as the teacher, use your initiative but stay within the parameters of the lesson plan.

The instructional unit on insect life cycles is designed to be taught in 55 minutes. Fifteen additional minutes will be needed to administer the posttest. As you teach the unit you should use your own style of presenting yourself and the lesson to the students and you should follow the outline as closely as possible. Even though you may not be in agreement with the way the plan has been prepared, you are being asked to follow this general plan to help maintain uniformity for research purposes. A time schedule has been prepared and attached to this outline which, if followed, should help you complete the lesson on time.

Sufficient copies of work sheets and reference materials have been prepared so that each student will have an individual copy.
All materials to be distributed to the students should be assembled in advance of the class session in order to conserve time. The procedure and timing of the procedures should be practiced several times before meeting the class.

Step 1: Meet the class, check the roll. Mention to the students that for this particular lesson, the class will continue until the lesson is complete. Do not indicate to the students that the lesson is a part of a research project.

Step 2: Introduce the students to the general subject of insects. Use your own ideas. A suggested introductory statement has been included with the lesson plan. Should this material be used, do not read it to the students. Make a verbal presentation.

Step 3: Introduce the lesson. A suggested approach has been included in the lesson plan. You may vary it if you feel you have an introduction that is more appropriate for your class.

Step 4: After introducing the lesson, move directly into those teaching activities which have been suggested to help the students accomplish the learning activities. Learning experiences 1 and 2 are the least difficult. You should be able to complete them in a short time. The procedure suggested has been designed to promote student learning in the shortest possible time. Should you have extra
time, apply it to the next set of student learning activities. It is important that you plan to have all material ready to distribute and/or use with the least possible delay.

**Step 5:** Develop, with your students, those questions that are included in student learning activities 3 and 4 of the lesson plan. Before class begins, place the worksheets and pictures that the students will use to answer these questions in the front of the reference booklet number 1. The booklet and the answer sheet should be passed out immediately after you have written the question(s) on the board.

**Step 6:** After students have been given approximately 20 minutes of supervised study, discuss the answers with them. Because of time limitation, make certain you cover the major points first. You may fill in as time permits.

**Step 7:** Give posttest. You should have these tests handy, but keep them out of the sight of the students. In order to keep the results of the test more accurate, make certain that each boy does his own work.

**Step 8:** Collect posttests. As you are collecting their tests, ask the students to make certain the name, date, class, and school have been filled in properly.
Step 9: Collect reference booklet number 2. In some cases these may be used in a second class.

<table>
<thead>
<tr>
<th>Minutes of Class Time</th>
<th>Student Learning Experiences</th>
<th>Teacher Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes</td>
<td>Assemble</td>
<td>Role call -- Announcements</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Listening to Introduction</td>
<td>Introduce subject</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Students display prior knowledge</td>
<td>Develop rapport and introduce the lesson</td>
</tr>
<tr>
<td>10 minutes</td>
<td>Complete student learning experiences 1 and 2 (see lesson plan)</td>
<td>Present prepared material and direct discussion</td>
</tr>
<tr>
<td>30 minutes</td>
<td>Complete student learning experiences 3, 4, and 5. (See lesson plan)</td>
<td>Present prepared material--Assist students in supervised study period</td>
</tr>
<tr>
<td>15 minutes</td>
<td>Complete posttest</td>
<td>Distribute tests--Give students directions for taking test</td>
</tr>
<tr>
<td>2 minutes</td>
<td></td>
<td>Collect posttests</td>
</tr>
</tbody>
</table>

72 minutes total
TO THE TEACHER

Suggested
INTRODUCTORY MATERIAL
for lesson on
"IDENTIFICATION OF INSECTS"
Suggested General Introduction for the lesson "Identification of Insects"

To The Teacher:

The following is a suggested general introduction to the lesson, "Identification of Insects". This material is not to be read to the students but is presented to you in hope that it might help you formulate a general verbal introduction to the lesson.

INSECTS

Since prehistoric times, insects have been competing with man for food. Although no one can be sure it is estimated that there are 500,000 insects for every human on the face of the earth. Insects have been so successful in adapting themselves to their environmental conditions that they are considered the most successful form of animal life in the world today.

Because of man's inability to control or destroy the harmful insects, millions of dollars worth of crops are damaged or destroyed each year. In Ohio alone, approximately 10 percent of all crops are damaged by these persistent and gluttonous little creatures.

There is little doubt but what each of you will be affected by insects at some time and in some way. It might be that you will suffer losses in your own crop project. Sooner or later, each of you will be faced with the problem
of insect control. Whether or not you are able to fight these pests in an intelligent manner will depend on your ability to accurately identify the insect you are fighting. To identify insects you must be familiar with the body parts of the insect and the characteristics of these body parts.

The lesson you are about to study, "Identification of Insects", is an introductory lesson in entomology—the science that deals with insects. It is designed to acquaint you with the external characteristics of the insect that will be helpful in identifying common insects.
Vocational Agriculture I
Teaching Plan
IDENTIFICATION OF INSECTS
Objectives

1. To assist the students in developing an understanding of the insect body parts that are useful in identification.

2. To teach the students to identify the European Corn Borer and the Potato Leafhopper.

Introduction (Suggested approach)

1. Students will display knowledge of the insect family.
   a. Place transparency one showing a tick on the projector.
      Ask the students to indicate what they think it might be. Allow several members of the class to express their opinion.
      Ask, "On what basis do you make such a judgment?"
   b. Place transparency two on the projector.
      Ask, "What do you think this animal is?" How does it differ from the first animal you were shown?
      By this time the class has probably suggested bug or insect for the pictures shown. Let the class indicate which is which.
      Identify the pictures for the students.

Student Learning Experiences

1. Students review the external body structure of the insect.
   a. Place transparency three showing the segmented body and external body parts of the grasshopper.
      Review the transparency with your students.
Make certain the class understands the term segment. If time permits point out the advantages of the segmented body for the insect.

Point out that all insects have the same segments and same body parts even though they may appear different.

b. Using transparency three, review the location of the body parts with the students.

Ask if there are any questions about the external body parts of the insect.

2. Students will note the differences in appearance of the two major types of insect mouth parts.

Place transparency four showing the chewing and piercing-sucking mouth parts on the projector.

Ask the students to suggest some insects with each type of mouthpart. Write a few of these insects on the transparency.

Point out some of the characteristics of each type of mouthpart.

Point out that it will be necessary to use a magnifying glass to see the mouthparts on most insects.

3. Students will become aware of the characteristics of the external body parts of the insect.

a. Point out that many of the animals in the lower classes have external body parts similar to those found in insects.

b. Ask, "Can we conclude that there is value in knowing the specific characteristics of the external body parts of insects?"

Many people are unable to distinguish between insects, ticks, spiders, etc.

Ask, "How can we select proper control measures, unless we can identify the insects?"
c. Ask, "What are the important characteristics of each of body parts?" (Note: Include only those on the student worksheet)

Distribute reference booklet No. 2 and student worksheet No. 1.

4. Students will learn to identify the European Corn Borer and the Potato Leafhopper.

a. Distribute colored photographs of the two insects.

Tell the students that the adult corn borer and the adult leafhopper will be showing up soon in Ohio.

Moths of the overwintering borers emerge from May to early July.

Adult leafhoppers usually arrive about the time the first alfalfa crop is harvested.

b. Emphasize that the damaging stages are the adult and larva stage of the European Corn Borer and the adult and nymph stage of the Potato Leafhopper.

c. Suggest to the students that the quickest way to identify common insects is by size, color, and shape.

d. Distribute the student worksheet No. 2. Give the student time to read page 6 of the reference booklet No. 1 and record what he finds.

5. Students will discuss the characteristics of the corn borer and the leafhopper.

a. After about 5 minutes place transparency number five on the projector.

Discuss the two insects with the students.

Note: If time permits it would be well to summarize the material which has been discussed.

6. Students will complete posttest.
References:

1. Booklet number 2, External Characteristics of Insects. (Student References)
2. The World of Insects Handbook. (Student Reference)
3. Destructive and Useful Insects. (Metcalf & Flint) (Teacher Ref.)
4. Supplemental material supplied with the lesson. (Teacher Ref.)

Equipment:

1. Overhead projector.
2. Transparencies 1, 2, 3, 4, and 5.
3. Screen.
Transparency 2
### Specific Characteristics of Insect Body Parts

<table>
<thead>
<tr>
<th>Insect Body Part</th>
<th>General Characteristics</th>
<th>Number Found on an Insect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg</td>
<td></td>
<td></td>
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<tr>
<td>Antennae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wing</td>
<td></td>
<td></td>
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<tr>
<td>Exoskeleton</td>
<td></td>
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<tr>
<td>Compound Eye</td>
<td></td>
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</tbody>
</table>

Worksheet No. 1
### SPECIFIC CHARACTERISTICS OF INSECT BODY PARTS

<table>
<thead>
<tr>
<th>Insect Body Parts</th>
<th>General Characteristics</th>
<th>Number Found on an Insect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg</td>
<td>A. The legs are jointed.</td>
<td>Three pair</td>
</tr>
<tr>
<td></td>
<td>B. Each leg has six moveable segments.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. The segments are not equal in length.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D. The legs are attached to the thorax.</td>
<td></td>
</tr>
<tr>
<td>Antennae</td>
<td>A. A segmented appendage</td>
<td>One pair</td>
</tr>
<tr>
<td></td>
<td>B. Attached to the insect's head</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Vary greatly in size and form.</td>
<td></td>
</tr>
<tr>
<td>Wings</td>
<td>A. Found only on the mature</td>
<td>Generally 2 pair--some</td>
</tr>
<tr>
<td></td>
<td>B. Attached to the thorax</td>
<td>only one pair</td>
</tr>
<tr>
<td></td>
<td>C. Wings have no bone, muscles or joints.</td>
<td>Some insects have none</td>
</tr>
<tr>
<td>Exoskeleton</td>
<td>A. A light hard shell which protects the internal organs of the insect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. It is not a boney structure</td>
<td></td>
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<tr>
<td></td>
<td>C. Very resistant to all chemicals</td>
<td></td>
</tr>
<tr>
<td>Compound Eye</td>
<td>A. Very conspicuous on the side of the head</td>
<td>One pair</td>
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<tr>
<td></td>
<td>B. Convex, round, oval or kidney shaped</td>
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<td></td>
<td>C. Usually appears shiny</td>
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Worksheet No. 1
IDENTIFICATION OF THE EUROPEAN CORN BORER
AND THE POTATO LEAF HOPPER

<table>
<thead>
<tr>
<th>Insect and Life Stage</th>
<th>Color</th>
<th>Shape</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td>European Corn Borer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larva</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato Leaf Hopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Larva</td>
<td></td>
<td></td>
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Worksheet No. 2
IDENTIFICATION OF THE EUROPEAN CORN BORER
AND THE POTATO LEAF HOPPER

<table>
<thead>
<tr>
<th>Insect and Life Stage</th>
<th>Color</th>
<th>Shape</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td><strong>European Corn Borer</strong></td>
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<tr>
<td>Adult</td>
<td>Female: Pale yellow to light brown, two dark zigzag lines on the outer 1/3 of wing.</td>
<td>Shaped like a moth</td>
<td>Female has a 1 inch wingspread</td>
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<tr>
<td></td>
<td>Male: Darker than the female, zigzag lines on outer 1/3 of wing.</td>
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<tr>
<td><strong>Larva</strong></td>
<td>Head dark brown to black, upper part of body gray to pink, rows of brown spots and pink lines extending lengthwise along side of larva, underneath side is white.</td>
<td>Wormlike</td>
<td>Up to 1 and 1/8 inch long.</td>
</tr>
<tr>
<td><strong>Potato Leaf Hopper</strong></td>
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<td></td>
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</tr>
<tr>
<td>Adult</td>
<td>Pale green in color</td>
<td>Winged—Wedge shaped insect</td>
<td>1/8&quot; long</td>
</tr>
<tr>
<td>Larva</td>
<td>White when they first hatch, they turn pale green in a few days</td>
<td>Wingless—Wedge shaped insect</td>
<td>Up to 1/8&quot; long</td>
</tr>
</tbody>
</table>
IDENTIFICATION OF INSECTS

An Insect! What Is It?

Insects are small, invertebrate animals (lack a backbone) which as adults, in nearly all cases, have six jointed legs. The body is divided into three regions - head, thorax and abdomen - and, in most groups, there are one or two pairs of wings. There is a pair of antennae, or "feelers," a pair of bulging compound eyes on the head and usually from one to three simple eyes, called ocelli, located on top or front of the head.

On the underside of the head, are located the mouth parts which vary greatly in form. Their type and detailed anatomy are important distinguishing features of the orders of insects. The mouthparts function either for chewing or sucking, or both in one order. There are two pairs of small feeler-like appendages to the mouth parts, which also vary in form and are used in descriptions. These are the maxillary palpi and the labial palpi.

The external parts of the reproductive organs, called the genitalia, are located at the end of the abdomen. The parts of the genitalia such as the claspers of the males and the parts of the ovipositor of the females vary greatly among the many species and in some groups are the chief means of identification. Genital characters are not here included in descriptions.

Skeleton Is on Outside of Body

Since insects constitute a division of the animal kingdom known as the phylum Arthropoda (the arthropods) along with spiders, mites, ticks, centipedes, millipedes and some others, they have certain fundamental characteristics in common. Insects have their skeletons on the outside of their bodies (an exoskeleton). Therefore, dead specimens, except the soft-bodied ones, do not shrivel or shrink, but they retain their shape. The muscles and internal organs dry or decay, but this does not generally alter the appearance of the creatures. The body is made up of ringlike segments, though in the head region and end of the abdomen there is considerable fusion of segments. The appendages in insects as well as of all arthropods are jointed. The heart is a pulsating tube located at the dorsum of the body cavity, which means along the back. The nerve cord is located along the middle line of the lower side of the body cavity and the alimentary canal, or digestive tract is a tube extending through the center of the body cavity.
A Guide to Insect Identification

The identification of insects to species is a task which generally can be done by the specialist in the group to which the insect belongs. Where a correct identification is vital or necessary, specimens should be sent to some entomologist who is well acquainted with the family or order for determination.

Immature stages of insects are difficult to identify beyond the order, though specialists can identify many nymphs, naiads, and larvae to family and even species. The identification of immature stages of insects does not come within the scope of this printing though at least the food and certain briefly described recognition features of many of them are included. Nymphs and naiads, which are the growing or feeding stages of insects with gradual and incomplete metamorphosis, rather closely resemble the adult forms except for size and wings. But the larvae of insects with complete metamorphosis, some of which are called grubs, caterpillars or maggots, bear no resemblance to their adult stages. Some illustrations include one or more of the immature stages with the adults. These may serve to assist in the identification of them and illustrate the order types.

Insect identification is actually so difficult and complex that students in undergraduate classes in college are usually not required to identify specimens further than to order and family. However, major insect pests, in most cases, can be readily identified to species.

Use of the Term "Bug"

Many people commonly refer to insects as well as most any other small creature by the semislang word "bug." This term is unscientific and generally indicates either that the user knows little about the subject or is very careless in his selection of terms. Insects are NOT bugs; they are insects. Only the insects in a single order, the Hemiptera of this manual, may be properly and technically called bugs. The chinch bug is a true bug: the stink bug, bed bug, and assassin bug are all true bugs. But a beetle is not a bug—it is a beetle, and beetles are insects. Teachers, county agents, and others dealing with the general public should set the pattern for correct use of these and other terms in the field.

The above material is taken from Insects in Kansas, Extension Division, Kansas State University, 1962.
General characteristics of insects

All insects have a total of six legs, or three pairs, at some time during their development-usually when they are adults. The body of an insect has three main parts: head, thorax, and abdomen. In certain stages of growth, however, these parts cannot always be clearly distinguished. The eyes, antennae (feelers), and mouth parts are in the head. The three pairs of legs (and the wings, if any) are attached to the thorax. In the abdomen, which is directly behind the thorax, are tiny air openings or pores, called spiracles. Sometimes prolegs or leglike projections, called claspers or filaments, are found on the abdomen.

As already mentioned, the body of an insect has a hard outer covering called an exoskeleton, which protects the fleshy internal organs against injury and loss of moisture. The material making up this exoskeleton is called chitin (pronounced ky-tin). The wings and breathing tubes are formed from extensions of this covering. The breathing tubes open through the air openings, or spiracles, which are arranged along the sides of the abdomen.

General Characteristics taken from Circular 746, Knowing and Controlling Insects, University of Illinois, College of Agriculture, May, 1962.

What are Insects?

Insects are animals with the following characteristics:

1. They have no internal backbone but rather their skeleton is on the outside of their bodies.
2. The adults have one pair of antennae, or feelers.
3. They have three pairs of jointed legs in the full-grown, or adult stage.
4. The adults have compound eyes and usually one or two pairs of wings.
5. They have three body regions: (1) the head with eyes, mouthparts, and antennae; (2) the thorax with legs and wings; (3) the abdomen (tail end).

Insects can be found almost everywhere; in water, in soil, under the bark of trees, in and on plants, in and on animals, and in the open air. Anyone interested in insect life will have little difficulty finding material no matter where he lives. An entomologist, (person who studies insects) living in a suburb of New York City, found more than 1,000 different kinds in his small backyard.
How do Insects Eat?

An insect's mouthparts are so arranged that they feed in several different ways. Some insects have jaws (mandibles) with which they are able to chew. These insects are capable of eating the leaves off of plants, leaving holes in the leaves, or even chewing the stem of the plant completely off. You no doubt have seen holes in cabbage plants made by insects with chewing mouthparts. Beetles, cutworms, grasshoppers, and armyworms feed in this manner.

Some insects feed by puncturing the surface with their beak and sucking up only liquids. It is often difficult to see exactly where they have fed on a plant. These insects are said to have piercing-sucking mouthparts. Plant lice (aphids) get all of their food by sucking the sap out of plants causing them to wilt and die. Stable flies and horse flies live on the blood which they are able to suck from our livestock. Other insects which feed in a similar manner are leafhoppers, chinch bugs, mosquitoes, and spittlebugs.

The above taken from 4-H Circular 251, Buckeye Bug-Catchers, Cooperative Extension Service, The Ohio State University.

Butterflies and moths have siphoning mouthparts which consist of a long coiled tube. This tube can be extended and used in sucking up nectar and other liquids. They are not able to actually puncture the plant, however.

What Is An Insect?

Everyone knows there are many kinds of animals. As a leader of an entomology club, you will want to know just where insects fit into this teeming mass of life. Animals, like many other things, are classified simply by dividing them first into large groups having similar characteristics. Then we subdivide each group into smaller and smaller groups until there are no longer any differences in structure upon which further divisions can be made.

Insects are members of the largest group (arthropods) in the animal kingdom. The arthropods include not only insects, but also spiders, mites, ticks, scorpions, daddy-long-legs, centipedes, millipedes, sowbugs, crabs, crayfish, and lobsters. All these animals are grouped together
because they have outside skeletons, segmental bodies, and jointed appendages.

The arthropods are divided into many classes. Insects are one of them. Adult insects differ from all other arthropods by having three body regions (head, thorax, and abdomen), six legs, and usually four wings.

Mites, spiders, and ticks all have two body regions and eight legs; centipedes have two legs on each body segment; millipedes have four legs on each body segment; and crustaceans have a total of 10 to 14 legs.

Most people refer to insects by a common name. The common name may apply to species like the housefly, or to a group of insects, such as grasshoppers. Even though common names are very important, they vary widely from one place to another.

Insects live all over the world. As new species are discovered, they are identified by insect taxonomists and given a scientific name. Being able to correctly identify insect species is an important role of the entomologist.


What is Entomology?

Entomology is the study of insects. The scientist who specializes in this field is called an entomologist.

In the study of entomology, you will learn how insects differ from other small animals; how to identify and name them; how to make and use special equipment; how to collect, preserve, label, exhibit, and rear insects; and how to control them. From all this, you will learn the economic importance of insects.

Insects

Insects are small animals. They belong to the largest group in the animal kingdom, the Arthropoda - which means joint-footed.

Arthropods have no backbones. Their bodies are jointed, and so are their legs and feet. The surfaces of their bodies
are covered with an organic material called an exoskeleton.

When fully grown or in the adult stage, insects have:
.
-three definite body regions - head, thorax, abdomen
-three pair of jointed legs
-one pair of feelers, or antennae
-compound eyes, usually
-one or two pair of wings

Taken from A Study of Insects, University of California, Agricultural Extension Service, 1966.

The European Corn Borer

The European Corn Borer is one of the most destructive pests of corn. From 1950 to 1965 it caused an average annual loss of more than 96 million bushels of field corn alone. Since it was discovered in Massachusetts in 1917, it has spread westward and southward over a large part of the important corn acreage east of the Rocky Mountains.

This insect passes the winter as a full-grown larva inside its tunnel in the stalk, stubble, or ear of corn, in weeds, or in other plant material where it has found shelter. At this time, the larva is almost 1 inch long and 1/8 inch in diameter. The head is dark brown or black. The upper part of the body is gray to light brown or pink, and has rows of brown spots and several brown or pink lines extending lengthwise. The underside of the body is cream colored and has no markings.

The pupa is brown and 1/2 to 5/8 inch long. It transforms into an adult (moth) in 10 to 14 days.

A female moth has a robust body and a wingspread of about 1 inch. The color is pale yellow to light brown. The outer third of the wings is usually crossed by two dark zigzag lines.

The male moth is smaller, has a more slender body, and is darker than the female. The outer third of the
wings is usually crossed by two zigzag streaks of pale yellow, and often there are pale-yellow areas on the forewings.

Potato Leafhopper

The yellowing and stunting of alfalfa seen during June, July, August, and September are primarily caused by the potato leafhopper, not a lack of moisture as many believe. Other species such as the pea aphid and plant bugs also do their share to reduce yields, but neither causes as much damage as the potato leafhopper. Insecticidal applications to control this pest are relatively inexpensive and frequently increase yields by 50 percent or more.

Life Cycle of the Potato Leafhopper

Adults are winged, pale-green, wedge-shaped insects about 1/8 inch long. Each year the adults are carried into Ohio by winds originating in the Gulf States, where the leafhoppers breed continuously. This insect is not known to overwinter in Ohio. The adults arrive about the time the first crop is being harvested.

Eggs are deposited in the stems and larger leaf veins of second-growth alfalfa, as soon as the new growth is 3 to 6 inches tall. After 6 to 9 days eggs hatch into white nymphs (immature leafhoppers) which turn pale-green after a few days. The period from egg to adult is usually 3 weeks. Adults and nymphs are present in alfalfa fields through September.
TO THE TEACHER

Procedural Outline for Teaching the Lesson On
"Insect Life Cycles"

READ CAREFULLY
IN PREPARATION FOR
THE LESSON
PROCEDURAL OUTLINE

To The Teacher:

This lesson has been designed to test the influence of prior knowledge of student performance objectives on student learning. Therefore, it is necessary that:

1. The students not be made aware of the performance objectives until immediately before the lesson is to be taught.

2. The students will not be told they are a part of an experiment.

3. The lessons will be taught as though it is part of the regular vocational agriculture curriculum.

4. The tests will be conducted as being part of the course and administered in such context.

5. You, as the teacher, will use your initiative but stay within the parameters of the lesson plan.

The instructional unit on insect life cycles is designed to be taught in 55 minutes. Fifteen additional minutes will be needed to administer the posttest. As you teach the unit you should use your own style of presenting yourself and the lesson to the students and you should follow the outline as closely as possible. Even though you may not be in agreement with the way the plan has been prepared, you are being asked to follow this general plan to help maintain uniformity for research purposes. A time schedule has been prepared and attached to this outline which, if followed, should help you complete the lesson on time.
Sufficient copies of work sheets and reference materials have been prepared so that each student will have an individual copy.

All materials to be distributed to the students should be assembled in advance of the class session in order to conserve time. The procedure and timing of the procedures should be practiced several times before meeting the class.

Step 1: Meet the class, check the roll. Mention to the students that for this particular lesson, the class will continue until the lesson is complete. Do not indicate to the students that the lesson is a part of a research project.

Step 2: Distribute copies of the performance objectives to each student. Ask the students to follow along as you carefully read the material. (Note: This procedure is not being advocated as a good teaching technique. It is being used here to insure that each student in the class has an equal opportunity of being exposed to the performance objectives.)

Step 3: Introduce the lesson. A suggested approach has been included in the lesson plan. You may vary it if you feel you have an introduction that is more appropriate for your class.
Step 4: After introducing the lesson, move directly into those teaching activities which have been suggested to help the students accomplish the learning activities. Learning experiences 1 through 6 are the least difficult. Plan to spend approximately twenty minutes with activities 1 through 6. The procedure suggested has been designed to promote student learning in the shortest possible time. Should you have extra time, apply it to the next set of student learning activities. It is important that you plan to have all material ready to distribute and/or use with the least possible delay.

Step 5: Develop, with your students, those questions that are included in student learning activities 7 and 8 of the lesson plan. Before class begins, place the worksheets that the students will use to answer these questions in the front of the reference booklet number 1. The booklet and the answer sheet should be passed out immediately after you have written the question(s) on the board.

Step 6: After students have been given approximately 10 minutes of supervised study, discuss the answers with them. Because of time limitation, make certain you cover the major points first. You
may fill in as time permits.

Step 7: Give posttest. You should have these tests handy, but keep them out of the sight of the students. In order to keep the results of the test more accurate, make certain that each boy does his own work.

Step 8: Collect posttests. As you are collecting their tests, ask the students to make certain the name, date, class, and school have been filled in properly.

Step 9: Collect Reference Booklet No. 2. In some cases these may be used in a second class.
### TIME SCHEDULE

<table>
<thead>
<tr>
<th>Minutes of Class Time</th>
<th>Student Learning Experiences</th>
<th>Teacher Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes</td>
<td>Assemble</td>
<td>Role call -- Announcements</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Listening to Introduction and Performance objectives</td>
<td>Read performance objectives</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Review familiar insects</td>
<td>Develop rapport and introduce the lesson</td>
</tr>
<tr>
<td>20 minutes</td>
<td>Complete student learning experiences 1, 2, 3, 4 &amp; 5 (see lesson plan)</td>
<td>Present prepared material and direct discus- sion</td>
</tr>
<tr>
<td>25 minutes</td>
<td>Complete student learning experiences 6 and 7 (see lesson plan)</td>
<td>Present prepared material--Assist students in supervised study period</td>
</tr>
<tr>
<td>15 minutes</td>
<td>Complete Posttest</td>
<td>Distribute tests--Give students directions for taking test</td>
</tr>
<tr>
<td>2 minutes</td>
<td></td>
<td>Collect posttests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>77 minutes total</td>
</tr>
</tbody>
</table>
INTRODUCTION AND STUDENT PERFORMANCE OBJECTIVES

FOR THE LESSON

"INSECT LIFE CYCLES"

THIS MATERIAL IS NOT TO
BE SHOWN TO THE STUDENTS UNTIL
IMMEDIATELY BEFORE THE
LESSON IS TO BE TAUGHT.
PERFORMANCE OBJECTIVES

To The Student:

The lesson you are about to study, "Insect Life Cycles", is an introductory lesson in entomology—the science that deals with insects. It is designed to help you understand insect life cycles and the characteristics and functions of each life stage. The information will be helpful to you when we discuss insect control in a later lesson.

To guide your study activities, performance objectives have been developed. The performance objectives will tell you several things about the lesson you are about to study. If you read them carefully you will know:

1. What you must learn from the lesson.
2. What kind of study material and references you will be using when studying the lesson.
3. What you will have to do to show that you understand the lesson material you have been studying.

Follow along as these objectives are read to you. They help focus your attention on the most important parts of the lesson on insect life cycles.

Objective 1: Recognizing Insect Life Cycles

Insects grow and develop in unusual ways. A thorough knowledge of the different insect life cycles is necessary if one is to be able to select appropriate control measures. Through class discussion and the reading of prepared reference material you will have an opportunity to study:
(1) the complete insect life cycle, (2) the incomplete insect life cycle, and (3) the life stages of insects. When you have completed the lesson, you will be able to identify the two insect life cycles and each of the various insect life stages in each life cycle. You will be able to demonstrate that you understand life cycles and stages by either labeling diagrams or selecting written statements that describe the different kinds of insect life cycles and stages.

Objective 2: Identifying the Activities and Functions of Insect Life Stages

While studying this lesson you will have an opportunity to study the characteristics of an insect at different times during its life cycle. First, you will study the characteristics of each life stage and the most important activities or functions performed by the different life stages in the insect life cycle. Secondly, you will relate the above characteristics to the insect life stages including: (1) the egg, (2) the larva, (3) the pupa, (4) the adult, (5) the nymph stage. When the lesson is completed you will be able to describe all of the distinguishing characteristics for each of the insect life stages by selecting diagrams which illustrate or written statements which describe the characteristics of the insect life stages.
TO THE TEACHER

Vocational Agriculture I

Teaching Plan

The Life Cycle of Insects
Objectives:

Student performance objectives have been prepared for this lesson. The objectives are part of the introduction to the lesson. Sufficient copies have been prepared in order that each student may have a copy of the objectives. To insure that each student has received prior exposure to the objectives, read the objectives to the student just before you begin to teach the lesson. (See section, "Introduction and Student Performance Objectives")

Introduction: (Suggested approach)

Students review familiar insects.

a. Ask the students to name some of the insects that they are familiar with.

List a number of these common insects on one corner of the blackboard. The list will probably include some insects with complete and some with incomplete life cycles.

b. Ask, "How do these insects develop?"

Prompt the class discussion by the use of related statements or questions that will lead the class into the first learning experience.

Student Learning Experiences:

1. Students view and discuss a complete insect life cycle.

   a. Place transparency number one of the complete insect life cycle on the projector.

   The transparency will show a diagrammatic sketch of the complete insect life cycle. (Note:
The various life stages are not named on the transparency. The students will supply the names of the life stages later in the lesson.

b. Ask several students to suggest what they think the diagram represents.

Don't spend too much time on this point. If necessary, prompt the students to help them bring out the concept of an insect life cycle.

After the students have suggested life cycle, write the term and its definition on the blackboard. (see glossary of terms)

Call the students attention to the different shaped figures on the diagram. "What are these figures called?"

Ask, "Does the term life stage mean anything to you?"

c. After some discussion, write the term life stage and its definition on the blackboard. (see glossary of terms)

2. Students view and discuss an incomplete life cycle.

a. Place transparency number two on the overhead projector.

Ask, "What does this diagram represent?" Someone will probably suggest a life cycle.

Point out that there is a considerable amount of difference between this diagram and the one seen earlier. Briefly discuss this fact.

b. Ask, "Can we conclude that there is more than one life cycle?"

Emphasize the fact that there are only two types of insect life cycles. Take advantage of this opportunity to lead the students into the next learning experience.

3. Students will be given an explanation of insect life cycles by the teacher.
a. At this time you should take time to elaborate on the difference between complete and incomplete life cycles.

Take advantage of as much of the previous discussion as you feel is appropriate or needed to explain the two life cycles. Be sure to include:

1. An explanation of the number of life stages in the life cycle of insects.

2. A definition of complete and incomplete insect life cycles. (Place on blackboard)

3. An explanation of how life stages relate to complete and incomplete insect life cycles. (Note: You may want to use the transparencies to show the differences.)

4. Students will assist in naming the life stages of the complete life cycle.

   a. Hand out student work copy of complete life cycle diagram. Place transparency number one, complete life cycle, on the projector.

   As a review ask the students if they understand what kind of a life cycle is represented in the diagram. Write incomplete life cycle on the transparency.

   Ask someone in the class to name the life stages of the complete insect life cycle. (Note: Assist the students with names if necessary.)

   As the life stages are named, be sure the students relate the name with the appropriate figure on the diagram.

   b. Write the names of the life stages on the transparency. Make certain the students can see the correct spelling of the life stages.

   c. To reinforce learning, write the names of the life stages under the definition of the complete life cycle which you placed on the blackboard.
5. Students will name the life stages of the incomplete life cycle.

Hand out student copy of incomplete life cycle diagram. Place transparency number two, incomplete life cycle, on the projector.

Following the same procedure used above, name the stages of the incomplete life cycle and write them on the transparency.

Be sure to clarify the fact that although there are a number of nymphs of different sizes there are still only three life stages in the incomplete life cycle.

6. Students will study characteristics of life stages in supervised study period.

a. Ask the students to review what they have discovered about insect life cycles thus far in the lesson. Don't let the discussion get out of hand.

b. Ask, "If we are to understand the insects well enough to control the insect, what other facts must we know about the life stages of the insect?"

c. Prompt the students to bring out the question, "What are the characteristics and functions of each of the insect life stages?"

After you have developed the question pass out the student worksheets upon which the students can record the information they find in a supervised study period.

Assist the students in finding the information in the booklet number 1 which will answer the question.

The majority of the students should be able to complete this part of the lesson in 10 to 15 minutes. Indicate to the students the amount of time they will have.
7. Students will be given an opportunity to discuss insect characteristics and functions.

In order to move the discussion along, place the transparency of the completed worksheet on the projector.

Point out that the students should fill in where they have left out information.

Use a piece of paper to cover all but the first stage shown on the worksheet. Compare what the students have recorded with what is on the transparency. (When finished, uncover the second, etc.)

Allow about 10 minutes for this discussion.

8. Students will be given a posttest.

Remove the information from the blackboard. Students should work on their own. Direct the student to complete the tests. Collect all tests. Collect reference material that is to be turned in.

References:

1. Booklet number 1, Insect Life Cycles. (Student Reference)
2. The World of Insects Handbook (Student Reference)
3. Destructive and Useful Insects. (Metcalf & Flint) (Teacher Reference)
4. Supplemental material supplied with the lesson (Teacher Reference)

Equipment:
1. Overhead projector.
2. Transparencies 1, 2 & 3.
3. Screen.
Glossary of Terms.

**Complete Life Cycle:** The cycle in which the insect goes through four stages of development, each different in appearance from the adult.

**Incomplete Life Cycle:** The cycle in which the insect goes through three stages of development, with the young resembling the adult insect except in size.

**Life Stage:** A radical change in structure and appearance during the insect's life cycle.
CHARACTERISTICS AND FUNCTIONS OF INSECT LIFE STAGES

"Teacher Supplement to Transparency 3"

**Adult Stage**

1. No growth occurs in the adult stage.

2. Female adult insects lay eggs or give birth to young.

3. The most mobile stage in the insect life cycle.

4. The mature stage of the life cycle.

5. Develops from the pupa stage.

**Larva Stage**

1. The growing stage for all insects with a complete life cycle.

2. Generally has a more or less worm-like body, strikingly different from that of the adult.

3. The larva often have provisional structures or organs of use only in this stage and which are lost when the adult stage is reached.

4. The larva lack compound eyes, though it may have simple eyes.

5. It may occupy the same habitat as the adult, but very often lives in a totally different sort of situation.

6. The larva commonly has a different type of mouth parts than the adult.

7. The larva is always separated from the adult by the pupa stage.

8. The larva develops from the pupa.
Nymph Stage

1. The nymph generally has a shape and body construction similar to that of the adult.

2. The growing stage of insects that have an incomplete growing cycle.

3. A nymph has a compound eye unless its parents are without compound eyes.

4. Nymphs have very few organs that are not possessed by the adult.

5. Nymphs always have the same type of mouth parts as the adult insect.

6. Nymphs generally occupy the same area and eat the same food as the adults.

7. Nymphs generally become adults without any prolonged inactive or pupal stage.

8. Nymphs possess the same body parts as adults.

9. Nymphs resemble the adult insect except in size.

10. Nymphs develop from eggs.

Pupa Stage

1. The stage in which locomotion ceases, feeding is suspended, respiration is reduced, and the insect undergoes a transformation period.

2. The stage in which wings, legs, eyes, antennae, mouth parts, and other appendages of the adult begin to form.

3. The stage in which the insect is neither injurious or harmful to man.

4. The stage in which the insect lives through the winter.
<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Characteristics and Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td></td>
</tr>
<tr>
<td>Larva</td>
<td></td>
</tr>
<tr>
<td>Nymph</td>
<td></td>
</tr>
<tr>
<td>Pupa</td>
<td></td>
</tr>
</tbody>
</table>
## CHARACTERISTICS AND FUNCTIONS OF INSECT LIFE STAGES

<table>
<thead>
<tr>
<th>Life Stages</th>
<th>Characteristics and Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adult</strong></td>
<td>A. The mature stage,</td>
</tr>
<tr>
<td></td>
<td>B. The mobile stage,</td>
</tr>
<tr>
<td></td>
<td>C. The reproducing stage,</td>
</tr>
<tr>
<td></td>
<td>D. The stage in which no growth occurs,</td>
</tr>
<tr>
<td><strong>Larva</strong></td>
<td>A. Has a worm-like body,</td>
</tr>
<tr>
<td></td>
<td>B. The feeding-growing stage in the complete life cycle,</td>
</tr>
<tr>
<td></td>
<td>C. The stage that always has chewing mouth parts,</td>
</tr>
<tr>
<td><strong>Nymph</strong></td>
<td>A. Resembles the adult except in size,</td>
</tr>
<tr>
<td></td>
<td>B. The feeding-growing stage in the incomplete life cycle,</td>
</tr>
<tr>
<td></td>
<td>C. Has the same type mouth parts as the adult,</td>
</tr>
<tr>
<td><strong>Pupa</strong></td>
<td>A. The dormant or semi-dormant stage,</td>
</tr>
<tr>
<td></td>
<td>B. Is not injurious to plants,</td>
</tr>
<tr>
<td></td>
<td>C. Generally enclosed in a cocoon,</td>
</tr>
<tr>
<td></td>
<td>D. The transformation stage in a complete life cycle,</td>
</tr>
<tr>
<td></td>
<td>E. Over-wintering stage for many insects,</td>
</tr>
</tbody>
</table>

Worksheet No. 3
TO THE TEACHER

Procedural Outline for Teaching the Lesson On
"Insect Life Cycles"

READ CAREFULLY
IN PREPARATION FOR
THE LESSON
PROCEDURAL OUTLINE

To The Teacher:

In order to maintain uniformity in the lessons being taught as part of this research project, it is necessary that:

1. The students not be given any indication of lesson objectives.

2. The students will not be told they are a part of an experiment.

3. The lessons will be taught as though it is part of the regular vocational agriculture curriculum.

4. The tests will be considered as being part of the course and administered in such context.

5. You, as the teacher, use your initiative but stay within the parameters of the lesson plan.

The instructional unit on insect life cycles is designed to be taught in 55 minutes. Fifteen additional minutes will be needed to administer the posttest. As you teach the unit you should use your own style of presenting yourself and the lesson to the students and you should follow the outline as closely as possible. Even though you may not be in agreement with the way the plan has been prepared, you are to follow this general plan to help maintain uniformity for research purposes. A time schedule has been prepared and attached to this outline which, if followed, should help you complete the lesson on time.

Sufficient copies of work sheets and reference materials have been prepared so that each student will have an
individual copy.

All materials to be distributed to the students should be assembled in advance of the class session in order to conserve time. The procedure and timing of the procedures should be practiced several times before meeting the class.

Step 1: Meet the class, check the roll. Mention to the students that for this particular lesson, the class will continue until the lesson is complete. Do not indicate to the students that the lesson is a part of a research project.

Step 2: Introduce the students to the general subject of insects. Use your own ideas. A suggested introductory statement has been included with the lesson plan. Should this material be used, do not read it to the students. Make a verbal presentation.

Step 3: Introduce the lesson. A suggested approach has been included in the lesson plan. You may vary it if you feel you have an introduction that is more appropriate for your class.

Step 4: After introducing the lesson, move directly into those teaching activities which have been suggested to help the students accomplish the learning activities. Learning experiences 1 through 6 are the least difficult. Plan to spend approximately
twenty minutes with activities 1 through 6. The procedure suggested has been designed to promote student learning in the shortest possible time. Should you have extra time, apply it to the next set of student learning activities. It is important that you plan to have all material ready to distribute and/or use with the least possible delay.

Step 5: Develop, with your students, those questions that are included in student learning activities 7 and 8 of the lesson plan. Before class begins, place the worksheets that the students will use to answer these questions in the front of the reference booklet number 1. The booklet and the answer sheet should be passed out immediately after you have written the question(s) on the board.

Step 6: After students have been given approximately 10 minutes of supervised study, discuss the answers with them. Because of time limitation, make certain you cover the major points first. You may fill in as time permits.

Step 7: Give posttest. You should have these tests handy, but keep them out of the sight of the students. In order to keep the results of the test more accurate, make certain that each boy does his own work.
Step 8: Collect posttests. As you are collecting their tests, ask the students to make certain the name, date, class, and school have been filled in properly.

Step 9: Collect Reference Booklet No. 2. In some cases these may be used in a second class.

**TIME SCHEDULE**

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<td>5 minutes</td>
<td>Assemble</td>
<td>Role call -- Announcements</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Listening to Introduction</td>
<td>Introduce the subject</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Review familiar insects</td>
<td>Develop rapport and introduce the lesson</td>
</tr>
<tr>
<td>20 minutes</td>
<td>Complete student learning experiences 1, 2, 3, 4 &amp; 5 (see lesson plan)</td>
<td>Present prepared material and direct discussion</td>
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<tr>
<td>25 minutes</td>
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</tr>
<tr>
<td>2 minutes</td>
<td></td>
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</tr>
</tbody>
</table>

77 minutes total
TO THE TEACHER

Suggested

INTRODUCTORY MATERIAL

for lesson on

"THE INSECT LIFE CYCLE"
Suggested General Introduction for the Lesson
"LIFE CYCLES OF INSECTS"

To The Teacher:

The following is a suggested general introduction to the lesson, "Insect Life Cycles". This material is not to be read to the students but is presented to you in hopes that it might help you formulate a general verbal introduction to the lesson.

INSECTS

Since prehistoric times, insects have been competing with man for food. Although no one can be sure it is estimated that there are 500,000 insects for every human on the face of the earth. Insects have been so successful in adapting themselves to their environmental conditions that they are considered the most successful form of animal life in the world today.

Because of man's inability to control or destroy the harmful insects, millions of dollars worth of crops are damaged or destroyed each year. In Ohio alone, perhaps 10 percent of all crops are damaged by these persistent and gluttonous little creatures.

There is little doubt but what each of you will be affected by insects at some time and in some way. It might be that you will suffer losses in your own crop project. Sooner or later, each of you will be faced with the problem
of insect control. Whether or not you are able to fight these pests in an intelligent manner will depend on your knowledge and understanding of the ways in which insects live and reproduce. If you are to control destructive insects, you need to know many things about them. How do they develop? Is there a life stage during which they can be controlled? What stage is easiest to control? Where do the insects rest or hide?

These questions are important to anyone who is interested in controlling insects. The lesson you are about to study, "Insect Life Cycles", is an introductory lesson in entomology—the science that deals with insects. It is designed to acquaint you with the ways in which insects grow and develop and prepare you for further study in controlling insects pests.
TO THE TEACHER

Vocational Agriculture I
Teaching Plan
The Life Cycle of Insects
Objective:

To assist the students in developing an understanding of insect life cycles and life stages.

Introduction: (Suggested approach)

Students review familiar insects.

a. Ask the students to name some of the insects that they are familiar with.

List a number of these common insects on one corner of the blackboard. The list will probably include some insects with complete and some with incomplete life cycles.

b. Ask, "How do these insects develop?"

Prompt the class discussion by the use of related statements of questions that will lead the class into the first learning experience.

Student Learning Experiences:

1. Students view and discuss a complete insect life cycle.

a. Place transparency number one of the complete insect life cycle on the projector.

The transparency will show a diagrammatic sketch of the complete insect life cycle. (Note: The various life stages are not named on the transparency. The students will supply the names of the life stages later in the lesson.)

b. Ask several students to suggest what they think the diagram represents.

Don't spend too much time on this point. If necessary, prompt the students to help them bring out the concept of an insect life cycle.
After the students have suggested life cycle, write the term and its definition on the blackboard. (See glossary of terms)

Call the students attention to the different shaped figures on the diagram. "What are these figures called?"

Ask, "Does the term life stage mean anything to you?"

c. After some discussion, write the term life stage and its definition on the blackboard. (See glossary of terms)

2. Students view and discuss an incomplete life cycle.

a. Place transparency number two on the overhead projector.

Ask, "What does this diagram represent?" Someone will probably suggest a life cycle.

Point out that there is a considerable amount of difference between this diagram and the one seen earlier. Briefly discuss this fact.

b. Ask, "Can we conclude that there is more than one life cycle?"

Emphasize the fact that there are only two types of insect life cycles. Take advantage of this opportunity to lead the students into the next learning experience.

3. Students will be given an explanation of insect life cycles by the teacher.

a. At this time you should take time to elaborate on the difference between complete and incomplete life cycles.

Take advantage of as much of the previous discussion as you feel is appropriate or needed to explain the two life cycles. Be sure to include:

1. An explanation of the number of life stages in the life cycle of insects.
2. A definition of complete and incomplete insect life cycles. (Place on blackboard)

3. An explanation of how life stages relate to complete and incomplete life cycles. (Note: You may want to use the transparencies to show the differences.)

4. Students will assist in naming the life stages of the complete life cycle.

   a. Hand out student work copy of complete life cycle diagram. Place transparency number one, complete life cycle, on the projector.

      As a review ask the students if they understand what kind of a life cycle is represented in the diagram. Write incomplete life cycle on the transparency.

      Ask someone in the class to name the life stages of the complete insect life cycle. (Note: Assist the students with names if necessary.)

      As the life stages are named, be sure the students relate the name with the appropriate figure on the diagram.

   b. Write the names of the life stages on the transparency. Make certain the students can see the correct spelling of the life stages.

   c. To reinforce learning, write the names of the life stages under the definition of the complete life cycle which you placed on the blackboard.

5. Students will name the life stages of the incomplete life cycle.

   Hand out student copy of incomplete life cycle diagram. Place transparency number two, incomplete life cycle, on the projector.

      Follow the same procedure used above, name the stages of the incomplete life cycle and write them on the transparency.

      Be sure to clarify the fact that although there are a number of nymphs of different sizes there are still only three life stages...
in the incomplete life cycle.

6. Students will study characteristics of life stages in supervised study period.
   
a. Ask the students to review what they have discovered about insect life cycles thus far in the lesson. Don't let the discussion get out of hand.

b. Ask, "If we are to understand the insects well enough to control the insect, what other facts must we know about the life stages of the insect?"

b. Prompt the students to bring out the question, "What are the characteristics and functions of each of the insect life stages?"

After you have developed the question pass out the student worksheets upon which the students can record the information they find in a supervised study period.

Assist the students in finding the information in the booklet number 1 which will answer the question.

The majority of the students should be able to complete this part of the lesson in 10 to 15 minutes. Indicate to the students the amount of time they will have.

7. Students will be given an opportunity to discuss insect characteristics and functions.

   In order to move the discussion along, place the transparency of the completed worksheet on the projector.

Point out that the students should fill in where they have left out information.

Use a piece of paper to cover all but the first stage shown on the worksheet. Compare what the students have recorded with what is on the transparency. (When finished, uncover the second, etc.)

Allow about 10 minutes for this discussion.
8. **Students will be given a posttest.**

Remove the information from the blackboard. Students should work on their own. Direct the student to complete the tests. Collect all tests. Collect reference material that is to be turned in.

References:

1. Booklet number 1, Insect Life Cycles. (Student Reference)
2. The World of Insects Handbook. (Student Reference)
3. Destructive and Useful Insects. (Metcalf & Flint) (Teacher Reference)
4. Supplemental material supplied with the lesson. (Teacher reference)

Equipment:

1. Overhead projector.
2. Transparencies 1, 2 & 3.
3. Screen.

**GLOSSARY OF TERMS**

**Complete Life Cycle:** The cycle in which the insect goes through four stages of development, each different in appearance from the adult.

**Incomplete Life Cycle:** The cycle in which the insect goes through three stages of development, with the young resembling the adult insect except in size.

**Life Stage:** A radical change in structure and appearance during the insect's life cycle.
CHARACTERISTICS AND FUNCTIONS OF INSECT LIFE STAGES

"Teacher Supplement to Transparency 3"

**Adult Stage**

1. No growth occurs in the adult stage.
2. Female adult insects lay eggs or give birth to young.
3. The most mobile stage in the insect life cycle.
4. The mature stage of the life cycle.
5. Develops from the pupa stage.

**Larva Stage**

1. The growing stage for all insects with a complete life cycle.
2. Generally has a more or less worm-like body, strikingly different from that of the adult.
3. The larva often have provisional structures or organs of use only in this stage and which are lost when the adult stage is reached.
4. The larva lack compound eyes, though it may have simple eyes.
5. It may occupy the same habitat as the adult, but very often lives in a totally different sort of situation.
6. The larva commonly has a different type of mouth parts than the adult.
7. The larva is always separated from the adult by the pupa stage.
8. The larva develops from the pupa.

**Nymph Stage**

1. The nymph generally has a shape and body construction similar to that of the adult.
2. The growing stage of insects that have an incomplete growing cycle.

3. A nymph has a compound eye unless its parents are without compound eyes.

4. Nymphs have very few organs that are not possessed by the adult.

5. Nymphs always have the same type of mouth parts as the adult insect.

6. Nymphs generally occupy the same area and eat the same food as the adults.

7. Nymphs generally become adults without any prolonged inactive or pupal stage.

8. Nymphs possess the same body parts as adults.

9. Nymphs resemble the adult insect except in size.

10. Nymphs develop from eggs.

**Pupa Stage**

1. The stage in which locomotion ceases, feeding is suspended, respiration is reduced, and the insect undergoes a transformation period.

2. The stage in which wings, legs, eyes, antennae, mouth parts, and other appendages of the adult begin to form.

3. The stage in which the insect is neither injurious or harmful to man.

4. The stage in which the insect lives through the winter.
<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Characteristics and Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td></td>
</tr>
<tr>
<td>Larva</td>
<td></td>
</tr>
<tr>
<td>Nymph</td>
<td></td>
</tr>
<tr>
<td>Pupa</td>
<td></td>
</tr>
</tbody>
</table>
CHARACTERISTICS AND FUNCTIONS OF INSECT LIFE STAGES

<table>
<thead>
<tr>
<th>LIFE STAGES</th>
<th>CHARACTERISTICS AND FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADULT</td>
<td>A. The mature stage.</td>
</tr>
<tr>
<td></td>
<td>B. The mobile stage.</td>
</tr>
<tr>
<td></td>
<td>C. The reproducing stage.</td>
</tr>
<tr>
<td></td>
<td>D. The stage in which no growth occurs.</td>
</tr>
<tr>
<td>LARVA</td>
<td>A. Has a worm-like body.</td>
</tr>
<tr>
<td></td>
<td>B. The feeding-growing stage in the complete life cycle.</td>
</tr>
<tr>
<td></td>
<td>C. The stage that always has chewing mouth parts.</td>
</tr>
<tr>
<td>NYMPH</td>
<td>A. Resembles the adult except in size.</td>
</tr>
<tr>
<td></td>
<td>B. The feeding-growing stage in the incomplete life cycle.</td>
</tr>
<tr>
<td></td>
<td>C. Has the same type mouth parts as the adult.</td>
</tr>
<tr>
<td>PUPA</td>
<td>A. The dormant or semi-dormant stage.</td>
</tr>
<tr>
<td></td>
<td>B. Is not injurious to plants.</td>
</tr>
<tr>
<td></td>
<td>C. Generally enclosed in a cocoon.</td>
</tr>
<tr>
<td></td>
<td>D. The transformation stage in a complete life cycle.</td>
</tr>
<tr>
<td></td>
<td>E. Over-wintering stage for many insects.</td>
</tr>
</tbody>
</table>

Worksheet No. 3
INSECT LIFE CYCLES

Booklet Number 1
Life Cycle

The Development of Insects

Most insects deposit or lay eggs of the normal shelled type. These eggs, which are of various sizes, shapes, and colors, are deposited singly or in clusters in many different situations. Some are laid in the soil, in logs, in stumps, in or on the leaves and stems of plants, on the surface of all parts of living plants, on rocks, and in the water. In some cases, however, the eggs are retained within the body of the female until after they have hatched and thus the young are produced in an active stage. Those which lay eggs, hatching later, are termed oviparous (o-vip'a-rous) while those which retain the eggs in the body until they hatch are termed ovoviviparous (o'vo-vi-vip'a-rous), for example, plant lice and scale insects. There are a few insects which supply nourishment to the young during its entire growing stage or before its birth. These are termed viviparous. Examples include certain flies.

The sexes of insects are separate. Many species of insects, however, reproduce parthenogenetically (without fertilization by the male). In fact, there are species of insects where the males are not known to exist.

The length of time spent in the egg differs in various species of insects from a few hours to many months. In hatching, either a hole is eaten in the shell or it is broken open and the young insect crawls from it, in many instances quite unlike the adult it is to become.

To reach maturity, it must grow and undergo changes in form, structure, and appearance. The changes in form, structure, and appearance which insects undergo in their development from the egg to the adult are usually spoken of as metamorphosis.

For an example of direct or gradual metamorphosis, the egg of a grasshopper produces a creature known as a nymph, which, except for the absence of the wings, resembles the adult. This form known as the nymph is the growing stage. In the process of growing, it sheds its outer covering or skin several times before it develops into a grown grasshopper. The casting off or shedding of the skin is known as molting. An insect developing as a grasshopper or gradually changing in its growth passes through incomplete metamorphosis. Chinch bugs, dragonflies, and plant lice also belong to this type.
Change Form as They Mature

The egg of a moth hatches into a caterpillar or larva which is the active feeding stage, or the stage in which the insect does its serious injury to plants. The caterpillar sheds its skin several times before it is fully grown. The caterpillar does not resemble the adult moth. When full grown, it spins a protective covering or casing of silk known as a cocoon. In this protective casing it transforms into a third stage known as the pupa. This from all outward appearance is the inactive, or dormant stage of its development. In this stage it takes no food. The pupa does not resemble the caterpillar from which it came nor the moth into which it later will develop. In many cases the insect passes the winter in the pupal stage, which, therefore, varies in length from a few days in summer to several months in winter. Finally, the shell splits open and the moth emerges with wings which are soft and limp, but which expand and harden in a few hours. The different forms of insects in these stages are so different that without experience and knowledge gained from study, one would not know that they belonged to the same individual. Such an insect undergoes distinct or complete metamorphosis.

Butterflies, houseflies, bees, wasps, ants, and beetles belong to this type. The growing stage of all insects which undergo the distinct changes in the larval stage, which is the caterpillar stage of the butterfly, the maggot stage of the housefly, and the grub stage of the May beetle and of the honeybee.

How Insects Eat

While a large number of insects eat their food by biting or chewing off small particles which they swallow, a great many others take their food by sucking it in a liquid form. If, for example, the mouth parts of a grasshopper are examined, it will be found that they include a distinct pair of jaws adapted for biting and chewing. Insects equipped with such jaws bite off portions of leaves or plants; chew and swallow them. If, however, the head of a squash bug is examined, no jaws will be found. Instead, there is a stout beak with a deep groove or channel in which lie four long bristles adapted for piercing and sucking. As the insect feeds, it thrusts the piercing mouth
parts through the outer layer of the bark or leaf into the soft, juicy tissue beneath and extracts the plant sap or juices.

How Insects Breathe

Breathing, or respiration, in insects is accomplished by means of a system of internal air tubes known as tracheae, through which the air is conducted directly to all parts or every cell of the insect. Some of the air tubes frequently open along each side of the abdomen or even the thorax, but never on any part of the head. The openings by which the air enters the tubes are known as spiracles which in some insects have valves by which the spiracles can be closed. Many of the immature stages of aquatic insects breathe by means of tracheal gills.

The tracheae are used not only in carrying air and oxygen to all parts of the body but also in receiving and removing much of the carbon dioxide and other gaseous wastes produced by the activity of the cells. The carbon dioxide is discharged from the air tubes through the spiracles or through the body wall. The blood of an insect does not flow to any important organs of the body to receive and carry oxygen, since in its movements throughout the body of an insect it comes in contact with the tracheal system and is kept pure insofar as oxygen is required.

The lining of the air tubes themselves is formed into elastic, coiled threads or thickenings and when the muscular pressure from the contraction is relieved the elasticity of the walls causes the tubes to regain their normal shape.

The foregoing taken from Insects in Kansas, Extension Division, Kansas State University, 1962.

How Insects Develop

Most insects start from eggs laid by the female. In general, the insects develop from the eggs in two different ways. One group, which is said to have a "complete life cycle," goes through four stages of development. These stages are egg, larva, pupa, and adult. The larva is a tiny worm which hatches from the egg. It grows steadily larger and eventually changes into a motionless resting
stage (pupa). In this stage an insect is best able to resist an adverse environment. The adult insect emerges by splitting the pupal skin. Beetles, flies, bees, butterflies, and moths are examples of this kind of insect. It is often helpful in identification to keep a worm or cocoon alive until it becomes an adult. Adult forms are usually easier to identify.

The other group has an "incomplete life cycle," and goes through just three stages of development. When the young hatch from the eggs, they look like adults except that they are smaller. They are called nymphs. The nymphs shed their skins as they grow larger, finally developing wings and becoming adults. Grasshoppers, crickets, roaches, and the true bugs are examples of this group.

The above taken from - Knowing and Controlling Insects, 4-H Club Entomology Manual, Circular 746, University of Illinois, College of Agriculture.

Life History of Insects

We study insect biology to learn where an insect 'lives, what it eats, what its habits are, and how it reproduces. Most of these questions can be answered by a study of the insect's life cycle. The LIFE CYCLE begins with the egg stage and continues through the reproducing adult stage.

Observations

Everything you can observe about an insect will be of value in understanding and predicting what it will do in the future.

Observations, such as those you will make, help entomologists know when and where to spray and dust for insect control. Observe these vital points:
- How long does an insect stay in one particular stage of growth?
- Where does it spend its time?
- What does it eat?

Preservation of the different stages is also very important.
Metamorphosis is the name given to the change in the shape of an insect as it grows. Insects are divided into four groups depending upon their method of metamorphosis.

APPENDIX I
ADJUSTING STATISTICAL MEANS

The statistical means (\(\bar{X}\)) generated by the analysis of data in this experiment were adjusted by using a formula suggested by Garrett and Woodworth: \(^1\)

\[
\bar{Y}_{My.x} = \bar{Y}_My - b (\bar{Y}_{Mx} - \bar{Y}_{GMx})
\]

- \(\bar{Y}_{My.x}\) Mean of dependent variable as adjusted by means of independent variables
- \(b\) Within regression coefficient
- \(\bar{Y}_My\) Mean of dependent variable
- \(\bar{Y}_{Mx}\) Mean of independent variable
- \(\bar{Y}_{GMx}\) Grand mean of independent variable

The basic formula was expanded to accommodate the experiment as follows:

\[
\begin{align*}
\bar{Y}_{T1} &= \bar{Y}_{U1} - b_1 (\bar{X}_{11} - \bar{X}_1) - b_2 (\bar{X}_{21} - \bar{X}_2) - b_3 (\bar{X}_{31} - \bar{X}_3) \\
\bar{Y}_{T1}, \bar{Y}_{T2}, \bar{Y}_{U1}, \bar{Y}_{U2} &\text{ Adjusted means of dependent variable} \\
\bar{Y}_{T1}, \bar{Y}_{T2}, \bar{Y}_{U1}, \bar{Y}_{U2} &\text{ Unadjusted mean of dependent variable} \\
b_1, b_2, b_3 &\text{ Within regression coefficients} \\
X_{11}, X_{21}, X_{31} &\text{ Marginal means for selected covariates} \\
X_1, X_2, X_3 &\text{ Overall means for selected covariates}
\end{align*}
\]

BIBLIOGRAPHY
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Books


Tyler, Ralph W. *Constructing Achievement Tests.* Columbus, Ohio: The Ohio State University, 1934.


Articles and Periodicals


**Unpublished Material**


