FACTORS ASSOCIATED WITH THE PROBLEM-SOLVING ABILITY OF HIGH SCHOOL STUDENTS ENROLLED IN VOCATIONAL HORTICULTURE

DISSERTATION

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iii
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>VITA</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>.PAGE</td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Problem Solving and Vocational Agriculture</td>
<td>3</td>
</tr>
<tr>
<td>Research in Problem Solving</td>
<td>4</td>
</tr>
<tr>
<td>Achievement and Problem Solving</td>
<td>6</td>
</tr>
<tr>
<td>Problem Statement</td>
<td>7</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>9</td>
</tr>
<tr>
<td>Limitations of the Study</td>
<td>11</td>
</tr>
<tr>
<td>Definitions</td>
<td>11</td>
</tr>
<tr>
<td>II. REVIEW OF LITERATURE</td>
<td>13</td>
</tr>
<tr>
<td>Problem Solving: An Overview of Concepts</td>
<td>13</td>
</tr>
<tr>
<td>Knowledge Base and Content-Specific</td>
<td></td>
</tr>
<tr>
<td>Problem Solving</td>
<td>22</td>
</tr>
<tr>
<td>Teaching Problem Solving</td>
<td>24</td>
</tr>
<tr>
<td>Assessing Problem-Solving Ability</td>
<td>31</td>
</tr>
<tr>
<td>Impact Research on Problem Solving</td>
<td>41</td>
</tr>
<tr>
<td>and Achievement</td>
<td></td>
</tr>
<tr>
<td>Variables Related to Problem-Solving</td>
<td>49</td>
</tr>
<tr>
<td>Ability and Achievement</td>
<td>61</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
<tr>
<td>III. METHODOLOGY</td>
<td>63</td>
</tr>
<tr>
<td>Population and Sample</td>
<td>63</td>
</tr>
<tr>
<td>Measurement of the Variables</td>
<td>67</td>
</tr>
<tr>
<td>Data Collection</td>
<td>83</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>85</td>
</tr>
</tbody>
</table>

iv
IV. FINDINGS ........................................ 87
    Descriptive Data ............................... 88
    Profile of the Sample ....................... 88
    Descriptive Data on the Variables ......... 91
    Correlational Analysis ...................... 112
    Pairwise Correlations of the Variables .... 112
    Variance Explained in the Dependent Variables .... 117
    Relationships between the Set of Criterion Variables and the Set of Predictor Variables .... 126

V. SUMMARY, DISCUSSION, AND IMPLICATIONS .......... 135
    Purpose and Objectives ...................... 135
    Procedures .................................. 137
    Summary of Findings ....................... 138
    Conclusions ................................ 143
    Discussion ................................ 145
    Implications .............................. 151

BIBLIOGRAPHY .................................. 159

APPENDICES .................................... 174
    A. Correspondence .......................... 174
    B. Test of Problem-Solving Ability
       in Horticulture .......................... 177
    C. Student Questionnaire .................. 189
    D. SOE Scoring Instrument ................. 198
    E. Teacher Questionnaire ................. 201
    F. Scale for Scoring FFA Participation .... 206
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Frequency Distribution of Students by Program Emphasis</td>
<td>90</td>
</tr>
<tr>
<td>2. Frequency Distribution of Students by Program Emphasis by Grade Level and Sex</td>
<td>90</td>
</tr>
<tr>
<td>3. Summary Statistics for Problem-Solving Ability Scores by Program Emphasis and Grade Level</td>
<td>93</td>
</tr>
<tr>
<td>4. Percent Distribution of Problem-Solving Ability Scores by Program Emphasis and Grade Level</td>
<td>94</td>
</tr>
<tr>
<td>5. Level of Reasoning of Responses to Problem Situation &amp;</td>
<td>97</td>
</tr>
<tr>
<td>6. Summary Statistics for Achievement Scores by Program Emphasis and Grade Level</td>
<td>99</td>
</tr>
<tr>
<td>7. Percent Distribution of Achievement Scores by Program Emphasis and Grade Level</td>
<td>100</td>
</tr>
<tr>
<td>8. Summary Statistics for Academic Aptitude Scores by Program Emphasis and Grade Level</td>
<td>102</td>
</tr>
<tr>
<td>9. Percent Distribution of Academic Aptitude Scores by Program Emphasis and Grade Level</td>
<td>103</td>
</tr>
<tr>
<td>10. Item Means of Problem-Solving Teaching Behavior from Students' Ratings and Teachers' Self-Raings</td>
<td>106</td>
</tr>
<tr>
<td>11. Percent of Students Having or Not Having Out-of-School SOE Projects by Grade Level</td>
<td>109</td>
</tr>
</tbody>
</table>
12. Summary Statistics for SOE Involvement
    Scores by Program Emphasis and Grade Level... 109
13. Summary Statistics for FFA Participation
    Scores by School, Grade Level, and FFA
    Activity Level ........................................... 111
14. Intercorrelations of the Variables ............. 114
15. Regression of Problem-Solving Ability
    Scores on Sets of Independent Variables ........ 120
16. Regression of Achievement Scores on Sets of
    Independent Variables ................................. 120
17. Regression of Problem-Solving Ability Scores
    on Independent Variables (Hierarchical
    Analysis) ................................................... 125
18. Regression of Achievement Scores on Inde-
    pendent Variables (Hierarchical Analysis) .... 125
19. Summary Statistics for Canonical Analysis ... 130
20. Canonical Structure for the Two Sets of
    Variables (for the First Variate) ................. 132
CHAPTER 1
INTRODUCTION

Ability to solve problems is an essential quality for human survival. This dimension of cognitive ability has been investigated since the early days of research in cognitive psychology. The recent decades have seen a growing number of classroom research and application efforts concerning the development of the problem-solving ability in students.

In spite of a continued interest in learning about this complex construct and in applying it to classroom situations, the level of problem-solving competence of students in general has been less than satisfactory (Picus, Sachse, & Smith, 1983; McTighe & Schollenberger, 1985). Results from the National Assessment of Educational Progress (NAEP) in recent years have indicated that "...while performance in basic skills is improving, students showed uniformly poor performance at the application or problem solving level" (Picus et al, 1983). Findings in vocational education in particular are even more discouraging. Thinking deficiencies have been cited as a major weakness of high school graduates in the workplace (Champaign, 1985).
Apparently, teaching vocational students to master the technical content and skills is not enough. The growing demand from the workplace and the current emphasis on the basics in the high school curriculum have stimulated a stronger interest in teaching vocational students the ability to think critically and to apply knowledge effectively. Leading vocational educators have asserted that teaching thinking skills to vocational students may be best achieved through integration with the existing vocational education programs. Champaign (1985) has this to say:

Intuition aside, learning mathematics and science is not the only way for students to attain thinking skills. In fact, these subjects have certain characteristics that make them undesirable vehicles for learning thinking skills... Perhaps students in these categories (those unsuccessful in the basic courses) would learn the skills better if they were presented in the context of more practical, real-life situations such as those studied in vocational education (p. 5).

The Carl D. Perkins Vocational Education Act (1984) suggests that assessment of vocational programs should include a consideration of whether problem-solving and basic skills are used in a vocational setting (Rosenfeld, 1985). In The Unfinished Agenda: The Role of Vocational Education in the Secondary School, The National Commission on Secondary Vocational Education (1985) proposed that secondary vocational education courses should provide instruction and practices in the basics as well as problem-solving skills. These cognitive skills have been recognized as the
necessary competencies a high school graduate needs to enter and advance in a career (National Academy of Science, 1984).

Problem Solving and Vocational Agriculture

The emphasis on the ability to think and to apply knowledge in a problem-solving manner may be relatively new to vocational education in some other areas, but is certainly not new to vocational agriculture. History reveals that, rooted in the basic notion of Dewey's reflective thinking, problem solving as an approach to teaching was advocated and used in vocational agriculture since the early decades of the 1900s. Today, this approach remains strongly recommended by leading agricultural educators.

Rosenfeld (1984) contended that the problem-solving orientation of vocational agriculture is "...more like the approaches learned in basic engineering and science than those learned in typical vocational-training programs" (p.1). Rosenfeld stated that this characteristic approach to teaching, together with other program components, distinguishes vocational agriculture from other typical vocational education programs. The benefits of using the problem-solving approach may be summed up as "helping students learn how to learn and how to transfer" (Warmbrod, 1970), which will eventually lead to the development of
"intellectual autonomy" in students (Crunkilton, 1984).

Historically, the problem-solving approach in vocational agriculture was advocated on the basis of two important premises, namely, the farm background of students and supervised farming programs engaged in by students. Today, with agricultural and educational environments much different from the past, there is an issue of whether the problem-solving teaching approach is practical or worth the time and effort of the teacher. An important argument is that the advocacy of the problem-solving approach rests primarily on traditional wisdom without an adequate empirical basis to substantiate its merit (Moore & Moore, 1984).

Research in Problem Solving

The investigation of human problem solving has moved from the study of content-free and puzzle-like tasks in the early research in cognitive psychology to the study of domain/content-specific problems in a more natural setting (Hill, 1979; Picus et al., 1983; Stewart, 1983; Ronning, McCurdy, and Ballinger, 1984). The more recent trend has emerged from research which suggested that general (content-free) problem-solving skills may not be readily transferable to a specific content area (Hill, 1979; Champaign, 1984; Perkins, 1985). McPeck (1983) emphasized the contextual element of thinking. Arguing against de Bono's advocacy of an explicit course on thinking outside a
content area, McPeck wrote:

Where de Bono thinks that content subjects hinder important thinking, others (including myself) would argue that the disciplines actually constitute it. Whichever way one decides the question, it is important to recognize that nothing short of an entire philosophy of the curriculum is at issue. (p. 169).

Mathematical problem solving has dominated educational research in problem solving, even in the sciences. On the other hand, far less research is found in non-mathematical problem solving in such areas as the applied sciences and social studies. The reason could be that the less structured nature of problems in these content areas (Voss, Green, Post, & Pennar, 1983) does not allow for a clearcut assessment of problem-solving ability. However, with a growing conception that knowledge about problem solving needs to be widely based in specific content areas (McPeck, 1983; Picus et al, 1983), research in problem solving in areas other than mathematics has begun to receive more attention.

Research in non-mathematical problem solving at this time is still predominantly confined to the scientific areas. Inquiry about problem solving in vocational education is rare. In a recent review of knowledge in cognitive psychology related to problem solving applicable to vocational teaching, Laster (1985) noted a lack of research in vocational education. Laster pointed out that "...more
basic and applied research (in problem solving) is needed, especially for full-scale evaluations involving vocational teachers and students in real classrooms..." (p. 27).

Researchers in home economics education have begun to take a leading role in research in problem solving, beginning with the development of instruments to assess practical reasoning in home economics (Tartell, 1983; Manifold, 1984; Laster, Matthew. Manifold, 1985; Thomas, 1986). Meanwhile, agricultural education, the profession which seems to have acknowledged the significance of problem-solving instruction earliest, presently has almost ignored research in this area.

**Achievement and Problem Solving**

From a perspective about learning that underlies the content-specific notion of problem solving, problem solving may be viewed as a complex application of an accumulated body of knowledge. That is, problem solving is the process which extends beyond knowledge attainment and retention. From this perspective, a solid knowledge base is an essential contextual element of effective problem solving (Greeno, 1980; McPeck, 1983; Thomas, 1986).

In educational research, a knowledge base in a content area is usually represented by achievement measured in that area. Because of the significant role conceptual knowledge
plays in the process of problem solving, a strong relationship between achievement and problem-solving competence could be expected. The presumed relationship, however, should not lead to the use of achievement as a substitute for problem-solving ability. The substitution of achievement as the criterion measure of problem-solving instruction is an approach found in several studies. The two cognitive variables, problem-solving ability and achievement, could be more appropriately viewed as two related subdomains of cognitive outcomes of instruction. The two variables should be treated accordingly in problem-solving research.

**Problem Statement**

If problem-solving ability is an important outcome of instruction in vocational agriculture, research is much needed to provide empirical knowledge about this construct in an agricultural education context.

Ronning et al. (1984) maintained that a viable theory of problem-solving instruction must take into account three factors. These factors are problem-solving strategies, knowledge base, and individual differences. These three factors were considered in this study. Because of the unique characteristics of vocational agriculture, the problem-solving approach to teaching is interwoven with
other program components. Therefore, at this exploratory stage of research, a descriptive and correlational approach to the problem was desirable. Taking into consideration program variables as well as student characteristics, this research attempted to determine the relationships between the aforementioned independent variables and problem-solving ability of high school students enrolled in vocational horticulture programs.

Two major questions were framed to guide this research:

1. How can students in vocational horticulture be described in terms of their ability to solve problems in technical horticulture?

2. What relationships exist between the problem-solving ability of students and the following independent variables?

   (1) Academic aptitude of students
   (2) Extent to which teachers use problem-solving teaching behaviors
   (3) Degree of students' involvement in supervised occupational experience (SOE)
   (4) Degree of students' participation in the FFA
   (5) Grade level of students
   (6) Emphasis of the program in which students are enrolled.
The secondary focus of this research was on horticultural achievement, an indication of the knowledge base of students. Two additional research questions were investigated, which include achievement as the second dependent variable:

3. What relationships exist between achievement and the independent variables named above?

4. What relationships exist between the set of cognitive performance variables (problem-solving ability and achievement) and the set of predictor variables (the independent variables)?

**Significance of the Study**

The lack of a research base for the emphasis on problem solving in agricultural education has been evident in the literature. Only seven studies addressing problem solving in vocational agriculture were documented, five of which were conducted prior to the 1960s (Hamlin, 1922; Dawson, 1952; Thompson & Tom, 1954; Miller, 1955; Andrews, 1957; Peterson, 1969; Flowers, 1986).

Only the study conducted by Thompson and Tom (1954) attempted to investigate problem-solving performance of students as an expected outcome of instruction. Other studies used agricultural achievement as the criterion variable. One could surmise that a lack of appropriate
instruments to assess problem-solving ability in agriculture may have discouraged research in this area. From the researcher-developed test of problem-solving ability in horticulture, this study could pave ways for more rigorous efforts in the development and further improvement of the much needed assessment procedures.

This study is an effort to investigate the relationships between the problem-solving ability of students and certain program variables which are claimed to be the cornerstones of vocational agriculture. Furthermore, with both achievement and problem-solving ability included in the study, more useful information can be obtained than has been the case of past research which focused on only one of the two criterion measures.

The aim of this research was not to assess the impact of the problem-solving approach to teaching vocational agriculture. Therefore, causal interpretations were not expected. However, the merit of this correlational approach lies in the resulting broad-based knowledge which could contribute to a theoretical framework for future research.
Limitations of the Study

Since a purposive sampling procedure was used, this study was limited to selected vocational schools as well as selected students enrolled in vocational horticulture programs in Ohio. Subjects identified as special needs students (less academically abled) were not included in the analysis because problem-solving ability was assessed by means of a paper-pencil test.

Definitions

Significant terms have been defined in this study as follows:

Problem. A stimulus situation which is new and perplexing to an individual, and to which the individual does not have a ready answer. This study focused on problems in horticulture.

Problem-solving ability. An ability to use thinking skills to integrate existing knowledge in order to arrive at a solution to a confronting problem. Problem-solving ability in this study was measured by scores on the test of problem-solving ability in horticulture.
Problem-solving teaching behavior. What teachers do to engage students in problem-solving learning experiences in the classroom and in the school laboratory, measured by ratings of students and self-ratings of teachers.

Academic aptitude. The combination of native and acquired abilities that are needed for school learning; likelihood of success in mastering academic work (Mitchell, n.d.). In this study, academic aptitude refers to scores on the California Short Form Test of Academic Aptitude (SFTAA) 1970, level 5.

Achievement in horticulture. Overall knowledge and understanding of concepts and skills in horticulture related to the basic principles of plant and soil science, indicated by scores on the Ohio Horticulture Achievement Test 1986.

Degree of SOE involvement. The opportunity and extent to which students engage in supervised occupational experience programs in horticulture, as reflected by scores (on the SOE score sheet) given by the horticulture teachers.

Degree of FFA participation. Level of student participation in the FFA (a national organization for students in vocational agriculture), as indicated by scores on a checklist of FFA participation at the chapter, state, and national levels completed by students.
CHAPTER II
REVIEW OF LITERATURE

Inquiry in human problem solving has a long research tradition. The literature in this area is rich both in cognitive psychology and education. This chapter begins with a synthesis of concepts necessary for an understanding of problem solving in an educational context. Because the focus of this research is on content-specific problem solving, the relationship between achievement and problem-solving ability will be reviewed. Next, since the measurement of problem-solving ability is a vital component of this research, approaches and procedures in problem solving assessment will be examined. This section will be followed by a brief overview of impact research. Finally, factors related to problem-solving ability will be reviewed from past research.

**Problem Solving: An Overview of Concepts**

The term problem solving, as used in this research, refers to 1) a cognitive ability and its underlying process or skills, and 2) a teaching/learning approach aiming at
enhancing problem-solving ability in students. To create a conceptual foundation, concepts related to problem-solving ability—the main dependent variable of this study—will be explored first.

Problem Solving Defined

The basic Gestalt view of cognitive psychology perceives problem solving as "something apart from learning" (Rowe, 1985). But from an educational standpoint, problem solving is regarded as a special case of learning. Gagné (1985) maintained that "Problem solving is not simply a matter of applying previously learned rules.... It is a process that yields new learning" (p. 178). This view of problem solving is fundamental to applied research in education and to the belief that problem solving is a learnable mental ability (Lochhead & Clement, 1979; Whimbey, 1980; Picus et al., 1983; de Bono, 1984; Costa, 1985).

Like any dimension of cognitive ability, there has not been an agreed-upon definition of problem solving. Problem solving is sometimes used as a broad term encompassing a number of other concepts referring to related or synonymous cognitive abilities. But most often, problem solving is used interchangeably with reflective thinking, critical thinking, or inquiry, depending on the disciplinary orientation. All these terms appear in John Dewey's discussion of his concept of reflective thinking (Kitchener, 1983).
Dewey's original notion of reflective thinking has been regarded as the root of later thoughts in problem solving. The following function of reflective thought as seen by Dewey (1933) is basic to an understanding of what problem solving is all about:

The function of reflective thought is, therefore, to transform a situation in which there is experienced obscurity, doubt, conflict, disturbance of some sort, into a situation that is clear, coherent, settled, harmonious. (p. 100-101).

Problem solving is a high-level intellectual ability. Gagné (1966) described problem solving as:

...an inferred change in human ability that results in the acquisition of a generalizable rule which is novel to the individual, which cannot have been established by direct recall, and which can manifest itself in applicability to the solution of a class of problems. (p. 132).

Research dealing with novice-expert problem solving has suggested that two kinds of knowledge are essential components of meaningful problem solving. Greeno (1980) referred to these two types of knowledge as: 1) conceptual knowledge which is the knowledge base about the problem, and 2) procedural knowledge which is the knowledge of how to execute a problem solution.

The procedural knowledge is of major interest when the basic strategy of problem solving is discussed. Whereas there has been a controversial issue over whether problem solving strategy is content-free or content-specific, a
general consensus is that problem solving is a complex mental process involving at least a common core of basic thinking skills which are manifest in any problem situation (Presseisen, 1985).

Describing problem solving as a set of skills or stages has been attempted in many models. Basic to all, however, is a five-stage model derived from John Dewey’s writing (1910). Also known as the Chain of Reasoning, the five stages are:

1. A felt difficulty;
2. Its location and definition;
3. Suggestion of possible solution;
4. Development by reasoning of the bearings of the suggestion;
5. Further observation and experiment leading to its acceptance or rejection, that is, the conclusion of belief or disbelief.

The steps in this model may not appear in the same order and may occur simultaneously in the problem-solving process.

A number of other models have been developed since the time of Dewey. In cognitive psychology, Rowe (1985) reviewed 14 models which range in the number of stages from 3 to 10. In the recent decades, most problem-solving models have been generated from research in the information processing paradigm.

One of the most frequently cited models for problem solving in education has been Polya’s four-stage model (Picus et al., 1983). Picus et al. (1983) compared the
models by Dewey and Poya and found that the primary difference is "the art of understanding and defining the problem" (p. 10) which is particularly emphasized in the Dewey's model.

Educators in vocational agriculture have followed closely the notion of reflective thinking as the basis of a problem-solving approach to teaching. The original five-stage model has been modified to include 6 stages, as follows (Newcomb, McCracken, & Warmbod, 1986):

1. Experiencing a provocative situation;
2. Defining the problem;
3. Seeking data and information;
4. Formulating possible solutions;
5. Testing proposed solutions;
6. Evaluating the results.

Because of the several models available, researchers often find it difficult to select a model to serve their research purpose. For example, after reviewing several problem solving models, Chiappetta and Russel (1982) identified three steps which they found common among the models. These steps are: 1) the presentation of a problem, 2) the gathering of relevant information to solve the problem, and 3) the analysis of information and the production of a solution to the problem. They then used these three steps as a basis of their research.

The previously mentioned six-stage model (Newcomb et al., 1986) was used as a theoretical and conceptual basis in this study.
Problem Solving and Other Related Mental Constructs

Research has consistently pointed out that problem solving and intelligence are closely related (Rowe, 1985). In a contemporary view, intelligence is a broad mental entity that is alterable rather than fixed (Sternberg, 1985b); and, like problem solving, is learnable. Recent research from the information processing model has attempted to identify underlying processes and skills of intelligence. The most recent work, lead by Sternberg, implies that general problem solving skill is one major aspect of intelligence (Sternberg & Baron, 1985). Thus, under his Triarchic Theory of intelligence, Sternberg placed the components of an intelligence test into a problem solving framework, especially in the contextual part of the test (Quellmalz, 1984; Sternberg, 1985b).

The literature in problem solving is so profused with the term critical thinking that a review of basic concepts of problem solving will not be complete without discussing the relationship between these two constructs.

Kitchener (1983) commented that, from a philosophical perspective, critical thinking is often narrowly referred to as traditional logic or the hypothetico-deductive method. Such a perspective probably leads to a notion that critical thinking is a procedural component of problem solving (Kolesnik, 1964; Madison, 1971; de Bono, 1984).
Kolesnik (1984) maintained that "In the same way that critical thinking involves reasoning, so does problem solving include critical thinking" (p. 235).

In contrast, there are those who tend to hold that problem solving is in fact a contextual aspect of critical thinking (Eisner, 1965; Young, 1980; Perkins, 1985). From this perspective, critical thinking encompasses other related thinking abilities, and a test of critical thinking may contain a portion measuring problem solving (Doran, 1978). Contemporary views of critical thinking may be grouped in this category (Sternberg, 1985a; Ennis, 1986).

Still there are others who view critical thinking as synonymous or almost synonymous with problem solving (Kitchener, 1983; Quellmalz, 1985; Kneedler, 1985). Research in critical thinking based on this conception is a useful source of knowledge about problem solving.

In spite of these seemingly conflicting viewpoints, a common ground lies between problem solving and critical thinking. This research is based on an assumption that there exists an overlapping core of underlying cognitive skills or processes which are basic to and manifest in these two domains of mental ability. Probably, a simple distinction is that critical thinking is more general, whereas problem solving is more goal-specific. Clearly, a teaching approach aimed at improving one of these abilities
will most likely enhance the other. Intelligence, on the other hand, is a much broader mental entity which includes as its major components problem solving and critical thinking abilities. These three constructs are now perceived to be learnable.

The Nature of Problem

A problem is much more than a question. Phipps (1980) defined a problem as "a life situation which creates a difficulty or state of suspense, confusion, and doubt. A problem requires thinking in its solution and not merely the finding of facts in a book" (p.50).

Two types of problems are referred to in the problem solving literature: well-structured and ill-structured. The distinction between these two types of problems is well described by Sternberg (1985c):

Well-structured problems are those in which a set of steps leading to a solution can be explicitly and clearly laid out; Ill-structured problems are those that resist such specificity of the steps to solution. (p. 196)

The concept of ill-structured problem is relatively new in the literature. Greeno (1980) noted that "one aspect of an ill-structured problem solution is the need to add materials in the problem space and the absence of definitely specified goals" (p.20). Some researchers call this kind of problem a "real problem". Laster et al. (1985)
added another dimension to an ill-structured problem in their study of practical reasoning in everyday family life. In a practical problem solution, they maintained, "facts and value standards are brought together" to arrive at a rational decision (p.7).

Both types of problems exist in any content area. However, certain areas such as mathematics and physics are oriented more toward well-structured problems in which a set of algorithms can be followed. Problems in social sciences as well as in everyday life tend to be ill-structured.

Well-structured problems in their strict sense are of limited value to problem solving in agriculture. On the other end, true ill-structured problems are not relevant to this research in which problem solving is examined within the realm of vocational agriculture instruction. The following criteria have been set to define the kind of problems which are pertinent to the purpose of this study.

-The problems are based on meaningful and somewhat novel situations;

-The problems are based on general knowledge in horticulture which is directly related to the principles of plant and soil science;

-The problems and test items are structure-oriented, but are not rigid(well) structured;

-The problems and test items do not call for a decision based on a value judgement.
This researcher believes that focusing on problems of this nature is an essential first step toward investigations of ill-structured problem solving in agriculture.

Knowledge Base and Content-Specific Problem Solving

The belief that a knowledge component in the area of a specific problem is a prerequisite to solving the problem is shared by many researchers (Hill, 1979; Greeno, 1980; Simon, 1980; Larkin, 1980; Ross & Maynes, 1982; McPeck, 1983; Mayer, 1983; Stewart, 1983; Ronning et al., 1984; Gagne, 1985). A knowledge base about the problem is required both to understand the problem and to solve it; the more extensive and integrated that knowledge base is, the more effective problem solving will be (Greeno, 1980). This concept is an underlying assumption of content-specific problem solving.

Greeno (1980) emphasized that, in meaningful problem solving, an interrelationship exists between the conceptual knowledge possessed by problem solvers and their knowledge of the procedures they use to solve problems. There is evidence to suggest that "skill in (problem-solving) processes alone, without conceptual knowledge about elements in situations or states of affairs is insufficient for problem solving" (Thomas, 1986, p. 28). From a study in genetic problem solving, Stewart (1983) recommended that
teachers need to be more explicit in helping students see how different concepts are related. This emphasis is particularly important if transfer of problem-solving skills is to be achieved. In vocational agriculture, this concept applies equally well. Drawbaugh and Hull (1971) suggested that in the transfer of knowledge, which is an essential element in problem solving, "Perceiving similarity between the new situation and the old implies a certain degree of knowledge and awareness of what to look for in a new situation" (p. 55). If this perception is wrong, a negative transfer may occur, such as "using diary qualifications to judge beef cattle" (p. 55). Problem solving is thus clearly a result of cumulative knowledge and experiences in a content area basic to the problem.

A well-known study by Bloom and Broder in 1950 (cited in Picus et al., 1983) was probably the first in educational research to document the significant role of content knowledge in problem solving. They observed that, "It became apparent that methods of problem solving by themselves could not serve as a substitute for basic knowledge of the subject matter" (cited in Picus et al., 1983, p. 18). The more recent convincing evidence came out of the research in expert-novice problem solving. One such study was reported in 1980 by Larkin et al. (cited in Good, 1984) in physics problem solving. The researchers found that the physics
experts approached the problems very differently from the novices who had taken only one or two courses in college physics. In vocational education, Manifold (1984) reported that decision-making skills and skill stages of students were significantly different when solving practical home economics problems based on different content areas.

The notion that content knowledge is closely linked to successful problem solving probably lead in many studies to the use of achievement as an indicator of effective teaching of problem solving. Yet, research has not investigated achievement and problem solving ability as two related cognitive outcomes.

Teaching Problem Solving

Direct teaching of problem solving strategies is believed to help students use their mental abilities more effectively in dealing with problems. Basic approaches to the teaching of problem solving are briefly reviewed in this section, with an emphasis on description of the approach used in vocational agriculture.
Approaches in Teaching Problem Solving

Problem solving is taught primarily with two approaches. First, based on the content-free notion of problem solving, the teaching of this skill is through a separate course or program which aims explicitly at improving thinking skills in general (Lochhead, 1981; de Bono, 1983). Generally known as cognitive process or heuristic instruction (Nickerson, 1984), this approach assumes that there are certain fundamental processes or skills which can be trained in order for the student to become an effective thinker, regardless of the content. Mathematical problem solving, although taught in existing mathematics courses, may also be grouped in this category.

A second approach to the teaching of problem solving follows the content-specific notion which has come out most clearly from the expert-novice research implying that specialized training is needed within specific subject domains (Picus et al., 1983; Ronning et al., 1984). Picus et al. (1983) concluded from a review of problem solving research in recent years that "Problem solving objectives are best taught through integration with existing curriculum" (p.1). With this growing trend of belief, problem solving in areas other than mathematics has begun to receive more attention in applications research as well as in classroom instruction.
Problem-Solving Approach to Teaching Vocational Agriculture

Vocational agriculture in the United States has enjoyed a successful history. Much of its success is attributed to four factors (Dickerson, 1984; Rosenfeld, 1984). First is the supervised occupational experience program (SOEP, also known in the past as the supervised farming program). Second is the curriculum design and approach emphasizing problem solving and rational thinking. Third is the students' organization—the FFA. Fourth is well prepared teachers with knowledge and skills to integrate the first three factors into teaching. Rosenfeld (1984) maintained that, unlike other areas of vocational education, "The strategy behind vocational agriculture is based on a production model in which workers make independent decisions and are encouraged to take initiatives" (p.1). Problem-solving teaching, which has been adopted as the central approach to teaching vocational agriculture, was cited as a key underlying element of this excellent model.

Problem solving in vocational agriculture is based on a sound philosophical foundation, dating back to its early days. W. W. Charters, whose work appeared about the time of Dewey's writings, wrote in one of his early books Teaching the Common Branches (1917) that the intrinsic function of agricultural education was to give information
about farm problems and their solutions. Therefore, courses of study in agriculture must be flexible and closely related to local necessities and problems. Charters blended Dewey's thoughts into the teaching of agriculture.

Since then, problem solving as a teaching approach has evolved along with other components of vocational agriculture, and has become almost synonymous with the program itself. During the 1950s, one of the criteria, recommended nationally, for a successful vocational agriculture program emphasized teaching problem solving on the basis of farming programs of the student (Andrews, 1957).

Today, problem solving has continued to receive support from teacher educators in agriculture. In 1977, The American Association of Teacher Educators in Agriculture studied standards of teacher education programs in agriculture/agribusiness. Findings indicated that of the teacher education programs in agriculture for which there were responses, about 99% supported the standard with regard to the use of the problem solving approach to teaching vocational agriculture. (Crunkilton & Hemp, 1982). High support of this teaching approach is also evidenced in current texts in agricultural education (Drawbaugh & Hull, 1971; Phipps, 1980; Binkley & Tullock, 1981; Crunkilton & Krebs, 1982; Newcomb, McCracken, & Warmbord, 1986). In spite of this overwhelmingly support from teacher educators, little
evidence has been reported on the extent to which agriculture teachers themselves use this approach in their teaching.

Some specific courses on thinking treat thinking skills (for example, critical thinking) as discrete skills which can be taught independently of each other (Kitchener, 1983). But in vocational agriculture, as in the other scientific subject areas, problem solving is introduced to students as a chain of reasoning process. Moreover, on the basis of a learning principle that "directed learning is more effective learning", the problem solving approach in vocational agriculture is oriented toward a directive teaching strategy (Warmbrod, 1970, p. 80). Warmbrod recommended that to teach by way of problem solving "...teachers must present clues to direct students toward successful discovery and applications of concepts and principles" (p. 80).

At The Ohio State University, teachers of vocational agriculture are recommended a six-step problem-solving teaching approach. Newcomb et al. (1986) compared this teaching process to Dewey's reflective thinking process (the learning process), as presented on the next page.
Learning Process  Problem-Solving Approach to Teaching

1. Experiencing a provocative situation; 1. Interest approach;

2. Defining the problem; 2. Group objectives;

3. Seeking data and information; 3. Questions to be answered;

4. Formulating possible solutions; 4. Problem solution;

5. Testing proposed solutions; 5. Testing solutions through application;


(Newcomb et al., 1986, p. 68).

Past research has suggested that successful problem-solving instruction requires: 1) attention to student motivation, 2) content knowledge, and 3) problem-solving skills and strategies (Picus et al., 1983, p. 5). The above procedure for teaching problem solving in vocational agriculture has been intended to meet all these factors. Each step of the teaching process is supported by principles of learning which are grounded in research on the psychology of learning.
Probably the most significant phase of problem-solving teaching is the testing of solutions through various means of application. Newcomb et al. (1986) called this step "the premier doing stage of the process" (p. 72). In vocational agriculture, applications are not limited to class exercises and laboratory activities; but they may very well occur through supervised occupational experience and FFA activities which are special components of the program. This interweaving of problem solving teaching with these two program components makes the problem solving approach in vocational agriculture unique as it allows individuals to solve real agricultural problems relevant to their needs.

On the other hand, the interrelationships among the program components mean that change in one component will most likely affect the others. In recent years, a concern has been raised about whether the problem-solving approach can function well today when changes have already begun to affect all program components (Dickerson, 1984; Moore & Moore, 1984). These factors include changes in the background of students as well as teachers, changes in the vocational agriculture curriculum, and changes in the agriculture industry. These changes, coupled with the complexity and the time-demanding aspect of the problem-solving teaching as perceived by many teachers, may have affected
the adoption of problem solving as the central teaching strategy (Moore & Moore, 1984).

Assessing Problem-Solving Ability

Related to the question of whether problem solving can be taught is the question of whether problem-solving ability can be measured and how.

Assessing any mental construct is basically difficult and involves a serious concern of validity because the test developer is forced to make inferences about inner mental processes based on limited testing procedures. The difficulty is compounded by "having to use quantifiable measures, and thus reducing thinking to a forced selection of multiple choice items, having to express mental functioning in a paper-and-pencil format, and trying to standardize creative insight..." (Costa, 1985, p.169). Above all, the confusion over the operational definition of thinking skills may also cause the test developer to focus on inappropriate behaviors as indicators of the thinking skills which are intended to be measured (Beyer, 1984).

This research employed a researcher-developed test of problem-solving ability. Because of the complexity involved in the procedure of test development, some approaches to test development are described in this section.
Testing Procedures

Ideally, several assessment procedures should be employed to achieve a valid evaluation of problem-solving ability. Some of the procedures used in problem solving research include paper-pencil tests, hands on tasks, clinical interview, and protocol analysis (the thinking-aloud technique). Of these procedures, the paper-pencil test is still recognized as the most practical and cost-effective technique when tests have to be administered to a large group of subjects.

Approaches in Test Development

Theories or models of thinking skills serve as a good foundation for test development. Sternberg and Baron (1985) maintained that, without a theoretical basis, there are potential shortcomings such as: 1) no psychological basis for claiming that the test measures thinking skills, and 2) no criteria against which to validate the test.

When a problem-solving model is employed, the test developer typically wants to measure discrete steps according to the model. In such a case, especially if the hierarchy of steps is an underlying assumption of the model, the test developer often confronts the problem of low
coefficients of agreement among judges in the process of assessing the validity of the test. The literature related to Bloom's Taxonomy of Cognitive Domain exemplifies well this potential problem (Furst, 1981; Fain & Bader, 1983). There is also a potential trade-off between validity and reliability of the test. For this research, overall problem-solving ability, not specific problem-solving skills, was measured.

Regardless of what problem-solving model is followed, some basic rules apply in the measurement of problem solving. First, the test must be situation-dependent or context-dependent. Test items of this nature begin with a stem introducing a situation or problem within a given content area, followed by relevant questions. Nitko (1983) listed the following advantages of context-dependent tests in measuring higher-order thinking skills (p. 218):

1. They provide an opportunity to test examinees on materials that are relatively close to the context toward which learning is directed;

2. They provide the same context for all persons;

3. The introductory materials (the situations or problems) tend to lessen the burden of memorizing, and sometime moderate the effects of prior experiences with the content.

The second rule for testing problem-solving ability is concerned with measuring the transfer of thinking. The given situation must not be the exact replica of problems
solved in class. The materials contained in the situation must be new or novel to the student (Bloom, 1956; Nitko, 1983; Gabel, Sherwood, & Enochs, 1984; Gagne, 1985; Quellmalz, 1985; Sternberg & Baron, 1985). However, in a meaningful assessment, Sternberg and Baron (1985) cautioned that "...the problems to which the processes are applied are relatively, but not wholly, novel" (p.43). In addition, Frederiksen and Ward (1978) suggested that, to allow for creative thinking, tests should be "sufficiently complex to represent problem situations confronted in reality; yet sufficiently simple to allow for the control and standardization required of well-designed psychometric procedures" (p. 1).

There are some disadvantages of situation-dependent tests that need attention. Apart from being difficult to construct, the questions may demand certain additional abilities such as reading comprehension, resulting in a test "going beyond the major focus toward which the questions are directed." (Nitko, 1983, p.218).

Typically, tests of structured problems contain primarily multiple-choice items aimed at measuring a particular skill component of the underlying problem-solving model. Open-ended or essay-type questions are found more common in ill-structured problems. However, in order to elicit reasons underlying the chosen choice, open-ended questions are
also found useful to supplement multiple-choice items (Dreyfus & Jungwirth, 1980; Quellmalz, 1984).

Published Tests of Thinking Ability

Defining problem solving broadly, Sachse (1981) reviewed 13 published tests of problem solving. Included in the review were tests measuring different aspects of thinking ability such as reasoning and critical thinking. In his latest review of critical thinking tests, Ennis (1986) came up with 8 comprehensive tests measuring overall critical thinking.

It is apparent from these two reviews that most if not all of the published tests measure general (content-free) thinking skills. Content-free tests have shortcomings in measuring thinking skills within content areas (Ross & Maynes, 1982). Furthermore, being general, these tests are likely to have a higher degree of assumption-bias (Ennis, 1986) than their content-specific counterparts. However, being produced commercially, these tests offer formats and procedures which are illustrative for the researchers who wish to develop content-specific test.

The two most widely used published tests are the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980),
and the Cornell Critical Thinking Test (Ennis, Millman, & Tomko, 1985). Both tests have been continuously tested and improved. Both are considered aspect-specific tests, that is, they measure specific skills of thinking ability (Ennis, 1986). The Watson-Glaser test is aimed at grade 9 to adulthood. The test consists of several situations, each followed by a set of items measuring different aspects of critical thinking. Because the test demands a relatively high level of reading skill, it is not appropriate for use with lower ability high school students.

Level X of the Cornell test, on the other hand, is aimed for average students from grades 4 to 14. The test is written in simple, everyday language. The situations and test items, in a sequential short story, seem to be more appealing to students than the Watson-Glaser test. Most multiple-choice items are framed in a comparative question format rather than the absolute format. For example, on the part "Judging Credibility of Observational Reports", questions are in the following three-choice format:

If you think the first statement is more believable,
Mark A on your answer sheet

If you think the second statement is more believable,
mark B

If you think the two are equally believable, mark C
Such a format allows for the assessment of comparative judgement with fewer test items than the ordinary absolute format. The comparative format was adapted for the test of problem-solving ability in horticulture in this research.

Apart from the shortcomings cited earlier, the Watson-Glaser and the Cornell tests have been criticized on a number of grounds. Modjeski(1982) reported that both instruments contain serious shortcomings according to the validity and reliability criteria of the 1974 American Psychological Association's Standards for Educational and Psychological Tests. The lack of construct validity was cited as a major weakness of the two aspect-specific tests.

**Researcher-Developed Tests**

Tests developed by researchers in content-specific research have not been adequate in meeting demands of different research purposes. Shaw(1983) pointed out that the lack of an "easily administered testing instrument which is designed to assess all levels of (problem solving) process skills" is a major reason why content-specific research has progressed slowly (p. 615). More often than not, researchers in this line of investigation have to develop their own problem-solving test.
Research in scientific problem solving provides a good source of literature on tests of content-specific and structure-oriented problem solving. Studies in process-oriented science, in particular, indicate that skills measured in some science-process tests are somewhat comparable to those in the Dewey model of reflective thinking (Doran, 1978).

Ross and Maynes (1983a) maintained that to have practical utility measurement devices must be "integrally related to instructional framework" (p. 63). Therefore, they placed particular emphasis on the content validity of the instruments in their research (Ross & Maynes, 1983a, 1983b). In the process of test development, no test items was pilot tested unless there was unanimous agreement on a set criteria from a panel of representative teachers. In addition, qualitative analysis of interviews with a sample of students also provided some assessment of validity with regard to student thinking process in the science content. Construct validity was also explored to confirm the theoretical expectations of the underlying thinking model.

In one study, Ross and Maynes (1983a) constructed tests of experimental problem-solving ability in secondary school science. Each test contained a situation, a multiple-choice question, and an open-ended question. The performance levels were first established and a learning hierarchy
for the selected skills of experimental problem solving were developed as criteria for scoring. The reliability of the tests was reportedly low, probably due to a very small number of test items. The researchers reported that a test of general transfer was also developed and used in the research, but the results were not reported because "student scores were so low on these items that a floor effect concealed the presence or absence of any effect from the instructional program" (p. 548). The open-ended questions were found to be more sensitive than the multiple-choice counterparts in measuring the experimental problem solving-ability of the students.

Examples of problem-solving tests in agricultural education research have been rare. Only two studies in the 1950s were reported to use a problem-solving test with vocational agriculture students (Thompson & Tom 1954; Miller, 1955). The test developed by Miller (1955) was concerned only with assessing the knowledge of students about the problem-solving process. As such, it was not relevant for this research.

In order to compare the impact of problem-solving teaching and traditional patterns of teaching vocational agriculture, Thompson and Tom (1954) developed a test on Solving Diary Problems to be used as one criterion of effectiveness of instruction. The test was designed to
measure the ability of students to solve farm managerial problems. Based on an assumption that a significant correlation exists between one's ability to make wise decisions and the ability to solve farm problems, the researchers specifically attempted to assess the ability to make wise decisions as an indicator for problem solving ability.

For each multiple-choice item, Thompson and Tom provided a situation in which all factual information necessary to make decisions was given. The student needed only to use that information to choose a solution to that problem. In addition, students were also asked to choose a particular reason for the chosen decision. The researchers believed that asking for reasons would decrease a tendency for the student to guess and would thus increase the reliability and validity of the test. The reasons given by students, however, were not used in scoring.

Their test of 13 problem situations involving 34 responses required 65 minutes for students to complete. The test had a Spearman-Brown coefficient of 0.84 and a difficulty index of 69.51%. Apart from the use of a panel of experts, validity was also assessed by three teachers who administered the pilot test to their students. The teachers were asked to assign grades to their students on the basis of their ability to solve diary problems faced by the average diary person. However, the "validity" coefficient between
test scores and teacher grades was found to be very low. As a point of interest, the test situations contain largely numerical information or statistical records. Consequently, the test measures mathematical problem solving to some extent.

In conclusion, a point made earlier needs to be reiterated. Assessing problem-solving ability through a paper-pencil test is particularly difficult when specific skills of problem solving are also measured. The selected examples from related research have provided some direction on how assessment of problem-solving ability can be achieved. The only cited example from research in agricultural education is also insightful regarding problems and concerns a test developer needs to be aware of when measuring problem solving ability in agriculture.

**Impact Research on Problem Solving and Achievement**

Although the main focus of this study is not to assess the impact of problem-solving instruction, this section presents a brief overview of impact research. The overview will set a stage for the later review on selected variables related to problem-solving ability and achievement of students.

As described earlier, problem solving is basically taught from two approaches based on either the content-free
or the content-specific framework. At this time, research has not provided enough evidence to conclude which approach is superior in helping students improve their problem-solving ability. Research from both approaches is reviewed here with more emphasis given to the content-specific studies.

The literature suggests that explicit courses or programs which include the teaching of problem solving appear to have, at best, face validity in terms of their effectiveness. These courses or programs are seldom evaluated formally, and thus evidence regarding their effectiveness is sparse (McPeck, 1983; Nickerson, 1984).

Among the programs which have been evaluated, assessment is typically based on tests of general problem-solving ability or, more often, of general mental ability (Nickerson, 1984). Nickerson (1984) further observed that "quantitative data on a few programs indicate that they produce modest improvements in performance on such tests" (p. 36).

Evaluations of content specific problem-solving courses tend to be more rigorous, especially in scientific areas. A few studies are reviewed to give a general picture of the impact of such efforts.

Ronning and McCurdy (1982) observed that many junior high school students were unable to use process skills necessary to attack problems in the sciences. Using a
researcher-developed instrument. Shaw (1983) found that sixth-grade students who had the process-oriented curriculum scored significantly higher on the test than those who received a science program emphasizing content primarily. He concluded that "...if a teacher is interested in teaching problem-solving processes in sciences, the teacher should develop or select a curriculum that has a strong and constant emphasis on the processess involved in problem solving" (p.622).

Laboratory is an important part for the practice of problem solving in an experiment by Chiappetta and Russell (1982). After reviewing several problem-solving models, the researchers came up with a three-step model which included: 1) the presentation of a problem, 2) the gathering of relevant information to solve the problem, and 3) the analysis of information and the production of a solution to the problem. These three steps were used as the basis for the laboratory activities but not for measuring the effectiveness of the course. Rather, an achievement test designed to measure the knowledge and application levels of Bloom's Taxonomy of Cognitive Domain was used as the criterion. Logical thinking, as well as the treatment, were found to account for the significant variance in the achievement scores.
Guyton (1984) compared a cognitive process method to a traditional method of nursing instruction on the efficiency, proficiency, and competency of clinical problem solving. The focus was on the way students used information in solving complex, ambiguous, and realistic problems. The formal reasoning ability of students and the amount of additional clinical experience were used as covariates. No significant difference was found between the two methods. The researcher concluded that the lack of a significant finding may reflect the limited teaching time or a lack of sensitivity of the problem-solving instrument.

Outcomes other than content-specific problem-solving ability and achievement have been investigated in some studies. For example, Story and Brown (1977) used critical thinking as a measure of the effectiveness of science-process instruction in high school biological science. They reported significant gains in students' ability to employ critical thinking after ten weeks of instruction. Details of the study cannot be located to review how the researcher defined critical thinking.

As frequently pointed out in this review of literature, research on problem solving in agricultural education has been rare. Only several studies have been located and reviewed here.
In his Master's thesis entitled "An Adaptation of the Problem Method to High School Animal Husbandry", Hamlin (1922) compared four different types of problems in teaching animal husbandry. The four types were: problems based on remote need, hypothetical problems, problems from the home farm, and current and miscellaneous problems from various sources. One finding was that, "The project with its attendant problems was found to be the best nucleus for instruction" (p. 80). The purpose of the research was on applications of the problem solving approach, not on comparing this approach with others.

Dawson (1952, cited in Andrews, 1957) compared lecture and problem-solving methods for teaching agronomy. The two methods were found to be equally satisfactory. However, since the subjects were college students, the results may be limited in generalization to high school vocational agriculture students.

Two other experimental studies were directly related to the teaching of problem solving in vocational agriculture. In 1954, Thompson and Tom compared the experimental (problem solving) pattern to the conventional pattern of teaching vocational agriculture. A pattern of teaching was defined broadly as "a series of broad areas of activities which a teacher systematically follows as he guides his pupils through a complete unit of instruction" (p. 5). The
two patterns of teaching were described in a comparative manner in the report. The effectiveness of the pattern of teaching was assessed by three instruments: 1) an achievement test called a Diary Enterprise Test, 2) a Test in Solving Diary Problems, and 3) the Myster's Attitude Toward Farming Scale. Using analysis of covariance with mental and reading abilities as covariates, no difference was found between the two patterns of teaching in either the ability to solve farm problems or in attitude toward farming. Interestingly, however, the problem solving pattern of teaching was significantly better only in gaining facts. Later, Andrews (1957) reviewed this study and cautioned about its validity as a result of the incomplete randomization and the method of treating the data.

In 1955, Miller followed a similar research approach used by Thompson and Tom. Three criteria for effectiveness used in the study were: 1) scores on a Fertility Test (an achievement test), 2) scores on a test on the Process of Soil Fertility Problems, and 3) the quality of student farm plans. The findings indicated that the problem-solving approach was significantly more effective than the conventional pattern on the quality of student farm plans but not on other criteria.

Andrews (1957) approached the study of problem-solving teaching in a more naturalistic way by using an ex post
facto research design. He first developed an opinionnaire on "Problem-Oriented Teaching in Vocational Agriculture" to determine the "most" and the "least" project problem-oriented teachers. The problem method was defined broadly as a method which "...includes any of the several teaching procedures, or a combination of them, in which the problems provided by the projects or supervised farm programs of the vocational agriculture pupils are centered" (p. 35). Student achievement and attitude, but not problem-solving ability, were used as the criterion measures. Findings indicated no significant difference between the two groups of students on the criterion measures. Andrews recommended two significant points for further research, however. He indicated a need for clarification of the meaning of problem-oriented teaching. He also suggested that a study should be done on how much teachers know about problem-oriented teaching.

By the 1960s, the problem-solving approach to teaching vocational agriculture had been referred to by some as a traditional method, and a new direction in teaching was sought. Peterson, in his study in 1969 concluded from a review of literature that vocational agriculture at that time tended to focus only on the problem-solving aspect of learning. He suggested that the restructuring of agriculture subject matter for high school students should receive attention in research.
Peterson (1969) compared the traditional approach (problem-solving) to the principles approach to teaching. He perceived the two approaches to differ primarily on the approach to organizing the content in agriculture. Peterson followed a quasi-experimental research design, using a pre-test of achievement, I.Q., farm background, and quality of supervised farming program to test for group equivalence. The principles approach was found to be significantly better in terms of student achievement in agriculture.

Only three recent studies in agricultural education were found which are related to problem solving. Kirts (1981) investigated the problem-solving approach and its impact on questioning strategies of student teachers in vocational agriculture. Later Falakdine (1984) studied mathematical problem solving in agricultural mechanics of vocational agriculture students. Neither of the two studies are concerned with agriculture problem-solving ability. Most recently, Flowers (1986, in Moss, 1986) investigated the effectiveness of a problem-solving approach to teaching. Achievement, not problem-solving ability, was used as the criterion measure of effectiveness. Details from the report were not available for review.

In conclusion, research in scientific problem solving has provided some evidence in support of the teaching of problem solving in existing content-oriented courses. On
the other hand, the literature on problem-solving research in agricultural education has been very limited in providing supportive evidence.

Variables Related to Problem-Solving Ability and Achievement

The six independent variables in this study are examined in this section in relation to problem-solving ability and achievement. Academic aptitude is the selected variable pertaining to individual differences. The underlying assumption of the problem-solving approach to teaching vocational agriculture is that problem-solving ability of students is, in part, a result of what the program components offer to students, and the extent to which the teachers as well as students attempt to maximize the benefit of the program. Accordingly, the 5 other variables directly related to vocational agriculture were included in this study as the program variables.

Academic Aptitude

Intellectual ability variables have commonly been considered as extraneous variables in impact research related to any dimension of cognitive ability. In problem-solving research, Chiappetta and Russel (1982) found that the intellectual ability variable appeared to have more
influence on achievement than the problem-solving approach to teaching. Among the intellectual ability variables, intelligence has been included most often in the research. The abundant literature indicates a strong relationship between intelligence and problem-solving ability (Rowe, 1985).

Closely related to the concept of intelligence is the concept of academic aptitude (Mehrens, 1982). Essentially, an aptitude is the capacity to learn (Walsh & Betz, 1985). Academic aptitude has also been referred to as scholastic aptitude, school learning ability, and academic potential (Mitchell, n.d.). Moreover, the terms academic aptitude and scholastic aptitude have been commonly used as alternative labels for what is measured by many tests of intelligence (Walsh & Betz, 1985).

Positive relationship between academic aptitude and achievement is well documented (Farmley, 1980; Johnson & Butts, 1983; Ennis, Millman, & Tomko, 1985). Past research has also established a strong relationship between academic aptitude and problem-solving ability. Early in 1950, Bloom & Broder (cited in Whimbey, 1984) reported that the habitual problem-solving style of low-aptitude students was notably different from the style of high-aptitude students. Recent studies supported this finding (Whimbey, 1984). Falls (1985) suggested that further study be conducted to
analyze individual differences in aptitude with problem solving as it takes place in natural settings. Research on problem solving in agricultural education needs also to consider this variable.

**Problem-Solving Teaching Behavior**

In a discussion of the content-free versus the content-specific approach for teaching problem solving, Ross and Maynes (1982) argued that teachers should not be forced to choose either end of the dichotomy. Ross and Maynes wrote:

> What is the value of teaching content if it is not used by students to solve problems? And how can problems be solved if students do not have the essential subject-matter based information? The real choice is about the balance between the two approaches, not which is preferable. (p. 1).

Thus teaching problem solving within a subject demands, first of all, that teachers balance the teaching of content and the teaching of problem-solving skills within the limited time available. To use a problem-solving approach well, teachers not only need to plan an area of instruction, they also need to think about how to actually solve the problems they plan to teach students (Newcomb et al., 1986). Teacher expertise in how to teach problem-solving skills is also a very important determinant of effective teaching; yet few teachers have such expertise (Ross and Maynes, 1982). In vocational agriculture, it has been argued that problem solving is a highly sophisticated
teaching procedure requiring a skillful teacher. As Moore and Moore (1984) put it, "Watching a master teacher use the problem-solving approach to teaching is like watching an artist at work" (p. 7).

Problem solving is an approach to teaching. Educators have agreed that there are direct, systematic instructional techniques that the teacher may integrate to involve students in deliberative reflective thinking (Warmbrod, 1970; Beyer, 1984). Among these techniques, discussion is a major means by which the teacher directs students through a problem-solving process (Kirtz, 1981). Through discussion, teachers use lead questions to elicit more than memory-type responses. The aim of problem solving is not just to answer questions, and problem solving should not be equated with question-answering (Warmbrod, 1969). However, all levels of questions are essential parts of this teaching procedure (Kirtz, 1981). Apart from using appropriate questions in the teaching process, the way the teacher uses questions in assignments and tests may also indicate the extent to which the teacher is aware of preparing students to solve problems. Past research has revealed that the nature of a test may condition the way students acquire and retain knowledge (Milton, 1982). Further, as far as teaching vocational agriculture is concerned, the role of teachers in fostering problem-solving ability in students extends beyond the in-class and laboratory activities.
Good teaching of problem solving starts with a positive attitude of the teachers toward the problem-solving approach. However, research has shown that positive attitude alone is not a good indicator that the teacher uses this approach in teaching. Drum and Wells (1984) found that teachers from various subject areas had a positive attitude toward problem-solving teaching, but only a few of the teachers were emphasizing it in their classrooms.

Therefore, the extent to which teachers use a problem-solving approach is an important factor to consider when problem-solving ability of students is assessed. To determine the extent of use is difficult, however. Unless an experimental design or the case approach is employed, the extent of use can only be approximated. The literature reveals that two past studies in agricultural education addressed this concern. Andrews (1957) used the opinions of teachers toward the problem-solving approach in order to group teachers into the most and the least oriented toward problem-solving teaching. Evidently, his method assumed that there was a link between teacher opinions and teacher behaviors. In 1981, Kirts studied the questioning strategy of vocational agricultural teachers as an expected outcome of a problem-solving approach used in teacher preparation. The extent of use was measured in terms of 1) level of classroom experience using problem-solving approach (in
week intervals), and 2) proficiency in using the problem-solving approach obtained from observational instruments and videotapes of student teaching performance. Both of these two methods were not feasible for this research since the study was not set in a controlled situation and time constraint does not allow for a thorough analysis of teaching behaviors. Moreover, these methods focused only on classroom teaching. Essentially, the extent to which teachers use problem-solving teaching behaviors must be approximated in this research by other means. The most promising and practical procedure for this study seems to be the use of the teachers’ self-ratings along with students’ ratings on the extent to which they were involved in problem-solving activities in the classroom and the school laboratory.

Program Components

Students must be taught to transfer knowledge about problem-solving strategies. From a review of problem-solving research, Picus et al. (1983) concluded that "transfer and use of a problem-solving strategy appears more likely when problems used in instruction are like those that will be routinely encountered later" (p.5). To teach for transfer, the teacher must provide opportunities for students to practice solving problems which are realistic, yet not the exact replica of what are provided in
Supervised occupation experience (SOE) in agriculture is a major part of vocational agriculture which allows students to practice transfer of agricultural problem solving in a realistic situation. Phipps (1980) provided a good description of SOE which reflects its major aspects:

Supervised Occupational Experience in Agriculture consists of all the practical agricultural activities of educational value conducted by students outside class or on school-released time for which systematic instruction and supervision are provided by their teachers, parents, employers, or others. (p. 199).

The project-oriented nature of SOE lends itself well to the teaching and learning of problem-solving skills. Ross and Maynes (1982) believed that "Problem-solving skills are most visible when students are asked to do a project because doing a project requires that the student use all the problem-solving skills" (p. 5).

With the changes in agricultural and educational environments, SOE has undergone some modifications in recent years. In certain states such as Ohio, SOE includes in-school laboratory experience as an addition or an alternative to ownership, placement or cooperative programs (Bar- rick, 1984; Sutphin, 1984). In fact, in-school laboratory and improvement projects may have become the major types of experience for SOE in horticulture.
Evidence on the educational benefits of SOE has begun to accumulate in the recent literature. Perception studies have revealed that the benefits of SOE are realized by students and their parents (Williams, 1979; Rawls, 1980). Benefits in learning achievement have also been documented. Neavil (1973) found a significant and positive relationship between the number of SOE experiences and agricultural achievement of tenth-grade students. Morton and McCracken (1979) concluded that, if extraneous effects of scholastic aptitude, opportunity to engage in SOE, number of years in vocational agriculture and number of instructor project visits are statistically controlled, higher quality SOE programs are likely to result in higher learning achievement in technical agriculture. More recently, Long and Israelson (1983) reported that students with supervised occupational experience obtained higher achievement scores than those who did not have the experience. Up to the present, research has not yet pinpointed the relationship between SOE and problem-solving ability.

One major concern in SOE research is how to obtain a valid indicator of SOE quality. McMillion and Auville (1976) were the first to come up with a system of calculating SOE quality based on income and productive man work units (PMWU). An equation was devised to transform the SOE data from student records into numerical scores. Later
studies (Morton & McCracken, 1979; Arrington, 1981; Harris, 1983; and Zurbrick, 1984) adapted this procedure in their research. These studies are oriented toward production agriculture.

Lee (1984) pointed out that quality of SOE should not be determined solely on the basis of income and scope. In agreement to this observation, Makin (1986) searched for a more appropriate measure of SOE quality in horticulture. He used a method of "paired comparison". Using their own criteria, supervisors were asked to compare pairs of teachers on the quality of SOE program supervised by each teacher. Apart from a possibility of being subjective, this procedure requires much time on the part of the rater in making judgements over numerous pairs of comparison.

As far as research in problem solving is concerned, a good indicator of student involvement in SOE is needed which also reflects the extent to which SOE provides experiences to enhance the development of problem-solving skills. Research in SOE has consistently pointed out that the teacher has the greatest influence on SOE quality (Case & Stewart, 1985). In addition, it is the assumed responsibility of the teachers to evaluate student learning from all aspects of the program (Barrick, 1983). Therefore, the teachers may be in the best position to evaluate students' involvement in SOE. Newcomb et al. (1986) suggested that
occupational experience evaluation should include the scope, the effort, and the condition of student project work. Additional criteria may be added which will reflect more the problem-solving aspect of the SOE programs. Such an evaluation procedure was considered in this research.

In addition to SOE, the FFA, another important component of vocational agriculture, also has potential for providing students with meaningful experiential learning. This highly successful youth organization has served as a tool of teaching as an intracurricular laboratory for leadership and personal development of students. Experiences from chapter meetings, committee work, contests, parliamentary procedure, public speaking, and state and national activities may help directly or indirectly develop abilities which contribute to problem-solving ability. Such abilities include:

- Involve others in group decisions and actions
- Make and substantiate decisions
- Collect and evaluate necessary information
- Demonstrate good judgement
- Provide constructive criticism

(Newcomb et al., 1986, p. 259).

Recent research has provided empirical support for the FFA. Townsend and Carter (1983), and Carter and Neason (1984) have documented the relationship of FFA participation and perceived benefits of the FFA in terms of leadership and personal development and cooperative efforts which have been stated as the major goal of this youth organization. Ricketts (1982) documented stronger support for
the FFA, when leadership and personal development abilities were measured from a criterion-referenced test. Research has not yet examined specifically the relationship between FFA participation and problem-solving ability of vocational agriculture students. Likewise, the relationship between FFA participation and achievement in agriculture has not been investigated in past research.

Degree of FFA participation which was used as the independent variable in past studies was determined from a checklist of FFA activities in which students participated. In the study by Ricketts (1982), a scoring key developed earlier by Welton and Warmbrod (Welton, 1971) was used to transform the checklist into a numerical score for each student. This procedure was adapted for use in this study.

Program Emphasis

Generally, curriculum planning in vocational agriculture is localized, allowing the teacher with some flexibility to adjust the program content in their taxonomic area. As a result, content emphasis can vary from teacher to teacher within the same specialized area and may influence the learning of students.

A study by Long and Israelsen (1963) indicated that teacher emphasis of content may have some influence on students' learning in certain areas. The researchers reported
a strong positive correlation between agricultural test scores of students and degree of teacher emphasis in the area of agribusiness. The relationship was reversed in production agriculture. This finding was partly explained by the fact that students participated more in SOE programs in production agriculture than in agribusiness.

In vocational horticulture, Parmley (1980) concluded that the relationship between horticultural achievement of students and teacher emphasis on the content was somewhat subject-matter specific. When analyzed by 10 areas of horticulture, significant relationships existed for only the areas of production floriculture, fruit and vegetable production, and turf services. No significant relationship was found for the overall horticultural achievement.

The extent to which program (content) emphasis has any influence on ability of students to solve agricultural problems has not been documented.

Grade Level of Students

It is evident that learning activities provided through the vocational agriculture program contribute substantially to the knowledge base and experiences of students in agriculture. Past research has clearly indicated the influence of number of years in the vocational agriculture program on student achievement (Morton & McCracken, 1979).
In Ohio, number of years in vocational agriculture varies only slightly among students enrolled in horticulture. Therefore, the decision was made to use the variable grade level in this study. Generally, grade level is correlated with achievement and thinking ability. However, when various factors are involved, the relationship between grade level and thinking ability could be low (Ennis, Millman, and Tomko, 1985).

Summary

The following highlights bring this review of literature into focus:

1. There has not been a clear distinction between problem solving and related mental constructs such as critical thinking.

2. There is evidence to suggest that a strong and positive relationship exists between achievement (the knowledge base) and content-specific problem-solving ability.

3. Research in content-specific problem solving has suggested that there are some advantages of teaching problem solving within existing courses. However, there has not been adequate empirical support for teaching problem-solving in vocational agriculture.

4. The Dewey model of reflective thinking has served as the basis for the problem-solving approach to teaching
vocational agriculture. This approach encompasses in-class as well as outside-class learning experiences.

5. Problem-solving ability of students enrolled in vocational agriculture has not been studied during the last 25 years.

6. Models of thinking skills are essential for developing valid problem-solving tests. Measuring problem-solving skills according to a specified model is desirable in terms of validity. However, such an approach is difficult. A test may be valid with reference to a specified model, but at the same time its reliability may be substantially reduced.

7. At present, appropriate instruments to assess problem-solving ability in agriculture are not available for use in research.

8. There is evidence to predict that the six independent variables in this study are positively related to agricultural achievement. Except for the variable academic aptitude, past research has not pinpointed the relationship between problem-solving ability and the other independent variables.
CHAPTER III
METHODOLOGY

A descriptive/correlational research design was employed in this study. Procedures used to obtain and analyze data are described in this chapter.

Population and Sample

A student was the unit of analysis. The population consisted of students in the horticulture programs in Ohio secondary schools during the 1986 school year. A purposive sampling procedure was employed to select schools as well as students.

Selection of Schools

Two criteria were specified for the selection of schools. First, the sample would include only horticulture programs which participated in the 1986 Ohio Vocational Education Achievement Test Program. This specification allowed the researcher to obtain scores on two tests which were available at the Instructional Materials Laboratory at The Ohio State University. The two tests were: 1) the Ohio

63
Horticulture Achievement Test, and 2) the California Short Form Test of Academic Aptitude (SFTAA level 5). These two tests were administered in March 1986 and yielded scores for the dependent variable achievement in horticulture and the independent variable academic aptitude.

Proximity of school location was the second criterion in selecting schools. Because it was important that the researcher administer the research instruments directly to students, only schools which are located within the radius of 100 miles from The Ohio State University campus were in the range of selection.

Eight joint vocational schools were selected. A letter explaining the objective of the study and requesting cooperation (Appendix A) was sent to the administrator, local supervisor, and horticulture teachers of each school. A letter of endorsement from the state horticulture supervisor was also sent to these individuals (Appendix A). This letter was followed by a telephone follow-up to the local supervisor in each school. Seven schools agreed to participate. For the one school which declined to participate, there were only 8 students in the horticulture program, half of which were identified as special needs students. Of the seven schools, one teacher with 15 students did not wish to take part in the study. Altogether, 14 teachers and 14 classes of vocational horticulture students were included in this study.
General information about the seven schools was obtained from the school records as well as from personal interviews with the teachers during data collection. The following gives a general profile of the selected schools.

The number of students enrolled in these schools ranged from 462 to 849 (mean=661). The number of students enrolled in agriculture programs (including horticulture) ranged from 28 to 83 (mean=60.86). Six of the 7 schools offered two or three programs in agriculture, one other school offered only the program in horticulture. There were from 34 to 70 teachers per school (mean=51.71). There were 1 four-teacher program, 5 two-teacher programs, and 1 one-teacher program in horticulture. Four out of the 7 horticulture programs were described as specialized programs, either in greenhouse/floriculture or landscape areas. The other three programs were of a combination nature. Three of the horticulture programs combined junior and senior students in the same class. All of the 7 programs combined special needs students with regular students.

More detail descriptions of the sample pertaining to program emphasis and grade level are presented in Chapter Four.
Selection of Students

All horticulture programs in the sample enrolled special needs students in the same class as regular students. These special needs students were identified as academically disadvantaged prior to entering the joint vocational school. Because the test of problem-solving ability calls for competency in reading and basic thinking at a level equivalent to regular vocational students, to include such an unique group of students in this study would complicate the data analysis and interpretation. Therefore, the decision was made to limit the sample to regular students only.

From the total of 197 students from the 14 classes of horticulture, 37 special needs students were identified from the school records and were excluded from the sample. Of the remaining 160 students, 139 were present on the day of data collection. Six students finished the test and the questionnaire in less than half of the expected time. Responses from these 6 students were checked and were found unuseable. Therefore, 133 responses from a total of 160 regular students(83.1%) were used in descriptive data analysis. Because records on the achievement and aptitude scores for 9 students were not available, the 9 students were treated as missing cases for these two variables in the descriptive analysis. For the correlation analysis, 124 cases(77.5%) with complete data were used. The following summarizes how the data sample was derived.
Number of schools selected 7
Number of classes(and teachers) 14
Number of students

Total 197
Regular students 160
Students present at data collection 139
Students with useable responses 133
Students with records of achievement and academic aptitude 124

To avoid bias in the process of data collection, 21 students who were absent were excluded from the study. Because of the purposive sampling procedure as described, the results of this study are limited in generalization.

**Measurement of The Variables**

Procedures and instruments used to obtained data pertaining to each variable are described in this section.

**Problem-Solving Ability in Horticulture**

Problem-solving ability in horticulture, the main dependent variable, was measured by a paper-pencil test developed specifically for this research (Appendix B). This is a content-specific test of problem-solving ability with the following four characteristics:

- The problems are based on meaningful and somewhat novel situations;
- The problems are based on general knowledge in
horticulture which is directly related to the principles of plant and soil science:

-The problems and test items are structure-oriented, but are not rigid(well) structured;

-The problems and test items do not call for a decision based on a value judgement.

Seven problem situations with 39 items follow the above criteria. One additional problem situation was designed to explore less-structured problem solving by asking students to justify their chosen answer. Because seven problem situations were used in the quantitative data analysis, procedures in developing the test are described pertaining to these seven situations. Problem situation 8 will be more appropriately described in Chapter 4.

Test items follow a comparative multiple-choice format, adapted from the format of the Cornell Critical Thinking Test level X (average high school level) developed by Ennis, Millman, and Tomko (1985). The literature indicates that a good test of thinking ability in a typical multiple-choice format is generally difficult to develop to serve the purpose well. Ennis (1986) suggested that if the multiple-choice format is used, the test should contain comparative items rather than the discrete multiple-choice items commonly used in achievement tests.

Each problem begins with a short story-like situation within the frame of reference of horticulture students. In the situation, adequate background information is provided
before a problem(s) is introduced. Following the situation, several possible solutions are listed and the student is asked to identify whether each solution: 1) would largely solve the problem(s), 2) might help reduce the problem(s), or 3) would not reduce the problem(s). Because of the nature of the problem in situation one, the student is asked to identify the cause of the problem not the solution as in the other six situations. The directions at the beginning of the test indicate clearly that, in order to come up with the best answers, the student needs to use the information provided in each situation as well as his/her knowledge in horticulture. With a score of either 0(wrong) or 1(right) for each listed solution(or cause), a total possible score of 39 can be achieved for the whole test.

One graduate student who was a former high school teacher of horticulture assisted in the initial development of the test. Another graduate student with experience in the horticulture industry in Ohio helped in the revisions of this instrument. The content of the Ohio Horticulture Achievement Test served as the frame of reference for the content of the problem-solving test. Five problem-solving skills, derived from Dewey’s model of reflective thinking provide the basis for the test development. These skills are: 1) defining the problem, 2) seeking data and information, 3) formulating possible solutions, 4) testing proposed
solutions, and 5) evaluating the results (Newcomb et al., 1986). Because measuring these five specific skills in isolation is highly complicated and beyond the scope of this research, only the measurement of composite problem-solving ability was the objective of this test. Thus, this test of problem-solving ability may be characterized as being content-specific with regard to the horticulture knowledge, but not aspect-specific (Ennis, 1986) with regard to problem-solving skills.

During the initial process of test construction, a sample of problem situations and test items in a multiple-choice format was reviewed by 2 teachers of horticulture in a selected school. The purpose of this initial review was to solicit responses from the teachers about the feasibility of the format and level of questioning of the test for use with students in vocational horticulture. The format and level of questioning were found to be inappropriate. The major problem was that items pertaining to the same situation were dependent, that is, one item may suggest an answer to other items. As a result, only a few items could be generated from one situation. Obviously, this was not practical because in order to generate enough items for the analysis, the test would end up being too lengthy requiring too much time for the student to read all situations. Upon a review of some widely used thinking tests, the decision
was made to follow the comparative multiple-choice format as described earlier. The initial review of the test by the teachers also revealed that the test needed to be more general in terms of the horticultural knowledge base required in solving problems.

After a major revision of the format and content, a draft of the total test with 8 problem situations was completed and reviewed by a panel of experts in agricultural education and horticulture. The criteria for assessing the content validity were: 1) content accuracy, 2) potential of the test to measure problem-solving ability of students in horticulture, and 3) basic test characteristics. The comparative question format was judged to be appropriate by the experts. However, the test needed to be revised on technical content and basic test characteristics.

A second draft of the test was reviewed by the content experts. Upon revision, the test with 8 problem situations was field tested with 4 classes of students from two schools not included in the sample. Three teachers from these schools were also asked to review the test. The purpose of this field test was to determine the suitability of the test as well as the time required for students to complete the test. The results indicated that the format was appropriate but further improvement was still necessary on the content and the test characteristics. One situation
was not useable and was replaced. After being revised, the test was reviewed again by the content experts.

The third draft of the test with 8 problem situations was pilot tested with another two classes of horticulture students not in the sample. An item analysis was performed to determine statistically the basic test characteristics which include item-total correlation, difficulty level, discrimination power, and the reliability. Based on the item analysis, several items were revised.

The final form of the test consists of 8 problem situations, 7 of which were used in the correlation analysis. Situation 8 was analyzed separately. After the actual data collection was completed, another item analysis was performed on the 39 test items of the 7 situations. The analysis revealed that one item in situation 3 showed a negative item-total correlation, a high difficulty index, and a negative discrimination index. Evidently, the item did not contribute to the total test. It was removed, leaving 38 useable items.

Because the test-retest and the alternate form procedure were not feasible for this study, internal consistency was used to estimate the reliability of the test. In spite of rigorous efforts to improve the test, the internal consistency was found to be only marginal (K-R 20=.61 for n=124, and .60 for n=133). However, the literature indicates that
assessing reliability of thinking tests has been an unresolved issue. Internal consistency gives an average intercorrelation of the items with each other. Because thinking ability is basically heterogeneous, internal consistency of thinking tests could be low as a result of the low intercorrelations of the items (Ennis, Millman, and Tomko, 1985). In addition, for this study, the relatively low number of test items (38) may also explain in part the low reliability of the test.

The item analysis yielded other basic psychometric characteristics of this test. With 133 cases, the mean difficulty index was .51, the mean discrimination index was .30, the mean item-total correlation was .26, and the standard error of measurement was 2.90.

Because the test is situation dependent, reading level of students is a factor of concern both in terms of validity and reliability of the test. The field test and several revisions helped alleviate this potential problem. Yet, reading level of the final form of the test was found to be somewhat higher than desirable for the level of students in vocational horticulture. Fog index (Extension Division, University of Missouri-Columbia, n.d.) was calculated to estimate the readability of each situation separately. The index ranged from 8.10 to 12.17 equivalent years of education. The average Fog index for the whole test was
10.32, indicating that the test requires a reading level equivalent to that of students in the 10th grade. A content analysis of situations with a relatively high Fog index (10 and above) revealed that most of the difficult words were technical terms in horticulture which could not be comprehensively replaced with simple and short words. Because technical terms (such as fertilizer and germination) are fundamental to students in horticulture, the calculated Fog index may overestimate the readability of the test.

Reading ability of students could be used to correlate with the problem-solving score to determine the extent to which the problem-solving test also measures the aspects of reading ability. But because most student records were not accessible, reading scores could be obtained for only 40 cases. Therefore, the option was to use the vocabulary score of the language section of the California Short Form Test of Academic Aptitude to represent a dimension of reading ability. The 25 items of the vocabulary sub-test includes word meanings, verbal comprehension, and word relationships. A correlation of .34 was found between problem-solving ability and vocabulary which is slightly less than the correlation between achievement and vocabulary (r=.41). On this basis, the test of problem-solving ability in horticulture is not more highly loaded with word meanings, verbal comprehension, and word relationships than
the achievement test in horticulture.

Achievement in Horticulture

Achievement was measured by the Ohio Horticulture Achievement Test, 1986. This test was developed and administered by the Instructional Materials Laboratory at The Ohio State University. The test is intended to measure general concepts and understanding in all areas of horticulture. Organized in 2 parts and 10 sections, the test consists of 363 multiple-choice items.

To be consistent with the test of problem-solving ability in horticulture, only the areas which are directly related to plant and soil science were selected for the analysis. These areas were:

- Scil Testing and Plant Science (20 items)
- Greenhouse Operations (43 items)
- Interior Plantscape Services (21 items)
- Landscape Services (56 items)
- Turf Services (39 items)
- Nursery (23 items)
- Garden Center (41 items)
- Fruit and Vegetable Production (23 items)

The areas which were not included were Retail Floriculture, Equipment and Mechanics, and Personal Development (the latter two were combined in one section of the test). Based on the sample mean scores (n=124), the internal consistency was calculated using the K-R 21 formula. The reliability for the 266 items was estimated at .94.
Academic Aptitude

Scores on academic aptitude of students were obtained from the California Short Form Test of Academic Aptitude (SFTAA) level 5, 1970. This test is included in the same test battery as the Ohio Horticulture Achievement Test.

The SFTAA contains two sections of basic cognitive ability testing. These are:

The language section, consists of:

(1) 25 items in the Vocabulary sub-test of word meanings, verbal comprehension and word relationships.
(2) 20 items in the Memory sub-test of retentive ability which is based on a story read to the students at the beginning of the test period.

The Non-language section, consists of:

(1) 20 items in the Analogies sub-test requiring the recognition of relationships which may be literal or symbolic.
(2) 20 items in the Sequences sub-test requiring the demonstration of comprehension of a pattern, rule or principle, as indicated by a series of numbers, letters, or geometric features.

The internal consistency (K-R 21) of .87 for the total test (85 items) was calculated from the sample mean (n=124).

The Extent to Which Teachers Use Problem-Solving Teaching Behaviors

Teachers were asked to rate themselves on the extent to which they engaged students in problem-solving learning experiences. In addition to teachers' self-ratings, another indication of problem-solving teaching behavior was
obtained from students’ ratings. The two ratings were based on the same rating scale and content.

The six steps of the problem-solving teaching approach being used at The Ohio State University (Newcomb et al, 1986) provided a framework for item construction of the two instruments. The six steps are: 1) interest approach, 2) group objectives, 3) questions to be answered, 4) problem solution, 5) testing solutions through application, and 6) evaluation of solution.

A five-point rating scale was used to indicate the extent of problem-solving teaching behaviors. The scale ranged from 1(almost never, or never) to 5(almost always, or always). (See Appendices C and E).

The teacher scale consists of 25 items and the student scale 26 items. Content validity of the instruments was assessed by a panel of agricultural education faculty. The teacher scale was field tested with 10 teachers of agriculture who were then graduate students at The Ohio State University. The student scale was pilot tested with two classes of students in vocational horticulture. Reliability coefficient of .78 (Cronbach’s alpha) was obtained from the pilot test of the student scale. Reliability was not assessed for the teacher scale due to the limited number of subjects.
The actual data collection revealed that 4 items on both scales may not solicit valid responses from teachers and students. Three of the 4 items were included as reversed items. These were (from the student scale):

- At the beginning of a unit of study, the teacher lists for us topics that we need to study in class.
- The teacher tells me all the information I need when I have to find answers to horticultural problems.
- The teacher gives tests which basically asked us to recall specific details of what we have studied.

The three items were intended to detect the potential response set. Analysis of the field and pilot tests revealed that there was no problem of response set. However, a problem exists on how to interpret the responses on these two items. If the ratings were high on these two items, would they be validly interpreted as low problem-solving behaviors? The experts did not agree on this point and the decision was made to remove these items.

Another item of concern was:

The teacher gives exercises or tests which require us to solve problems in horticulture (similar to the test we have just worked on today).

From discussion with students and analysis of the items, the researcher learned that students seemed to have a problem differentiating between test of cognitive memory and test of higher-order thinking. It seemed that, to students, every test is concerned with problem solving. This item was dropped from both instruments.
Based on 21 items on the teacher scale and 22 items on the student scale, the reliability coefficients (Cronbach's alpha) were calculated to be .89(n=14) and .87(n=133) respectively.

**Degree of Involvement in Supervised Occupational Experience**

Teachers were asked to score their students on the degree of involvement in supervised occupational experience (SOE) programs. The SOE Score Sheet (Appendix D) includes the following criteria for evaluation:

1. **Opportunity (for out-of-school SOEP)**
   - 1.1 Opportunity for students to engage in out-of-school SOEP
   - 1.2 Extent to which the opportunity has been used by the student

2. **Quality (for any type of SOEP), the extent to which the student:**
   - 2.1 has taken part in planning the SOEP
   - 2.2 has participated in decision making about the SOEP (for example, making decisions when confronted with problems)
   - 2.3 has used approved practices learned in class in the SOEP
   - 2.4 has kept accurate records of the SOEP
   - 2.5 has evaluated his/her projects
   - 2.6 has, overall, demonstrated time and managerial commitment to the SOEP

Students enrolled in vocational horticulture generally have limited opportunities to engage in out-of-school SOE programs (Makin, 1986). Theoretically, out-of-school SOE
projects could provide opportunities for students to apply knowledge and to solve problems in real life situations. On this basis, the SOE scoring sheet must include criteria related to cut-of-school SOE projects. For the quality criteria, the activities listed were selected to reflect the practices of problem-solving behaviors.

As indicated in Appendix D, the possible score for each criterion ranged from 1(very low) to 5(very high). A total score for each student was obtained by summing the scores for each criterion. The total possible score was 40. Teachers were instructed that individual students be compared to the rest of the class on each criterion. The purpose of this procedure was to ensure variability of scores.

The content validity of the instrument was established by a panel of experts in agricultural education. In addition, five teachers were asked to try out and review the instrument. In the actual data collection, 4 out of 14 teachers were randomly selected to rescore their students. The test-retest reliability was calculated by correlating the two sets of scores. The reliability coefficients were .79, .87, .89, and .95 for the four teachers. Because the data were collected at the end of the school year, follow-up of data would be very difficult. This was a reason why not all the 14 teachers were requested to rescore their students.
Degree of FFA participation

Students were asked to indicate the FFA activities in which they had participated at all levels as a member of the FFA. The FFA participation checklist (Appendix C) to obtain this information was adapted from the instrument developed by Ricketts (1982). The checklist includes activities at the chapter (local), district, state, and national levels. Activities included were selected aspects of FFA which may directly or indirectly provide practices contributing to problem-solving ability of students (Refer to Newcomb et al., 1986, p. 259).

Using the scale for scoring, slightly modified from the original scale by Welton and Warmbrod (Appendix F), a total possible weighted score of 89 could be obtained.

After the content validity was established by experts, the checklist was field tested with two classes of students in vocational horticulture. An observation during the field test revealed that some students tended to have difficulty in categorizing their activities. Although the checklist was later revised, the problem was not totally overcome. Therefore, on the actual data collection, students were encouraged to consult their teacher when they were uncertain about some activities on the list. In addition, responses of students were later validated by their teacher.
Due to the nature of the instrument, reliability could be achieved only by a test-retest procedure. Considering that some students may have problems with providing accurate information, such a reliability procedure would not be feasible. For this reason, reliability was not attempted. With considerable efforts put in the validity procedure during the data collection, an acceptable level of consistency of responses could be expected for this kind of factual information.

Grade Level of Students

Grade levels of students were indicated by their teachers. In addition, for descriptive purposes, number of years enrolled in vocational agriculture was requested on the student questionnaire.

Program Emphasis

Program in which students were enrolled was classified into three types according to the content emphasis. These were greenhouse/floriculture emphasis, landscape emphasis, and combination of the first two. The classification was verified by the state horticulture supervisor and the teachers in this study. A description of program emphasis is presented in Chapter 4.
Data Collection

The researcher contacted the Instructional Materials Laboratory at The Ohio State University to request access to test scores on achievement in horticulture and academic aptitude of students in the sample. The researcher also visited all the 7 schools to administer the researcher-developed instruments directly to students in a group situation.

The test of problem-solving ability in horticulture (Appendix B) was administered first. Students were allowed 40 minutes to complete the test. After students filled out their name on the back of the test booklet, the written instructions were read to students. Students were not encouraged to guess wildly. This point is very important for a test measuring thinking ability (Ennis, Millman, & Tomko, 1985). However, no penalty would be given for wrong answers, and students were encouraged to answer all the questions to the best of their knowledge. After 40 minutes (or after all students had finished the test before the 40 minutes limit), the student questionnaire was administered. The questionnaire (Appendix C) consists of three parts: classroom activities, supervised occupational experience, and FFA participation. After students filled out the information about their name and number of years they had been enrolled in vocational agriculture/horticulture,
written instructions on the questionnaire were read to students pertaining to each part of the questionnaire. For the last part, FFA participation, students were encouraged to consult their teacher if they were uncertain about the kind of FFA activities they had actually participated. Students were given 20 minutes to complete the questionnaire. After all the questionnaires were collected, the teacher together with the researcher reviewed responses of all students on the FFA participation instrument to ensure that accurate information was obtained.

During the time when students were taking the test and completing the questionnaire, the teacher was asked to score each student on degree of SOE involvement. The SOE score sheet and instructions (Appendix D) were provided for the teacher. The teacher was also asked to complete the teacher questionnaire on classroom activities (Appendix E).

Information about each school was obtained from the school records. The researcher also discussed with teachers the nature of their horticulture programs.
Data Analysis

To summarize and organize data, descriptive statistics were obtained. These statistics include frequencies, percentages, measures of central tendency, and measures of dispersion.

Three levels of correlation were analyzed. Simple correlations of all the variables were obtained from Pearson product-moment and point-biserial correlation coefficients. After the general pair-wise relationships were established, two steps of regression analysis were performed on each of the two dependent variables, namely, problem-solving ability and achievement. In the first regression analysis, the independent variables were formed into two sets which are the academic aptitude set and the program variables set. Regressions on the two sets yielded semi-partial multiple regression coefficients indicating the unique variance in each dependent variable accounted for by the two variable sets. These analyses were followed by hierarchichal analysis on each dependent variable which yielded information on $R^2$ increments contributed by selected individual variables.

Finally, at the third and most generalized level of correlation, a canonical correlation analysis was performed. At this stage, all the variables were grouped into two sets. The set of criterion variables includes problem-solving ability and achievement in horticulture, and was
labelled cognitive performance variables. The set of predictor variables consists of all the six independent variables. Canonical correlation was calculated to determine the relationship between the two sets of variables. The variance explained in the set of criterion variables by the other set was estimated from the redundancy index. Structure coefficients then provided information on the relative importance of each variable in the multivariate relationships. The basic nature of canonical correlation analysis is discussed in Chapter 4.

For all significant tests, the alpha level was set a priori at .05.

Three computer programs available at the Computing Center at The Ohio State University were used to analyze data. In addition to item analysis on the test of problem-solving ability which were obtained from the Office of Evaluation, reliability estimates were achieved from the reliability procedure of the Statistical Package for the Social Sciences (SPSSx). All other analyses were obtained from the Statistical Analysis System (SAS). Lastly, the Biomedical Computer Programs (BMD) was used to supplement the analysis on canonical correlation.
CHAPTER IV
FINDINGS

Findings are presented in this chapter in two parts. Part one contains descriptive data, the background for the interpretations and discussions of correlational results. In part two, a series of correlational analyses are reported in three consecutive sections. First, simple correlations of all the variables are described to establish a basic profile of all pair-wise relationships. Next, separate regressions of each dependent variable yield information on the variance explained by the independent variables. Finally, this chapter ends with findings on multivariate relationships between the criterion set and the predictor set of variables.

The interpretations are centered around problem-solving ability, the major dependent variable of this study. Comparative interpretations of findings pertaining to problem-solving ability and achievement (the second dependent variable) are also presented throughout in order to explicate the nature of the relationship between the two dependent variables.
Descriptive Data

Profile of the Sample

From discussion with teachers, the researcher learned that declining enrollment is a problem facing most if not all programs in vocational agriculture in Ohio. Consequently, some programs, especially vocational horticulture in the vocational school, have undergone some modifications to attract potential students. One change which has been implemented is developing specialized programs to suit specific interests of students. Apparently, this specialization has lead to more diversified programs within the same area. Basically, horticulture programs in vocational schools in Ohio may be described as being either specialized or less specialized. Specialized programs can be further described according to the area of content emphasis; one is greenhouse/floriculture emphasis, the other is landscape emphasis. The less specialized programs are usually, but not limited to, the combination of the two.

The sample of students for this study came from horticultural programs with one of the three content emphasis: greenhouse/floriculture, landscape, and combination. This categorization of programs was verified by the respective teachers and further confirmed by a state supervisor whose specialization is horticulture. However, the three categories were not intended to imply that they represent three
entirely different programs. Rather, the categories represent horticultural programs with varied emphases of content.

Teachers in a specialized program reported that their course of study included general horticultural knowledge and practices, but that one content area was dominant. For certain combination programs, different areas of study were emphasized in each of the junior and senior years. For instance, greenhouse/floriculture may be taught primarily in the junior year and landscape taught only in the senior year, or vice versa. Evidently, this further complicates the categorization of programs. For this study, to reflect more accurately the specialized nature of the programs, junior students in the combination program who had studied primarily either greenhouse/floriculture or landscape were grouped into one of the corresponding specialized programs.

Tables 1 and 2 summarize the general characteristics of students in this sample.

Almost one-half (46.6%) of the students were in the program (or class) which was oriented toward greenhouse/floriculture emphasis. The remaining students were nearly equally distributed in the landscape group (28.6%) and the combination group (24.8%). (Table 1).
Table 1

Frequency Distribution of Students by Program Emphasis

<table>
<thead>
<tr>
<th>Program Emphasis</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse/Floriculture</td>
<td>62</td>
<td>46.6</td>
</tr>
<tr>
<td>Landscape</td>
<td>38</td>
<td>28.6</td>
</tr>
<tr>
<td>Combination</td>
<td>33</td>
<td>24.8</td>
</tr>
<tr>
<td>Total</td>
<td>133</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2

Frequency Distribution of Students by Program Emphasis by Grade Level and Sex

<table>
<thead>
<tr>
<th>Program Emphasis</th>
<th>Grade level</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Junior</td>
<td>Senior</td>
</tr>
<tr>
<td>Greenhouse/Floriculture</td>
<td>48 77.4 14 22.6</td>
<td>6 9.7 56 90.3</td>
</tr>
<tr>
<td>Landscape</td>
<td>24 63.2 14 36.8</td>
<td>28 73.7 10 26.3</td>
</tr>
<tr>
<td>Combination</td>
<td>6 18.2 27 81.8</td>
<td>4 12.1 29 87.9</td>
</tr>
<tr>
<td>Overall</td>
<td>78 56.6 55 41.4</td>
<td>38 28.6 95 71.4</td>
</tr>
</tbody>
</table>
The programs can also be described in terms of the make-up of students in a class. Five out of 14 classes were a combined junior-senior class for the entire two years. The other 9 classes consisted of either juniors or seniors. As reported in Table 2, more than half of the students in the sample (58.6%) were junior students. When broken down by program emphasis, a higher percentage of juniors was found in the greenhouse/floriculture group (77.4%) than in either of the other two. In contrast, the combination group consisted of mostly senior students (81.8%). Only a few students indicated having additional years of study in vocational agriculture and/or horticulture.

There were more females (71.4%) than males (28.6%) in the sample. Almost all students in the greenhouse/floriculture group were female (90.3%), and the similar trend was found in the combination group (87.9%). To the contrary, the majority of the landscape students were male (73.7%). (Table 2).

Descriptive Data on the Variables

The variables to be included in the correlational analyses are described in this section. For each variable, basic summary statistics are provided. Distributions of scores were also presented for the three cognitive variables, namely, problem-solving ability, achievement, and academic aptitude.
Problem-Solving Ability

Scores from problem situations 1 to 7 on the test of Problem-Solving Ability in Horticulture were used in the correlational analyses. Situation 8 was designed to elicit a pattern of responses on a less-structured problem and was analyzed separately.

Scores from the problem situations 1 to 7 represent 0 (incorrect) and 1 (correct) responses. Students were instructed that, to come up with the best answers, they need to use their basic knowledge in horticulture as well as the information provided in situations. From Table 3, the highest score obtained for the entire sample was 30 which is 78.9% of the total correct answers (38). The overall mean of 19.16 indicates that students, on the average, answered about half of the items correct. The distribution of scores was slightly skewed toward the positive end (skewness=.22). The highest group mean score was from the landscape group (mean=20.71). The greenhouse/floriculture and the combination groups performed at about the same level (means=18.56 and 18.48, respectively). On the average, senior students performed slightly better than junior students (means=19.65 and 18.90, respectively).

To study the distribution of the problem-solving scores, individual scores were converted into percent of correct responses and then grouped into four levels (Table 4).
Table 3
Summary Statistics for Problem-Solving Ability Scores
by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/ Grade Level</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Emphasis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/ Floriculture</td>
<td>62</td>
<td>18.56</td>
<td>4.09</td>
<td>29.00</td>
<td>8.00</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>38</td>
<td>20.71</td>
<td>4.53</td>
<td>30.00</td>
<td>12.00</td>
</tr>
<tr>
<td>3. Combination</td>
<td>33</td>
<td>18.48</td>
<td>5.21</td>
<td>29.00</td>
<td>11.00</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>78</td>
<td>18.90</td>
<td>4.27</td>
<td>30.00</td>
<td>8.00</td>
</tr>
<tr>
<td>2. Senior</td>
<td>55</td>
<td>19.65</td>
<td>5.17</td>
<td>29.00</td>
<td>11.00</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>133</td>
<td>19.16</td>
<td>4.59</td>
<td>30.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Overall skewness = .22
Table 4
Percent Distribution of Problem-Solving Ability Scores by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>&lt; 40%</th>
<th>40-49%</th>
<th>50-59%</th>
<th>≥ 60%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Program Emphasis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>14</td>
<td>22.6</td>
<td>13</td>
<td>21.0</td>
<td>24</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>5</td>
<td>13.2</td>
<td>9</td>
<td>23.7</td>
<td>11</td>
</tr>
<tr>
<td>3. Combination</td>
<td>12</td>
<td>36.4</td>
<td>8</td>
<td>24.2</td>
<td>3</td>
</tr>
<tr>
<td>Grade Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>17</td>
<td>21.8</td>
<td>18</td>
<td>23.1</td>
<td>27</td>
</tr>
<tr>
<td>2. Senior</td>
<td>14</td>
<td>25.5</td>
<td>12</td>
<td>21.8</td>
<td>11</td>
</tr>
<tr>
<td>Overall</td>
<td>31</td>
<td>23.3</td>
<td>30</td>
<td>22.6</td>
<td>38</td>
</tr>
</tbody>
</table>
Overall, the scores were almost equally distributed in the four levels. When classified by program emphasis, however, a higher percentage of students in the landscape group (34.2%) and the combination group (30.3%) had 60% or higher correct answers than students in the greenhouse/floriculture group (17.7%). On the other hand, a higher percentage of students in the combination group achieved less than 40% correct answers than the other two.

Broken down by grade, the distribution showed interesting results. A higher percentage of senior students (32.7%) achieved 60% or higher scores than junior students (20.5%). However, both grades showed nearly equal proportions of students at the level of 50% or higher (52.7% and 55.1%, respectively).

Problem situation 8 allows the researcher to gain some insight about the thinking process of students when solving problems. Responses for this situation are reported in a more qualitative manner.

The problem situation was framed in the context of landscape, but did not require very specific knowledge in that area in order to come up with a justifiable answer. Students were asked to select an appropriate type of plant for a landscape purpose. Adequate information was provided for students to make a sound judgement on the basis of criteria implied in the situation. Although one kind of plant
should be a better choice than the others for the particular situation, alternatives may also be acceptable, provided that most of the criteria are met. To some limited extent, students may apply value judgements to their decisions. With regard to the nature and type of response, problem situation 8 is more flexible.

After indicating the choice of plant, students were asked to give reasons to justify their decision. The researcher categorized the reasons given by the students into 5 levels of reasoning, as follows:

Level 0: Students were assigned this level when no reason was given.

Level 1: Reasons given were totally irrelevant to the problem. The student might be either confused about the problem and the question or unable to use the information provided.

Level 2: Some logical reasoning was attempted on the basis of the student’s experiences and/or information in the situation. However, the student failed to meet the required criteria. The reasoning may also be based on a wrong assumption.

Level 3: At this level, the student demonstrated an ability to use some relevant information and to weigh the alternatives. Yet, not all criteria were considered.

Level 4: At this level, the student used all the relevant information to the full benefit. All the criteria were carefully considered. For example, the student may actually compare the total cost of using different kinds of plants against their benefits for the particular purpose.
Clearly, the ability to use relevant information in seeking alternatives was the most important consideration for the above categorization of reasoning. Results of the analysis are reported in Table 5.

Only 5 out of 133 students (3.8%) failed to give any reason and were consequently assigned level 0. Over one-half (56.3%) of the students could give at least some logical reasons, and nearly one-half (44.3%) were able to give justified reasons.

Because inter-rater reliability was not attempted, the finding on problem situation 8 may be interpreted with some caution regarding the consistency in scoring.

Table 5
Level of Reasoning of Responses to Problem Situation 8

<table>
<thead>
<tr>
<th>Level of Reasoning</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (no reason given)</td>
<td>5</td>
<td>3.8</td>
</tr>
<tr>
<td>1 (irrelevant reason)</td>
<td>13</td>
<td>9.8</td>
</tr>
<tr>
<td>2 (somewhat logical reason)</td>
<td>40</td>
<td>30.1</td>
</tr>
<tr>
<td>3 (justified reason)</td>
<td>59</td>
<td>44.3</td>
</tr>
<tr>
<td>4 (well justified reason)</td>
<td>16</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>133</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
Achievement in Horticulture

Scores on horticulture achievement were obtained from the Ohio Horticulture Achievement Test 1986. As described in Chapter Three, only scores from the areas directly related to the basic principles of plant and soil sciences were included in the analysis. From the total possible score of 286 the overall mean score for this sample was 113.38 which is 42.8 percent of the total possible score. (Table 6).

The overall skewness of .92 indicates a markedly skewed distribution toward the positive end. Group means suggest that the skewness was caused by the disproportionate low scores by the greenhouse/floriculture group. The landscape group scored highest (mean=125.63), followed by the combination group (mean=116.00). The mean score for the greenhouse/floriculture group was 104.39, suggesting that this group of students were less knowledgeable than their counterparts in general horticulture which is related to plant and soil sciences. The reader is reminded that the achievement score does not represent the overall achievement in all areas of horticulture. Rather, it is an indicator of achievement in horticulture related to plant and soil sciences. Analyzed by grade, senior students scored higher than junior students (means= 121.49, 107.71).
Table 6
Summary Statistics for Achievement Scores by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Emphasis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>57</td>
<td>104.39</td>
<td>24.36</td>
<td>180.00</td>
<td>56.00</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>35</td>
<td>125.63</td>
<td>41.55</td>
<td>224.00</td>
<td>71.00</td>
</tr>
<tr>
<td>3. Combination</td>
<td>32</td>
<td>116.00</td>
<td>29.89</td>
<td>179.00</td>
<td>64.00</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>73</td>
<td>107.71</td>
<td>26.66</td>
<td>189.00</td>
<td>56.00</td>
</tr>
<tr>
<td>2. Senior</td>
<td>51</td>
<td>121.49</td>
<td>38.17</td>
<td>224.00</td>
<td>68.00</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>124</td>
<td>113.38</td>
<td>32.47</td>
<td>224.00</td>
<td>56.00</td>
</tr>
</tbody>
</table>

Overall skewness = .92
9 missing cases
<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>&lt;40%</th>
<th>40-49%</th>
<th>50-59%</th>
<th>≥60%</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><strong>Program Emphasis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>37</td>
<td>64.9</td>
<td>14</td>
<td>24.6</td>
<td>4</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>14</td>
<td>40.0</td>
<td>8</td>
<td>22.9</td>
<td>5</td>
</tr>
<tr>
<td>3. Combination</td>
<td>13</td>
<td>40.6</td>
<td>10</td>
<td>31.3</td>
<td>8</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>42</td>
<td>57.5</td>
<td>20</td>
<td>27.4</td>
<td>7</td>
</tr>
<tr>
<td>2. Senior</td>
<td>22</td>
<td>43.2</td>
<td>12</td>
<td>23.5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>64</td>
<td>51.6</td>
<td>32</td>
<td>25.8</td>
<td>17</td>
</tr>
</tbody>
</table>

9 missing cases
The distribution of scores by level of percent correct responses (Table 7) reveals a similar trend. More than half (64.9%) of the greenhouse/floriculture group scored in the range of lower than 40%. Conversely, the landscape group showed the heighest percentage of students (22.9%) obtaining scores of 60% or higher. When distributed by grade level, junior students performed more poorly than senior students. More junior students (57.5%) achieved lower than 40% correct than senior students (43.2%). Overall, about half of the total sample (51.6%) performed at a level of lower than 40%.

Compared to the findings on problem-solving ability, students were found to perform more poorly (on the basis of percent correct response) on achievement. This was particularly evident for the greenhouse/floriculture group. For both tests, senior students performed better than junior students.

**Academic Aptitude**

From the total possible points of 85 on the California Short Form Test of Academic Aptitude (1970, level 5), the overall mean was 45.11, slightly above the 50% level (Table 8). Somewhat contradictory to the findings on problem-solving ability and achievement, the mean score for the combination group (47.69) was higher than those of the other
Table 8
Summary Statistics for Academic Aptitude Scores by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Emphasis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>57</td>
<td>44.26</td>
<td>11.46</td>
<td>70.00</td>
<td>28.00</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>35</td>
<td>44.14</td>
<td>12.40</td>
<td>64.00</td>
<td>20.00</td>
</tr>
<tr>
<td>3. Combination</td>
<td>32</td>
<td>47.69</td>
<td>13.06</td>
<td>75.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Grade Level</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>73</td>
<td>43.04</td>
<td>11.77</td>
<td>70.00</td>
<td>20.00</td>
</tr>
<tr>
<td>2. Senior</td>
<td>51</td>
<td>48.09</td>
<td>12.19</td>
<td>75.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Overall</td>
<td>124</td>
<td>45.11</td>
<td>12.15</td>
<td>75.00</td>
<td>13.00</td>
</tr>
</tbody>
</table>

Overall skewness = .23
9 missing cases
Table 9
Percent Distribution of Academic Aptitude Scores by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>&lt; 50% n</th>
<th>50-59% n</th>
<th>60-69% n</th>
<th>≥ 70% n</th>
<th>total n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Program Emphasis</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>31</td>
<td>54.4</td>
<td>12</td>
<td>21.0</td>
<td>7</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>18</td>
<td>51.4</td>
<td>2</td>
<td>5.7</td>
<td>11</td>
</tr>
<tr>
<td>3. Combination</td>
<td>11</td>
<td>34.4</td>
<td>9</td>
<td>28.1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>42</td>
<td>57.5</td>
<td>12</td>
<td>16.5</td>
<td>10</td>
</tr>
<tr>
<td>2. Senior</td>
<td>18</td>
<td>35.3</td>
<td>11</td>
<td>21.6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>60</td>
<td>48.4</td>
<td>23</td>
<td>18.6</td>
<td>25</td>
</tr>
</tbody>
</table>

9 missing cases
two groups. Mean score for the greenhouse/floriculture group (44.26) was about the same as that of the landscape group (44.14). Junior students had a lower mean score (43.04) than senior students (48.09).

The distribution of percent scores (Table 9), however, shows that about one-half of the greenhouse/floriculture group (54.4%) were in the range of score lower than the 50% level. A higher percentage of the landscape group performed at the level of 60% or higher as compared to the other groups. Also interestingly, as high as 75.4% of the greenhouse/floriculture group scored lower than the 60% level in contrast to 57.1% and 62.5% of the landscape and the combination groups, respectively. Again, more junior students achieved lower scores (less than 50%) than their senior counterparts (57.5% and 35.3%, respectively).

Findings up to this point suggested that program emphasis, grade level, and academic aptitude together may have had some influence on the performance of students on problem-solving ability and achievement.

**Problem-Solving Teaching Behavior**

Two comparable versions of rating instruments, one for students and one for teachers were used to measure the extent to which teachers used problem-solving teaching behaviors. Students were asked to rate, on the scale of
1(almost never or never) to 5(almost always or always) the level at which they engaged in the problem-solving learning behaviors provided for or encouraged by their teachers. The teachers were asked to rate themselves, on the same scale, the extent to which they provided or encouraged problem-solving learning experiences for their students.

Table 10 compares the item mean scores for ratings obtained from students (as a class) and their respective teachers. Overall, the teachers rated themselves higher than the students, suggesting that they used the problem-solving behaviors slightly more than half of the time (teacher mean = 3.29, student mean = 2.98). Class means of students' ratings ranged from 2.53 to 3.57. Means for teachers' ratings ranged from 2.95 to 4.24.

Correlation between class ratings and teachers' ratings was low ($r = .28$). A closer analysis revealed that the responses of individual students varied considerably for each item, suggesting that individual students perceived differently the extent to which they experienced problem-solving activities. Possibly, this variation may also suggest that students could not fully comprehend the context of the items on the questionnaire, and therefore could not very well reflect on their experiences.

The low correlation between the two ratings may be interpreted that the two were indicators of different
Table 10
Item Means of Problem-Solving Teaching Behavior from Students' Ratings and Teachers' Self-Ratings

<table>
<thead>
<tr>
<th>Class</th>
<th>Students' Ratings</th>
<th>Teachers' Self-Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Class Mean&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>2.53</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2.73</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>2.75</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>2.78</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>2.86</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>2.88</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>2.91</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>2.97</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>3.10</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>3.16</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>3.25</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>3.36</td>
</tr>
<tr>
<td>13</td>
<td>6</td>
<td>3.42</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>3.57</td>
</tr>
<tr>
<td>Overall</td>
<td>133</td>
<td>2.98</td>
</tr>
</tbody>
</table>

 NOTE
Correlation between students' ratings and teachers' self-ratings (Pearson Product-Moment Correlation Coefficient) = .28

<sup>a</sup> from 22 items
<sup>b</sup> from 21 items
perspectives of the extent to which problem-solving teaching/learning activities took place in the classroom. The items on the student questionnaire were worded such that they reflect more of the extent to which students engaged in problem-solving learning activities. The teachers, on the other hand, were asked to rate themselves on the extent to which they provided or encouraged student problem-solving activities. Granted that teachers of vocational agriculture in Ohio receive some preservice or inservice training on the problem-solving approach to teaching agriculture, the teachers should be in a position to respond more validly to the items on the questionnaire. Based on this assumption, the decision was made to use the teachers' responses for the correlational analysis.

Supervised Occupational Experience Involvement

From an SOE scoring instrument, individual students were evaluated by their teachers on their opportunity to engage in supervised occupational experiences and the quality of their activities. The state of Ohio (Agricultural Service, 1984) recommends that legitimate SOE experiences in horticulture may include a combination of the following types of activities:

- In-school laboratory
- and
- Job placement
- or
- Small business enterprise
- or
Production project
and
40 hours in improvement project(s)

Through discussions with the state horticulture supervisor and the teachers, this researcher learned that supervised occupational experience for most horticultural students, especially for the juniors, were mostly limited to in-school laboratory experiences.

Table 11 summarizes the types of out-of-school SOE projects which students reportedly had. Overall, more than half (60.9%) of the students had improvement projects, but only about one-third (33.1%) had placement projects. Slightly more than half (56.4%) of the junior students reported having improvement projects as compared to 67.3% of senior students. Only 16.7% of junior students indicated that they had placement projects. Slightly more than half of the senior students (56.4%) had this type of experience. The data clearly revealed that out-of-school SOE was very limited, especially for junior students.

Having established the background information, we now turn to the findings on SOE involvement. Based on the SOE score sheet, the teachers were asked to evaluate each student with respect to other students in the class. This procedure ensures the distribution of scores in a class. Eight criteria on the SOE Scoring Sheet yielded a total composite score of 40. Summary statistics for SOE involvement are reported in Table 12.
### Table 11
Percents of Students Having or Not Having Out-of-School SOE Projects by Grade Level

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Improvement Project</th>
<th>Placement Project</th>
<th>All cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Having n</td>
<td>%</td>
<td>Not Having n</td>
</tr>
<tr>
<td>Junior</td>
<td>44</td>
<td>65.4</td>
<td>34</td>
</tr>
<tr>
<td>Senior</td>
<td>37</td>
<td>67.3</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>81</td>
<td>60.9</td>
<td>52</td>
</tr>
</tbody>
</table>

### Table 12
Summary Statistics for SOE Involvement Scores by Program Emphasis and Grade Level

<table>
<thead>
<tr>
<th>Program Emphasis/Grade Level</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Emphasis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Greenhouse/Floriculture</td>
<td>62</td>
<td>25.90</td>
<td>6.59</td>
<td>39.00</td>
<td>9.00</td>
</tr>
<tr>
<td>2. Landscape</td>
<td>38</td>
<td>26.13</td>
<td>7.96</td>
<td>36.00</td>
<td>12.00</td>
</tr>
<tr>
<td>3. Combination</td>
<td>33</td>
<td>24.36</td>
<td>4.36</td>
<td>35.00</td>
<td>16.00</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Junior</td>
<td>78</td>
<td>24.71</td>
<td>6.52</td>
<td>38.00</td>
<td>12.00</td>
</tr>
<tr>
<td>2. Senior</td>
<td>55</td>
<td>26.84</td>
<td>6.45</td>
<td>39.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Overall</td>
<td>133</td>
<td>25.59</td>
<td>6.55</td>
<td>39.00</td>
<td>9.00</td>
</tr>
</tbody>
</table>

Skewness = .02
The overall mean was 25.59, slightly above the 50% point of the total possible score. Mean scores varied slightly among different program emphases. The landscape group scored highest (mean=26.13), followed closely by the greenhouse/floriculture group (mean=25.90). The combination group mean was found to be 24.36. There was greater variation of scores in the landscape group than in the other two groups. Of note, based on the background information on status of supervised occupational experience, the SOE involvement scores reflect more of the in-school laboratory than the other types of experience.

**FFA Participation**

Based on the checklist of FFA activities, students were asked to indicate the activities in which they participated at the chapter, district, state, and national levels. These responses were verified by their teachers. From Table 13, a composite weighted score for each student was calculated using a scoring scale (Appendix F). The total possible composite score of 89 was obtained by summing the weighted scores for all levels of FFA activities. The overall mean was found to be 9.26, indicating that the degree of FFA participation was extremely low. A wide range of scores was observed from 1 to 41. A closer analysis of the responses revealed that this sample could be
Table 13
Summary Statistics for PFA Participation Scores by School, Grade Level, and PFA Activity Level

<table>
<thead>
<tr>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>12.00</td>
<td>8.51</td>
<td>41.00</td>
<td>3.00</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>11.94</td>
<td>8.23</td>
<td>26.00</td>
<td>2.00</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>10.16</td>
<td>9.33</td>
<td>32.00</td>
<td>2.00</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>8.47</td>
<td>3.89</td>
<td>18.00</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>7.77</td>
<td>8.66</td>
<td>33.00</td>
<td>2.00</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>7.10</td>
<td>7.40</td>
<td>32.00</td>
<td>1.00</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>6.67</td>
<td>4.39</td>
<td>14.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

| Grade Level | Junior | 78 | 7.95 | 7.87 | 41.00 | 1.00 |
|             | Senior | 55 | 11.13| 7.46 | 33.00 | 1.00 |

| PFA Activity Level | Chapter | 133 | 6.21 | 4.29 | 23.00 | 1.00 |
|                   | District | 133 | 0.92 | 1.58 | 9.00  | 0.00 |
|                   | State    | 133 | 1.78 | 2.98 | 15.00 | 0.00 |
|                   | National | 133 | 0.35 | 1.13 | 4.00  | 0.00 |

| Overall | 133 | 9.26 | 7.83 | 41.00 | 1.00 |

Skewness = 1.54
described simply as being either non-active or somewhat active in the FFA. With the majority of students being inactive, the distribution of scores skewed severely toward the positive end (skewness=1.54).

When broken down by school, the means ranged from 6.67 to 12.00. Overall, senior students participated more (mean=11.13) than their junior counterparts (mean=7.95). The breakdown by FFA activity level revealed that FFA participation was concentrated at the chapter level (mean=6.21). Almost all students reported that they did not participate at the national level at all.

Some students indicated to the researcher that they simply did not wish to join the FFA. According to these students, FFA is an agricultural organization to which horticultural students such as themselves did not belong.

Correlational Analysis

Having established the background data, the next step in the analysis is to determine the relationships among the variables. Findings in this part are divided into three sections pertaining to three steps of correlation analyses.

Pairwise Correlations of the Variables

Pearson product-moment correlation coefficients were computed for all pairs of variables and are reported in
Table 14. Findings on the relationships between each dependent variable and the other variables are presented first, followed by the intercorrelations among the independent variables.

**Relationships between problem-solving ability and other variables**

Problem-solving ability was correlated positively and substantially with the other two cognitive variables, achievement ($r = .52$) and academic aptitude ($r = .57$). The relationships were significant at the $.001$ level. The magnitude of these relationships suggest that the higher the level of basic cognitive skills and general knowledge in horticulture a student had the better he/she tended to be in solving horticultural problems.

Problem-solving ability was also correlated with five other variables. The data revealed low positive relationships between problem-solving ability and SOE involvement ($r = .29$), significant at $.001$ level, and landscape emphasis ($r = .21$), significant at $.05$ level. The relationships with other variables ranged from negligible to low and were not statistically significant.
Table 14
Intercorrelations of the Variables (n = 124)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Dependent</th>
<th></th>
<th>Independent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Dependent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Problem-Solving Ability</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Achievement</td>
<td>.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>Independent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Academic Aptitude</td>
<td>.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00</td>
</tr>
<tr>
<td>4. Problem-Solving Teaching Behavior</td>
<td>.11</td>
<td>.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.01</td>
</tr>
<tr>
<td>5. SOE Involvement</td>
<td>.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.26&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>6. FFA Participation</td>
<td>.16</td>
<td>.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.18&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>7. Program Emphasis: Greenhouse/Floriculture</td>
<td>-.13</td>
<td>-.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.06</td>
</tr>
<tr>
<td>8. Program Emphasis: Landscape</td>
<td>.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.04</td>
</tr>
<tr>
<td>9. Program Emphasis: Combination</td>
<td>-.08</td>
<td>.05</td>
<td>.12</td>
</tr>
<tr>
<td>10. Grade Level</td>
<td>.08</td>
<td>.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.20&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>significant at p < .001  
<sup>b</sup>significant at p < .01  
<sup>c</sup>significant at p < .05  
<sup>d</sup>coded as 0 = not being in the group, 1 = being in the group  
<sup>e</sup>coded as 0 = junior, 1 = senior
Relationships between achievement and other variables

As presented in the preceding section, achievement was correlated positively and substantially with problem-solving ability ($r = .52$). Achievement also correlated at about the same level with academic aptitude ($r = .59$).

Relationships with other variables ranged from low to moderate, except with the combination group which showed a negligible correlation. Moderate positive associations existed between achievement and the variables SOE involvement ($r = .39$), and problem-solving teaching behavior ($r = .37$), which were significant at the .001 level. Low positive correlations were found with FFA participation ($r = .28$) and landscape emphasis ($r = .24$), both significant at the .01 level. Grade level was also significantly related to achievement ($r = .21$) at the .05 level. The only negative correlation was with greenhouse/floriculture emphasis ($r = -.26$) and was significant at the .01 level.

In comparison to findings on problem-solving ability, achievement was found to be correlated at a higher degree with all the independent variables.
Intercorrelations among the independent variables

Data in social research is often characterized by high intercorrelations among the independent variables. Examining the pattern of such relationships is one informal detection of the potential multicollinearity problem which may interfere with regression results.

Refering once more to Table 14, the three dummy variables for program emphasis were all significantly correlated. Only the first two dummy-coded variables, namely, greenhouse/floriculture and landscape, are used in the upcoming regression analyses. There was a negative and substantial correlation between these two dummy variables \( r = -0.59 \). Such magnitude of relationship is not at all unusual, considering that dummy-coded variables are partially redundant (Cohen and Cohen, 1983). These two dummy variables will be treated as one set of variables in the regression analysis.

Grade level was correlated negatively and moderately \( r = -0.38, p = 0.001 \) with greenhouse/floriculture emphasis, and positively and substantially \( r = 0.54, p = 0.001 \) with combination program. The descriptive data presented earlier revealed that most students (77.4%) in the greenhouse/floriculture group were junior students. Conversely, most
students (81.8%) in the combination group were senior students. Grade level was also correlated significantly with FFA participation (r = .20, p = .05). These findings together suggest that grade level may contribute very little in the regression analysis due to the redundancy. To put it differently, the variable grade level was already measured in part through the variables program emphasis and FFA participation.

SOE involvement was correlated positively and significantly with academic aptitude (r = .26, p = .01). However, it was correlated more with the two dependent variables. SOE involvement was also correlated positively and significantly with FFA participation (r = .33, p = .001), and the correlation was higher than the correlation between FFA participation and the two dependent variables. The overlap between SOE involvement and FFA participation suggests that the latter may likely to be suppressed in the regression analysis.

Variance Explained in the Dependent Variables

The first step in the regression analysis was to determine the proportion of variance in each dependent variable accounted for by the independent variables when the latter
are grouped into two sets, namely, the academic aptitude set and the program variables set. The next step examined the contribution of individual independent variables to the explained variance.

Variance explained by sets of independent variables

Grouping the independent variables into sets allows the researcher to study the unique contribution of the set of variables directly related to vocational horticulture, while holding academic aptitude constant.

Academic aptitude represents a one-variable set which is not considered a program variable. The set of program variables, on the other hand, consists of all the other independent variables which were correlated with the dependent variable of interest. For the dependent variable problem-solving ability, five variables were included in the set of program variables: SOE involvement, problem-solving teaching behavior, FFA participation, and the two dummy variables for program emphasis. Grade level was not included because its correlation with problem-solving ability was negligible. For the dependent variable achievement, six independent variables, including grade level, make up the set of program variables.
Two separate simultaneous regressions were performed, one for each dependent variable. For each analysis, semi-partial multiple regression coefficients for sets \((sR^2)\) were computed from the full model sum of squares (type III SS). \(sR^2\) represents the amount of variance uniquely explained by a set of interest when the other set is partialed out from the model. Summary statistics for the two regressions are presented in Tables 15 and 16.

**Problem-solving ability.** The results indicated that both sets of independent variables accounted for a significant unique variance explained in problem-solving ability (Table 15). The overall \(R^2\) of .407 indicates the total amount of variance explained by all variables. This \(R^2\) was significant at .0001 level.

Academic aptitude alone accounted for 27.4% of the variance in problem-solving ability when the set of program variables was partialed out. The semi-partial multiple correlation was significant at .0001 level. Program variables together accounted for 8.1% of variance when academic aptitude was partialed out. This unique contribution was also significant, at the .01 level.
Table 15
Regression of Problem-Solving Ability Scores on Sets of Independent variables (n = 124)

<table>
<thead>
<tr>
<th>Variable Set</th>
<th>$K_A$</th>
<th>$K_B$</th>
<th>$sR^2$</th>
<th>$F$</th>
<th>$P&lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Aptitude</td>
<td>5</td>
<td>1</td>
<td>.274</td>
<td>54.07</td>
<td>.0001</td>
</tr>
<tr>
<td>Program Variable$^a$</td>
<td>1</td>
<td>5</td>
<td>.081</td>
<td>3.20</td>
<td>.01</td>
</tr>
</tbody>
</table>

Overall $R^2 = .407$, $p < .0001$

$^a$ Include: SOE participation, problem-solving teaching behavior, FFA participation, and the two dummy variables for program emphasis.

Table 16
Regression of Achievement Scores on Sets of Independent Variables (n = 124)

<table>
<thead>
<tr>
<th>Variable Set</th>
<th>$K_A$</th>
<th>$K_B$</th>
<th>$sR^2$</th>
<th>$F$</th>
<th>$P&lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Aptitude</td>
<td>6</td>
<td>1</td>
<td>.247</td>
<td>66.32</td>
<td>.0001</td>
</tr>
<tr>
<td>Program variables$^a$</td>
<td>1</td>
<td>6</td>
<td>.219</td>
<td>9.80</td>
<td>.0001</td>
</tr>
</tbody>
</table>

Overall $R^2 = .568$, $p < .0001$

$^a$ Include: SOE involvement, problem-solving teaching behavior, FFA participation, the two dummy variables for program emphasis, and grade level.
Achievement. From Table 16, the overall $R^2$ indicates that 56.8% of the variance in achievement was significantly explained by all variables together ($p=.0001$). This explained variance was about 16% higher than that found in problem-solving ability. The semi-partial multiple correlation for the set of academic aptitude indicated that 24.7% of variance was accounted for by academic aptitude when the other set was partialled out ($p=.0001$). The set of six program variables together accounted for 21.9% of the variance in achievement ($p=.0001$), nearly as much as did academic aptitude.

In sum, academic aptitude explained slightly greater unique variance in problem-solving ability than in achievement. On the other hand, program variables accounted for much higher unique variance in achievement than in problem-solving ability.

Variance Explained by Selected Independent Variables

A more detailed step in regression analysis is useful to understand the nature of problem-solving ability and achievement in relation to other variables.

Two strategies are commonly used in entering independent variables into a regression model in order to determine the
increment in $R^2$ due to each variable. In a step-wise analysis, the selection of variables and their order of entering are strictly determined from the data, resulting in a set of the best predictors (for that sample) with significant $R^2$ increment at each step. The limitations of this strategy lie not only on potential instability of findings (particularly when the sample size is not large enough), but also on the mechanics of eliminating some variables which are interrelated (Cohen and Cohen, 1983).

Using a hierarchical strategy, on the other hand, the researcher has some control over the selection and ordering of the independent variables based on their research importance. Although armed with only a modest theoretical basis about the relative importance of the independent variables, this researcher maintains that this approach provides more useful information for the purpose of this study.

Two separate regressions were performed, one for each dependent variable. For each analysis, only the independent variables which were correlated significantly with the dependent variable were selected. In addition, both dummy variables for the variable program emphasis were entered in one step. The entering order of the independent variables was determined on the basis of the theoretical background and the magnitude of their relationships to the dependent
variable of interest.

Problem-solving ability. Four variables were entered in the model in the following order:

Academic aptitude ($r = .57$)

SOE involvement ($r = .29$)

Program emphasis

Landscape ($r = .21$)

Greenhouse/Floriculture ($r = -.13$)

As presented in Table 17, a total of 40.6% of the variance in problem-solving ability was explained by the four selected variables. This explained variance was significant at .0001 level. $R^2$ increment for each step was calculated from the order-dependent sum of squares (type I SS). In the first step, academic aptitude accounted for 32.7% of the total variance which was significant at .0001 level. Since this was not a unique variance, it was essentially higher than reported in the previous analysis on sets. In the second step, SOE involvement explained 2.2% additional variance which was also significant ($p = .05$). In the last step, the two dummy variables were entered and together accounted for another 5.7% of variance in addition to the first two steps. The $R^2$ increment at this step was also significant ($p = .01$). For each dummy variable, only landscape emphasis made significant additional contribution of
5.4% of variance (p=.001). Due to its relationship with the other dummy variable, greenhouse emphasis accounted for only .3% additional variance.

Achievement. Six variables were selected to enter in the model in the following order:

- Academic aptitude (r=.59)
- SOE involvement (r=.39)
- Problem-solving teaching behavior (r=.37)
- FFA participation (r=.28)
- Program emphasis
  - Greenhouse/floriculture (r=-.26)
  - Landscape (r=.24)

From Table 18, the total variance explained in achievement was 56.8%, significant at .0001 level. First, 34.9% significant variance (p=.0001) was accounted for by academic aptitude, followed by an additional 5.9% by SOE involvement (p=.0001). Problem-solving teaching behavior contributed another 10.8% of the variance (p=.0001). The fourth variable entered, FFA participation, accounted for only .6% variance in addition to what already been accounted for by the first three variables. This variance increase by FFA participation was not significant (p=.20), suggesting that a suppression occurred by its correlation with SOE involvement. In the last step, program emphasis accounted for
Table 17
Regression of Problem-Solving Ability Scores on Independent Variables (Hierarchical Analysis, n = 124)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>R²</th>
<th>R² Increment</th>
<th>F</th>
<th>P &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic aptitude</td>
<td>.327</td>
<td>.327</td>
<td>65.37</td>
<td>.0001</td>
</tr>
<tr>
<td>SOE involvement</td>
<td>.349</td>
<td>.022</td>
<td>4.45</td>
<td>.05</td>
</tr>
<tr>
<td>Program emphasis</td>
<td>.406</td>
<td>.057</td>
<td>5.61</td>
<td>.01</td>
</tr>
<tr>
<td>Landscape</td>
<td>.403</td>
<td>.054</td>
<td>10.88</td>
<td>.001</td>
</tr>
<tr>
<td>Greenhouse/Floriculture</td>
<td>.406</td>
<td>.003</td>
<td>0.48</td>
<td>.50</td>
</tr>
</tbody>
</table>

Overall F = 20.30, p < .0001

Table 18
Regression of Achievement Scores on Independent Variables (Hierarchical Analysis, n = 124)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>R²</th>
<th>R² Increment</th>
<th>F</th>
<th>P &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic aptitude</td>
<td>.349</td>
<td>.349</td>
<td>94.47</td>
<td>.0001</td>
</tr>
<tr>
<td>SOE involvement</td>
<td>.408</td>
<td>.059</td>
<td>15.87</td>
<td>.0001</td>
</tr>
<tr>
<td>Problem-solving teaching behavior</td>
<td>.516</td>
<td>.108</td>
<td>29.18</td>
<td>.0001</td>
</tr>
<tr>
<td>FFA participation</td>
<td>.522</td>
<td>.006</td>
<td>1.66</td>
<td>.20</td>
</tr>
<tr>
<td>Program emphasis</td>
<td>.568</td>
<td>.046</td>
<td>6.23</td>
<td>.01</td>
</tr>
<tr>
<td>Landscape</td>
<td>.568</td>
<td>.010</td>
<td>2.78</td>
<td>.10</td>
</tr>
<tr>
<td>Greenhouse/Floriculture</td>
<td>.558</td>
<td>.036</td>
<td>9.79</td>
<td>.01</td>
</tr>
</tbody>
</table>

Overall F = 25.63, p < .0001
4.6% significant increase in variance (p=.01). The dummy variable greenhouse/floriculture emphasis, entered first, explained significant $R^2$ increment (3.6%, p=.01). The other dummy variable explained only 1% increase in variance (p=.10).

In review, only three independent variables contributed significant $R^2$ increment in problem-solving ability. For achievement, four independent variables added significant variance. Problem-solving teaching behaviors did contribute significantly in the model for achievement, but did not enter the model for problem-solving ability.

Relationships Between the Set of Criterion Variables and the Set of Predictor Variables

The finding that problem-solving ability and achievement were substantially correlated can be interpreted that they represented two related sub-domains of cognitive performance. Together, they are the desired outcomes of any program in vocational agriculture.

Separate analysis on each dependent variable provides meaningful findings. However, further treatment, considering the two dependent variables simultaneously, would enable the researcher to obtain the optimum information from the research data.
Canonical correlation analysis is a generalized multivariate procedure which enables the researcher to study relationships between two sets of variables. For this study, the two sets are: 1) the criterion variables (or the formerly labelled dependent variables), and 2) the predictor variables (or the independent variables). Canonical correlation analysis usually stands on its own, but may be meaningfully supplemented by a series of univariate analyses (Cooley and Lohnes, 1971), depending on the objective of the research. For this study which major emphasis was placed on problem-solving ability, the researcher was justified to present the correlation findings from a more specific approach (regression analysis) to a more general one (canonical correlation analysis).

To aid the discussion of canonical findings, basic concepts and major elements of this analytical procedure are briefly reviewed, based on the discussions by Levine (1977), Hair, Anderson, Tatham, and Grabowsky (1977), and Thompson (1985).

In simple terms, the underlying logic of canonical correlation analysis involves the derivation of a linear composite of variables from each set of variables so that the correlation between the two linear composites is maximized. Such linear composite is termed canonical variate. The
number of pairs of variates to be generated equals the number of variables in the smaller set. For this data, two variates for each set were derived.

Once the canonical variates are generated, canonical correlation can be obtained for each function (each pair of variates). This statistic represents the magnitude of relationship (or the link) which exists between a pair of canonical variates. The square of this correlation provides an estimate of the shared variance between the pair of variates.

The next step involves the significant testing of the canonical function(s). Two statistics are usually used for this purpose. First, a multivariate test (such as Wilks' Lambda) determines whether there is an overall significant relationship. Second, separate tests (Bartlett's chi-square is common) will further determine whether each function is significant.

The next unique element of canonical correlation analysis involves a determination of practical significance and practical importance of the statistically significant function(s). Stewart and Love's redundancy index (Levine, 1977) is very useful as a better measure of shared variance than the squared canonical correlation. The redundancy index indicates the ability of a set of variables to explain variation in another set, and vice versa. This
statistic is analogous to $R^2$ in multiple regression (Hair et al., 1979).

The final major task of the researcher is to interpret the nature of whatever relationships exist between the two sets of variables. Canonical structure coefficients, also known as canonical loadings, help to achieve this objective by presenting the relative contributions of each variable to the canonical relationships. This statistics is particularly useful for data with multicollinearity problem (Levine, 1977; Hair et al., 1979).

Findings from the canonical correlation analysis for this study were obtained through the SAS CANCORR and the BMDP6M procedures. Results are summarized in Table 19.

Two functions (two pairs of variates) were derived. The first function yielded a canonical correlation of .791. The correlation obtained from the second function was only .291. From Table 19, Wilks' Lambda of .343 with an F value of 11.623 indicated that there was an overall significant relationship between the two sets of variables ($p < .0001$). Bartlett's test further indicated that only the first function was significant ($\chi^2$-square=126.26, $p < .0001$).

The redundancy index for the set of criterion variables further confirmed that the first function provided the most
<table>
<thead>
<tr>
<th>Function</th>
<th>Canonical Correlation</th>
<th>Squared Canonical Correlation</th>
<th>Chi-Square</th>
<th>df</th>
<th>p&lt;</th>
<th>Trace Coefficient</th>
<th>Redundancy Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.791</td>
<td>.625</td>
<td>126.26</td>
<td>14</td>
<td>.0001</td>
<td>.745</td>
<td>.466</td>
</tr>
<tr>
<td>2</td>
<td>.291</td>
<td>.085</td>
<td>10.46</td>
<td>6</td>
<td>.1064</td>
<td>.251</td>
<td>.022</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>.488</td>
</tr>
</tbody>
</table>

meaningful relationship between the sets. The redundancy coefficients were found to be .466 for the first function, and only .022 for the second function. The cumulative redundancy index indicated that 48.8% of variance in the criterion set was explained by the canonical variates for the predictor set. Trace coefficients indicated that .745 of the total variance was extracted from the criterion set for the first function.

At this point the findings clearly indicated that there was a significant relationship between the two sets of variables. Further, canonical correlations, significant tests, and redundancy coefficients are in agreement in indicating that the first function (first pair of variates) was statistically as well as practically significant. The next procedure was to determine the nature of the canonical relationship and the relative importance of each variable to the relationship.

Canonical structure coefficient (canonical loading) represents a simple linear correlation between an original observed variable in each set and the canonical variate of the corresponding set. This coefficient can be interpreted in a similar fashion as a factor loading. For this study, the magnitude of structure coefficients are determined as:

- below absolute .25    low
- absolute .25 to .64   moderate
- absolute .65 or more  high
Table 20
Canonical Structure for the Two Sets of Variables
(for the First Variate)

<table>
<thead>
<tr>
<th>Variable Set</th>
<th>Structure Coefficients (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion Variables</strong></td>
<td></td>
</tr>
<tr>
<td>(Cognitive Performance)</td>
<td></td>
</tr>
<tr>
<td>Achievement</td>
<td>.95</td>
</tr>
<tr>
<td>Problem-Solving Ability</td>
<td>.77</td>
</tr>
<tr>
<td><strong>Predictor Variables</strong></td>
<td></td>
</tr>
<tr>
<td>(Related Factors)</td>
<td></td>
</tr>
<tr>
<td>Academic Aptitude</td>
<td>.83</td>
</tr>
<tr>
<td>SOE Involvement</td>
<td>.51</td>
</tr>
<tr>
<td>Problem-Solving Teaching Behavior</td>
<td>.40</td>
</tr>
<tr>
<td>FFA Participation</td>
<td>.34</td>
</tr>
<tr>
<td>Program Emphasis</td>
<td></td>
</tr>
<tr>
<td>Landscape Emphasis</td>
<td>.32</td>
</tr>
<tr>
<td>Greenhouse/Floriculture Emphasis</td>
<td>-.30</td>
</tr>
<tr>
<td>Grade Level</td>
<td>.24</td>
</tr>
</tbody>
</table>
Table 20 reports that for the criterion set the coefficients for both variables were high. Achievement, however, carried a higher weight (.95) than problem-solving ability (.77) in the relationship with their canonical variate. These differential weights may also be interpreted that the two variables were the measures of different but related sub-domains of cognitive performance. For the predictor side, academic aptitude was related most (.83) to the canonical variate for the predictor set. Moderate loadings were found on the variables SOE involvement (.51), problem-solving teaching behavior (.40), FFA participation (.34), landscape emphasis (.32), and greenhouse/floriculture emphasis (.30). The two dummy variables for program emphasis contributed in the opposite direction to the relationship. Lastly, grade level showed some degree of relationship to the canonical variate (.24), but was considered unimportant relative to other variables in the same set.

To summarize, the canonical correlation analysis yielded a simple solution(function) about the relationship between the two sets of variables. From the significant solution, high correlation exists between the criterion set and the predictor set. The total amount of variance in the criterion set explained by the the predictor set was quite high (48.8%). The canonical structure analysis revealed the relative contribution of each variable to its canonical
variate, regardless of the existing intercorrelations among the variables. The findings suggested that vocational horticulture students who possessed a higher level of knowledge in general horticulture and exhibited a higher level of problem-solving ability tended to have a higher level of academic aptitude, were engaged more in SOE projects, were exposed more to problem-solving learning activities, and participated more in the FFA activities. Such described students were likely to come from the horticulture program which emphasized the landscape content, but not likely to come from the program which emphasized the content on greenhouse/floriculture.

Regression analysis is a special case of canonical correlation analysis. Thus, findings from canonical analysis corresponds to the findings from the regression analysis reported earlier. The merit of canonical correlation lies in its more general interpretations when problem-solving ability and achievement were considered together as a set of cognitive performance. Further, the canonical structure analysis avoided the problem of intercorrelations among the variables and thus revealed more accurately the nature of relationships and the relative importance of the variables. However, this researcher maintains that, the optimum information for this particular research is achieved when interpretations are derived from findings of both specific and general levels of correlational analysis.
CHAPTER V
SUMMARY, DISCUSSION, AND IMPLICATIONS

Problem-solving ability is a much needed quality in the workplace. To teach students to solve problems in agriculture is to teach them the strategy of transferring their technical knowledge and skills effectively in real-life situations. Research is needed to provide a direction for developing such a desirable quality through the program of vocational agriculture. At the present stage of knowledge about problem solving in agricultural education, research should begin by revealing the nature and level of problem-solving ability of students in vocational agriculture. The research should also determine the extent to which program variables, the perceived antecedent variables of problem-solving ability, contribute to the development of this ability in students.

Purpose and Objectives

This study was an effort to begin the above-mentioned line of inquiry. The primary purpose of this study was to describe problem-solving ability of students enrolled in
vocational horticulture and its relationships to selected variables. In addition to problem-solving ability, achievement of students, a related cognitive variable, was also investigated as another dependent variable.

The two most important research questions investigated were:

1. How can students in vocational horticulture be described in terms of their ability to solve problems in horticulture?
2. What relationships exist between problem-solving ability of students and the following independent variables?
   (1) Academic aptitude of students
   (2) Extent to which teachers use problem-solving teaching behaviors
   (3) Degree of students’ involvement in supervised occupational experience (SOE)
   (4) Students’ level of participation in the FFA
   (5) Grade level of students
   (6) Emphasis of the program in which students are enrolled

Two additional research questions were also investigated:

3. What relationships exist between achievement and the independent variables?
4. What relationships exist between the set of cognitive performance variables (problem-solving ability and achievement) and the set of predictor variables (the independent variables)?

Procedures

A purposive sample of 133 students was selected from a population of regular students (not identified as "special needs" student) enrolled in the horticulture programs of 7 joint vocational schools in Ohio. All the selected schools participated in the 1986 Ohio Vocational Education Achievement Test Program.

Data on achievement in horticulture and academic aptitude were obtained from the Instructional Materials Laboratory at The Ohio State University. The researcher visited the seven schools to collect data on the other variables. A test of problem-solving ability in horticulture was developed to assess the ability of students to solve problems. A researcher-developed questionnaire was used to obtain data on students' ratings of the extent to which their teachers used problem-solving teaching behaviors, type of their SOE projects, and their PFA participation level. A teacher questionnaire, also developed by the researcher, was used to obtain teachers' self-ratings on
the extent to which they used problem-solving teaching behaviors. Teachers were also asked to evaluate each of their students on the degree of SOE involvement. Grade levels of students were obtained from teachers. Lastly, the programs in which students enrolled were classified into three types of content emphasis: greenhouse/floriculture, landscape, and combination. The classification was verified by the teachers and a state horticulture supervisor.

Descriptive statistics were calculated to describe the sample on all the variables in this study. Correlational analysis was conducted in three consecutive steps which included simple correlations, regression analyses on sets of variables and on individual variables, and canonical correlation analysis.

Summary of Findings

Descriptive Data

Slightly more than one-half (59%) of the students in the sample were juniors and almost one-half (47%) were enrolled in the horticulture program which emphasized the content in greenhouse/floriculture. Female students made up the majority (71%) of the sample.

Nearly one-half (46%) of the students scored lower than 50% of the total possible on the test of problem-solving
ability in horticulture. The landscape group on the average performed best on this test; but the mean scores of the three groups did not differ greatly (means=21, 19, 18). The analysis of level of reasoning for the less-structured problem (problem situation 8) revealed that about one-half (56%) of the students were able to justify their answers.

About three-fourths (77%) of the students scored lower than the 50% level of correct responses on the Ohio Horticulture Achievement test. The mean score of the greenhouse/floriculture group (mean=104) differed markedly from the mean scores of the landscape and the combination groups (means=126 and 116, respectively). The percent distribution of achievement scores revealed a similar trend.

For academic aptitude, nearly one-half (48%) of the sample scored less than 50% of the total possible. The combination group scored slightly higher (mean=48) than the other two groups (means=44, 44). However, the percent distribution indicated that a higher percentage of the landscape group (43%) were at the level of 60% or higher on academic aptitude than the other two groups (25%, 37%).

The analysis by grade revealed that, on the average, senior students scored slightly higher than junior students on academic aptitude (means=48, 43, respectively). Students of the two grade levels differed more markedly on achievement (means=122, 108). Performance on the test
of problem-solving ability was at about the same level between the seniors and juniors (means=20, 19).

Overall, students reported that they engaged in problem-solving learning experiences about half of the time in class. The teachers, on the average, rated themselves higher, reporting that they employed problem-solving teaching behaviors slightly more than half of the time. The correlation between the two ratings was low.

Supervised occupational experience of students was limited mostly to in-school laboratory experience, especially for junior students. Overall, the average SOE involvement score was slightly above the 50% level (mean=26). Means for the three groups of program emphasis differed only slightly (means=24, 26, 26).

On the average, FFA participation level was very low (mean=9, total possible=89), with a wide range of scores within the sample. The distribution of scores was skewed markedly, resulting from having very few high scores. Participation was concentrated almost exclusively at the chapter level.
Correlational Findings

Simple correlations

Pearson product-moment correlation coefficients revealed that problem-solving ability, achievement, and academic aptitude were correlated positively and substantially. Problem-solving ability was also correlated positively and significantly with degree of SOE involvement and being in the landscape group. Achievement was correlated positively and significantly with SOE involvement, problem-solving teaching behavior, FFA participation, grade level and being in the landscape group. There was a negative and significant relationship between achievement and being in the greenhouse/floriculture group.

The variance explained

A total of 40.7% of the variance in problem-solving ability was significantly explained by all the independent variables, except grade level. For achievement, 56.6% of the variance was explained by all the independent variables. Simultaneous regressions on sets of independent variables indicated that the sets of academic aptitude and program variables accounted for a significant proportion of variance in both problem-solving ability and achievement. The significant semi-partial multiple correlations revealed
that academic aptitude explained 27.4% unique variance in problem-solving ability and 24.7% in achievement. The set of program variables accounted for 8.1% and 21.9% unique variance in problem-solving ability and achievement, respectively.

Hierarchical analysis revealed that significant increments in $R^2$ in problem-solving ability were contributed by the variables academic aptitude(32.7%), SOE involvement(2.2%), and program emphasis(5.7%). For achievement, the significant increments in $R^2$ were accounted for by academic aptitude(34.9%), SOE involvement(5.9%), problem-solving teaching behavior(10.8%), and program emphasis(4.6%). FFA participation was entered in the fourth step in the regression for achievement, but did not account for significant $R^2$ increment.

Relationships between the two sets of variables

Canonical correlation analysis was performed on the criterion set (problem-solving ability and achievement) and the predictor set (the independent variables). The first canonical function was significant and yielded a high correlation of .791. The redundancy index indicated that a total of 48.8% of the variance was explained (predicted) by the predictor set. From canonical structure analysis, problem-solving ability and achievement were both
correlated highly with their canonical variate, but achievement carried a higher weight. For the predictor set, only academic aptitude was correlated highly with its canonical variate. SOE involvement, problem-solving teaching behavior, FFA participation, and the two dummy variables for program emphasis (greenhouse/floriculture and landscape) all had moderate loadings.

Conclusions

Based on the findings on this sample, the following conclusions can be drawn:

1. Most students have limited knowledge in general horticulture related to plant and soil sciences. Most have less than an average level of academic aptitude and do not demonstrate a very high level of problem-solving ability.

2. The higher the academic aptitude and the general knowledge in horticulture students possess, the better they tend to be able to solve problems in horticulture.

3. Students who are enrolled in the program which emphasizes the landscape content tend to outperform students in the combination program or the program which emphasizes greenhouse/floriculture. Conversely, students in the greenhouse/floriculture group tend to be less knowledgeable
in general horticulture and less capable in solving problems than their counterparts.

4. Senior students are likely to acquire more extensive knowledge in general horticulture than junior students. However, senior students are not likely to solve horticultural problems better than junior students.

5. The more students become involved in supervised occupational experience, the more likely they will acquire knowledge in general horticulture and the better they tend to perform when solving problems in horticulture.

6. Students who participate more in the FFA tend to have a higher level of knowledge in general horticulture. However, FFA participation is not likely to vary with problem-solving ability.

7. Teachers' perceived extent to which they employ problem-solving teaching behaviors is related to achievement but not to problem-solving ability in horticulture.

8. Of the variables studied, academic aptitude explains the highest proportion of variance in problem-solving ability and achievement in horticulture.

9. When academic aptitude is held constant, program variables together may be used to explain problem-solving
ability as well as achievement in horticulture of students. Taken individually, degree of SOE involvement and program emphasis can explain the two dependent variables. Problem-solving teaching behavior can explain only achievement, not problem-solving ability.

10. All the independent variables in this study as a set can predict cognitive performance of students, when the latter is defined as a criterion variable set which includes problem-solving ability and achievement. As far as the relative weight of the independent variables is concerned, academic aptitude is the most important variable in the predictor variables set. Grade level, on the other hand, is relatively unimportant to the relationship between the two sets of variables.

Discussion

The diversity of the content emphasis in horticulture appeared to have some influence on the outcome of this study. The area of greenhouse/floriculture includes a study of retail floriculture which, by its basic nature, may not be directly related to the general knowledge of plant and soil sciences. The absence of the retail floriculture content from the achievement and problem-solving tests explains in large part why the greenhouse/floriculture group scored lower than the other two groups
on the two tests. The difference was more evident for achievement because the achievement test measures more specific knowledge than the problem-solving test.

Past research in cognitive development has indicated that most students, even at the college level, do not function at a cognitive level necessary to solve problems (Chiappetta, 1973). Therefore, the finding that the majority of students did not perform well on the problem-solving test was not far from expectation. In fact, research in home economics education found a similar trend (Tartell, 1983; Manifold, 1984). However, an analysis of situation 8 (the less-structured problem), although limited by what might be criticized as being subjective, indicated that more than half of the students were able to justify their answers. This finding is more encouraging, yet needs further verification from future research.

Based on percent of correct responses, the finding that students overall scored better on the problem-solving test than on the achievement test may be of some surprise. One is likely to expect that a problem-solving test is more difficult than an achievement test of the same content area. However, Baron (1985) noted from his findings that "knowledge items are the most difficult items on the test because of their sensitivity to instruction and recall." (p.38). A review of items of the two tests in this study
revealed similar observations which partly explain this finding.

The fact that problem-solving ability, achievement, and academic aptitude were correlated with each other in the broad range around .50 is consistent with the literature on cognitive tests. Ennis, Millman, and Tomko (1985) provided a succinct interpretation of such a pattern of relationships:

"... as one might expect on the ground that scholastic aptitude would influence acquisition of both critical thinking ability and subject matter knowledge, that critical thinking ability would be of some help in acquiring subject matter knowledge (figuring things out), and that subject matter tests often do call for a degree of critical thinking... (p.17)."

Accordingly, the use of academic aptitude as a predictor variable was appropriate. However, the significant correlation of .52 between problem-solving ability and achievement should not lead to an interpretation that one test could substitute for the other. Ennis (1986) cautioned against a misleading assumption of "the things correlated are the same". (p.6). For this study, the correlation merely indicated that the two tests share some common overlapping components, namely, the basic cognitive skills and the content knowledge. Similarly, the finding that academic aptitude was correlated with problem-solving ability and achievement at about the same range should also be interpreted carefully. It will be grossly misleading to interpret that the
aptitude test measures the same level of thinking skills as the problem-solving test does. Chapter 3 revealed that the test of academic aptitude consists of subsections measuring primarily basic cognitive skills, including memory, but less of higher-order cognitive skills which are essential in effective problem solving.

Grade level appeared to vary with achievement, a consistent finding with the literature. On the other hand, because grade level may reflect things other than achievement and thinking ability, a low correlation between grade level and thinking ability is not unusual (Ennis, Millman, and Tomko, 1985). Yet, the negligible correlation between grade level and problem-solving ability as found in this study may be somewhat unexpected. One explanation is that the junior and senior students may function at about the same cognitive developmental stage.

Among the program variables, SOE involvement appeared to be an important factor for both achievement and problem-solving ability. This finding supported earlier findings which revealed the benefits of SOE on students' achievement. In interpreting the results on SOE involvement, however, one should keep in mind that this variable was not a direct measure of SOE experience—the actual data calculated from student SOE records. Rather, it was an indicator of students' activities through their SOE projects which may
provide problem-solving experiences. Such measurement was also limited by the fact that SOE for this sample consisted mostly of the in-school laboratory activities.

The significant but low correlation between FFA participation and achievement may be interpreted that higher-achieving students tend to be more active in the FFA. Further, since most of the contest and award programs provided through the FFA are related to technical knowledge, the significant relationship is logical. On the contrary, FFA activities do not typically include activities which directly enhance problem-solving skills in technical content. This may explain why FFA participation was not significantly correlated with problem-solving ability.

To reinforce desirable problem-solving behaviors of students, a strong and constant teaching emphasis on the process involved in solving problems is imperative (Ross & Mayne, 1982; Shaw, 1983). As reviewed in Chapter Two, even with the purposeful experimental treatment of problem-solving instruction, impact studies often failed to come up with significant improvement in problem-solving behaviors of students. Clearly, planned intervention was not introduced in this study. Therefore, it was not very surprising that the extent to which teachers use problem-solving teaching behaviors was not related to problem-solving ability. On the other hand, the significant correlation found
with achievement may be viewed as consistent with some reported impact studies which used achievement as the dependent variable. In all, the findings could be interpreted that the teachers in this study may not actually use problem-solving teaching behaviors to the degree that would benefit beyond the knowledge and comprehension level of learning.

Collectively, the program variables did explain a significant proportion of variance in problem-solving ability and achievement, a finding which is encouraging for agricultural educators. Specific regressions on problem-solving ability, however, revealed less encouraging results. Only SOE involvement and program emphasis accounted for significant increments in $R^2$, a total of only 8.1%. If program emphasis was regarded as an "intervening variable", SOE involvement would be the only significant program variable. This finding on problem-solving ability, once again, confirmed the need for a strong and purposeful emphasis on the problem-solving approach to teaching.

The canonical results interestingly revealed that FFA participation carried interpretable weight in explaining the cognitive variables (problem-solving ability and achievement). The findings confirmed that grade level played an insignificant role when the two cognitive outcomes are considered together. Lastly, the canonical
structure indicated the influence of the variable program emphasis. Without the knowledge from prior research, these findings need further investigation.

Implications

Research investigating problem solving is rare in agricultural education. Further, current research related to problem solving has not specifically investigated problem-solving ability as the dependent variable. Clearly, findings from this study alone cannot yet provide sufficient information for use in program improvement in vocational agriculture. The findings do not offer definitive answers of what constitutes problem-solving ability, of how problem-solving ability in horticulture can be enhanced through the instructional program of vocational agriculture, or how problem-solving ability can be best measured. However, this research does offer some valuable insights and set the stage for broader as well as more in-depth studies about problem-solving ability of students in vocational agriculture. Implications of this study are discussed in two sections: measurement concerns and future areas of investigation.
Measurement Concerns

Research on problem solving in education is handicapped by a lack of appropriate criterion measures. An achievement test, as has been used in many studies, cannot very well substitute for a problem-solving test. On the other hand, content-free thinking tests which are now available commercially do not reflect the ability of students to solve problems in a particular subject-matter area. The experience from this study lead the researcher to believe that content-specific test of problem solving combines the strengths of achievement and general thinking tests in one. This kind of test allows for more meaningful interpretations of research in content-specific problem solving as it is aimed for a specific content area and population. Therefore, the development and further improvement of problem-solving tests which are specific to vocational agriculture should receive a high priority in future research.

The basic test characteristics of the test of problem-solving ability in horticulture are not at a desired level, but are considered adequate for the purpose of this pioneering effort. A well-established test like the Cornell Critical Thinking Test shared similar basic characteristics when used with vocational students (see Tartell, 1983).
The test used in this study could certainly be improved with additional experience in test development.

Considerable efforts were made to ensure the content validity of the test. The panel of experts generally agreed that the test covers problems which are related to basic principles and practices in horticulture. In addition, the test does have face validity with regard to its ability to measure thinking skill. "It (the test) really makes students think", as one expert put it. The correlation between this test and the other cognitive tests, as discussed in the previous section, also suggests modest evidence of its construct validity.

More specific research could also establish a stronger evidence of the criterion validity. As critical thinking shares basic underlying elements with problem solving, a well established test of critical thinking could be used to estimate criterion validity of the test.

This test of problem-solving ability in its present form was intended to measure the composite skill in solving problems, but not specific skills or processes involved. With a selected problem-solving model at hand, process studies can be conducted to analyze specific skills students actually perform. This line of investigation can provide strong evidence for construct validity of the test.
More specific answers to the "how" and "why" of a problem-solving process can also be studied using procedures such as interviews and protocol analysis (analysis of detail records of the actual thinking process of subjects; Gabel, Sherwood, & Enoch, 1984; Rowe, 1985). The problem situation in this study, though limited in scope, illustrated the potential of problem-solving research using ill-structured problems. This format also allows the researcher to study problem-solving processes of a more practical nature—the everyday problems in agriculture with no definite right or wrong answer and which value judgement plays some role in the decision-making process. Several leaders of critical thinking tests have already begun some work on ill-structured problems (Ward, Frederiksen, & Carlson, 1980; Ross & Maynes, 1982; Ennis, 1986). Some work has also been done in content-specific problem solving (Gabel, Sherwood, & Enoch, 1984). Furthermore, machine scoreable ill-structured tests have paved ways for a more efficient use of this otherwise limited format of testing with a larger sample (Ward, Frederiksen, & Carlson, 1980).

Generally, low(reduced) reliability is not unusual for tests measuring thinking skills, especially when internal consistency is concerned (Ennis, Millman, and Tomko, 1985). The reliability of the problem-solving test used in this research could be improved. If multiple choice remains the format for the test, correction for guessing which is often
used for scoring thinking tests (see Ennis, Millman, and Tomko, 1985; Ward, Frederiksen, & Carlson, 1980) may be considered in future research of structured problems. Lengthening the test may be an option, provided that the test can be conveniently administered in two separate days so that students would remain attentive to the test. In all, reliability and discrimination power could be improved through repeated pilot tests and item analyses.

Another measurement concern facing this researcher was how to assess the extent to which teachers use problem-solving teaching behaviors. Items contained in the instruments for students and teachers were derived from the model of problem-solving teaching in vocational agriculture being advocated at The Ohio State University. Therefore, the items are theoretically based. However, the use of students' ratings and teachers' self-ratings could only approximate the extent of actual use of problem-solving teaching behaviors. The fact that the two ratings were not highly correlated raised some concern about validity of the measurement. This researcher maintains that if students' ratings will be used with low ability students, as was the case in this sample, most items may need to be revised such that they are more concise and comprehensible.

Researchers are often cautioned against the use of teachers' self-evaluation alone to measure teacher
behavior. This point should be especially considered in impact research where the treatment measure is evidently crucial. Alternative measures to supplement teachers' self-ratings should be considered. Ratings of actual teacher performance and student behaviors in the classroom or laboratory may be a good alternative. The ratings can be performed by teacher educators or state supervisors who are cognizant about the problem-solving approach to teaching vocational agriculture. Observation strategy may be used to qualify the nature of the teaching and learning behaviors. Observation strategies are particularly useful for vocational agriculture because the backgrounds of students become more and more diverse.

Future Areas of Investigation

Three lines of investigation in problem solving are suggested: broad-based research, specific research focusing on the problem-solving process, and impact and application-oriented research.

First, replication of research is needed. Correlational studies based on the theoretical framework used in this study should be conducted in other specialized areas of vocational agriculture. Comparative studies may be considered using subjects from both comprehensive schools and vocational schools. Although not yet documented, there are
some strong indications that findings from these two sub-populations may be different due to such student factors as academic ability, prior courses taken and/or experiences in agriculture, the nature of supervised occupational experience, level of FFA participation, and number of courses as well as performance in the basic academic subjects.

Additional variables may be investigated in correlational studies. The teacher variables, for example, should be studied in relation to the problem-solving ability of students. The variables in this group may include: 1) teacher's knowledge about a problem-solving process, 2) teacher's competence in solving agricultural problems, 3) teacher's knowledge of a problem-solving approach to teaching agriculture and the skills of using the approach, and 4) teacher's attitude toward a problem-solving approach to teaching agriculture.

Secondly, future research may consider a qualitative approach to investigate in-depth the problem-solving process itself. Case studies, for example, would allow the researcher to answer the questions "How does one go about solving problems?" and "How efficiently can one solve problems?". As suggested earlier, interview and protocol analysis are excellent strategies for this line of research. Another aspect of the problem-solving process which could be investigated in more depth is problem-solving teaching
behavior. Researchers may choose to use a qualitative approach as the major design of research or to use qualitative strategies to supplement quantitative research.

Finally, impact research can be designed to provide some causal interpretations about the problem-solving approach to teaching vocational agriculture. Impact research could begin with pure research, using experimental or quasi-experimental designs, which will lead to larger-scale application-oriented research in the future. Instruments must be well-developed for the measurement of the treatment as well as the outcome variables before impact research can begin.

To conclude, desirable cognitive outcomes of vocational agriculture include solid background knowledge in agriculture and an ability to apply that knowledge in given situations. Accordingly, future research in problem solving should include both cognitive dimensions, achievement and problem-solving ability, as the dependent variables.
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APPENDIX A

CORRESPONDENCE

174
March 13, 1986

Dear (school administrator):

We request the assistance of the students and teachers in the horticulture classes at ___ with a research project being conducted by the Department of Agricultural Education at The Ohio State University. The project investigates the problem-solving ability of students enrolled in horticulture courses. Specifically, we request (1) permission to administer a problem-solving test to students enrolled in the horticulture courses and (2) that the horticulture teacher complete an instrument and questionnaire about the course and the students who are enrolled. It will take approximately one hour for students to complete the test. Our estimates are that it will take teachers approximately 30 minutes to complete the instrument and questionnaire. In addition, we request that we be allowed to record certain academic information from the records of students that are maintained at the school.

All data will be confidential and no individual student or school will be identified in the research report. Only grouped data will be presented. Ms. Pompan Chuatong, a graduate student in the Department, is the principal investigator for the study. She will travel to the school to administer the test and collect the information from the horticulture teachers and from school records.

The research that we are requesting your assistance with is designed to provide information that can be used to improve our preservice and inservice teacher education programs for persons who are now teaching and preparing to teach horticulture in specialized programs in joint vocational schools and career centers.

Within the next few days we will call ___ to answer any questions you may have and to get your response to our request for assistance. After the schools that will be participating are determined, we will schedule a time during April when it will be most convenient for Ms. Chuatong to visit your school.

If you have questions, please call me at (614) 422-6321. Please note the enclosed letter from Mr. James Scott, district supervisor, endorsing this request for the involvement of your school in this project.

Very truly yours,

J. Robert Warnbrod, Professor & Chairman
Department of Agricultural Education

KB:cr
Enclosure

cc (the local supervisor)
(teachers of vocational horticulture)
TO: Selected Vocational Agriculture Supervisors, Directors, and Teachers

FROM: Jim Scott, Horticulture State Supervisor, Agricultural Education Service

Enclosed you will find a research instrument developed by the Department of Agricultural Education at The Ohio State University. I have served on a review panel for the development of the instrument and strongly encourage active participation by you and your vocational horticulture program.

I believe the study could provide valuable insights to the problem-solving abilities of horticulture students in Ohio.

Once again, I encourage you to actively participate in the study.

JPS:cr
APPENDIX B

TEST OF PROBLEM-SOLVING ABILITY IN HORTICULTURE
Solving Problems in Horticulture

Department of Agricultural Education
The Ohio State University
Columbus, Ohio 43210
March-April 1986

No.
INSTRUCTION

1. This is a test of your skills in solving horticultural problems.

2. The test consists of 8 problem situations in horticulture. There are several items following each situation. To answer these questions, you will have to use your basic knowledge in agriculture and horticulture along with the information provided in the situations. Answers MUST PERTAIN TO the corresponding problem situation.

3. For each question, you will be asked to answer in one of these ways:
   - WRITE the letter indicating your choice in the space provided,
   - CIRCLE the letter in front of the best answer,
   - WRITE a brief answer in the space provided.

4. Please do not guess wildly at any answer. If you have no idea at all what the answer is, do not choose an answer. But if you have a good idea, even though you are not positive, answer the question.
Situation #1 asks you to identify the CAUSES of the problem(s).

SITUATION #1

Last March, Linda prepared her vegetable garden. She bought tomato seeds from a seed company.

Using the available materials in the school greenhouse, Linda filled the flats with a sterilized mixture of equal parts perlite, vermiculite, and peat moss. Since bench space in the greenhouse was not available, she placed the seeded flats under one of the benches.

She checked on the flats daily, watering whenever the soil became dry. At the end of three weeks, she noted that about 70% of the plant seeds had germinated. Of those which germinated, most had long stringy stems.

*****

Attempting to explain the outcome of her efforts, Linda came up with a list of six possible CAUSES of the problem(s).

Indicate whether each of the following:

- a) was a **main** cause of the problem(s), or
- b) contributed **partly** to the problem(s), or
- c) was **unlikely** to cause the problem(s).

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

- Inappropriate soil mixture
- Low soil temperature
- Inadequate nutrient supply in the seeds
- Using seeds with a low percentage of germination
- Inadequate amount of light on the flats
- Having damping-off disease after germination
Situations 2, 3, 4, 5, 6, and 7 ask for your suggestions to SOLVE or prevent problem(s).

SITUATION #2

John wants a maple tree in his backyard. Since he needs more shade in the backyard, the best place to plant the tree is approximately four feet from the concrete patio. He is concerned with the root development of the tree in future years, especially if the roots grow under the patio and crack the concrete.

*****

Listed below are some suggestions to SOLVE this possible problem.

For each suggestion, indicate whether it:

- would largely solve the problem(s), or
- might help reduce the problem(s), or
- would not reduce the problem(s)

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

___Plant the tree deeper than usual to encourage deeper root growth.

___Choose a variety type of maple tree with a deeper root system.

___Prune the limbs on the patio side of the tree to control root growth.

___Encourage deeper root growth through appropriate watering and fertilization.

___Use systemic herbicides to control root growth on the patio side of the tree.
SITUATION #3

As part of his class project, Ted decided to root yew and juniper cuttings for production in the school nursery. In November, Ted carefully selected 50 cuttings of yew and 50 cuttings of juniper from the school landscape.

The cuttings were placed in a sterilized soil mix in the school greenhouse and were kept moist. After 10 weeks, Ted found that about 50% of the cuttings showed signs of root development.

*****

What could you suggest to Ted for the next time he wants to propagate yew and juniper cuttings?

For each suggestion listed below, indicate whether it:

a) would largely solve the problem(s), or
b) might help reduce the problem(s), or

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

___ Dip the cuttings in fungicide before placing in the soil mix.
___ Root the cuttings directly in 4-inch pots.
___ Dip the cuttings in IBA hormone before placing in the soil mix.
___ Apply fertilizer into the soil mix.
___ Select varieties of yew and juniper which reproduce more easily.
___ Select and root the cuttings only in spring.
SITUATION #4

Pat works at a retail garden center. One summer day, a customer carried into the store a plastic pot of sickly looking philodendron. The customer said to Pat, "I bought this plant here a month ago. Look at it now. Some leaves are turning brown and the plant has stopped growing. This plant obviously has a disease."

Pat picked up the plant and carefully examined the leaves and stem and felt the moist soil. Pat saw no evident sign of disease or insect injury. Pat then asked the customer how the plant was cared for at home.

The customer explained, "I placed this plant near a window on the south side of my house. This way it would receive sunlight all day. I water it thoroughly once everyday to prevent dryness from the sunlight. I also fertilized it two weeks ago."

*****

If you were Pat, what would you recommend to the customer to improve the health and condition of the philodendron?

For each suggestion listed below, indicate whether it:

| a) would largely solve the problem(s), or |
| b) might help reduce the problem(s), or |
| c) would not reduce the problem(s) |

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

___ Water the plant less frequently, and move it to a shadier area.
___ Repot the plant into a clay pot, and move it to a cooler area.
___ Increase fertilizer, and water the plant every day in the late afternoon.
___ Water the plant less frequently, and increase ventilation.
___ Repot the plant into a larger plastic pot, and use pesticide to control brown spots.
___ Increase fertilizer and ventilation, and water more frequently.
SITUATION #5

As part of his class project last spring, Jim was to establish a lawn at a new home in his neighborhood. The lot had been graded, with a slope about 5 feet per 100 feet away from the house across the backyard.

After a soil test, Jim applied the proper amounts of nitrogen, phosphorus and potassium and handraked the ground into a smooth, loosened surface ready to receive the seeds.

Next, Jim bought the necessary amount of Bluegrass mix recommended for his location in Ohio. Using a push-type seeder, he made sure that he applied the seeds to the ground evenly. Using a sprinkler, Jim kept the soil moist throughout the germination period. After one month, the germinating grass was thin and found in patches throughout the yard. Weed growth was found.

*****

What suggestion would you offer Jim to improve his lawn next time?

For each suggestion listed below, indicate whether it:

a) would largely solve the problem(s), or
b) might help reduce the problem(s), or
c) would not reduce the problem(s)

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

___ Cover the lawn lightly with a mulch such as straw or light soil.
___ Increase the amount of seeds used.
___ Sow the seeds and fertilizer together when the daytime temperature exceeds 75°F.
___ Grade the slope to less than 2 feet drop per 100 feet.
___ Seed a lawn only in the autumn months.
SITUATION #6

Last spring Joann had the responsibility of a home vegetable garden. She used the 15-15-10 fertilizer which her parents bought the previous year. She followed the directions on the bag which indicate that 5 pounds of the fertilizer is required for every 1000 square feet of garden. She applied all the required amount of fertilizer in one application at the beginning of the growing season.

In addition to the usual rainfall in Ohio, Joann used a sprinkler to water her garden once a week. Disease was not a problem in her garden last year. However, the vegetable production was not good.

*****

Based on the above information, what suggestion would you offer to Joann to improve her vegetable production next time?

For each suggestion listed below, indicate whether it:

a) would largely solve the problem(s), or
b) would help reduce the problem(s), or
c) would not reduce the problem(s).

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

____ Use compost materials to increase the organic content of the soil.

____ Increase the amount of fertilizer suggested on the directions.

____ Split the required amount of fertilizer in two halves, and apply each half six weeks apart.

____ Use a sprinkler to water the garden every other day.

____ Have the soil tested before planting, and follow the test result.
SITUATION #7

A horticulture class decided to produce a crop of poinsettias for the Christmas holiday. The rooted cuttings were delivered in September and potted in six-inch plastic pots in the school greenhouse. The greenhouse, located near a parking lot, is a double glass structure.

The cultural practices during the production months included watering, pinching, and fertilizing with daytime temperature of 73°F and nighttime temperature of 63°F.

Two weeks after Thanksgiving, the poinsettia plants were all green and bushy. The plant height varied from 15 to 18 inches. They looked healthy with no sign of insect or disease problem. However, the plants were not marketable for Christmas.

*****

What suggestion could you offer for poinsettia production next time?

For each suggestion listed below, indicate whether it:

a) would largely solve the problem(s), or
b) would help reduce the problem(s), or

WRITE a OR b OR c IN EACH BLANK (each letter may be used more than once)

_____ Use a variety of poinsettia which gives desirable color.
_____ Root your own cuttings in six-inch pots.
_____ Pot the poinsettia cuttings earlier.
_____ Monitor the light period for the poinsettia plants.
_____ Use growth regulator.
_____ Increase fertilization at flowering stage.
Situation # 8 asks you to choose the best answer and give your reasons.

SITUATION # 8

You have been hired to design and plant a landscape for a private home owner. In your visit with the family you find that they enjoy their privacy year round. Instead of having a fence, they wish to have screening plants placed along the back of the lot. You also find that there is no problem of high winds in this area.

As with all new home owners, they are anxious for a complete landscape but know that the cost of materials may restrict their desires.

Based on the plant information provided below, what kind of plant would you suggest?

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Number of Plants Needed</th>
<th>Growth per Year</th>
<th>Final Height</th>
<th>Cost per 3 gallon pot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous shrub</td>
<td>25</td>
<td>8 inches</td>
<td>6 feet</td>
<td>$12</td>
</tr>
<tr>
<td>Deciduous tree</td>
<td>18</td>
<td>10 inches</td>
<td>20 feet</td>
<td>$16</td>
</tr>
<tr>
<td>Evergreen shrub</td>
<td>20</td>
<td>10 inches</td>
<td>8 feet</td>
<td>$14</td>
</tr>
<tr>
<td>Evergreen tree</td>
<td>16</td>
<td>14 inches</td>
<td>30 feet</td>
<td>$17</td>
</tr>
</tbody>
</table>

1. Which plant would you choose to suit the needs of this family? (CIRCLE the letter of the best answer)
   a. Deciduous shrub
   b. Deciduous tree
   c. Evergreen shrub
   d. Evergreen tree

2. Give 3 reasons for recommending this kind of plant:
   1) _______________________________________________________
   2) _______________________________________________________
   3) _______________________________________________________
APPENDIX C

STUDENT QUESTIONNAIRE
STUDENT QUESTIONNAIRE

Department of Agricultural Education
The Ohio State University
Columbus, Ohio 43210
March-April 1986

On the following few pages you will be asked to answer questions about your background and your participation in school activities related to horticulture. The information you provide will be used in a study on problem solving in horticulture. Thank you for your help.

No.____
PART I: CLASSROOM ACTIVITIES

We would like to know about your classroom learning activities in horticulture. Particularly, we are interested in how you learn to solve horticultural problems.

The term "problem" as used here means true-to-life horticultural situations which you do not have a ready answer for. To come up with a good answer, you need to relate information together and think through the problem. You cannot simply recall facts in order to have a good answer.

EXAMPLE of horticultural problem:

"We did not have a good crop of poinsettias this year. How can we do differently next year?"

The situations in the problem-solving test you have just finished are good examples of the kind of horticultural problems we are concerned with in part I of this questionnaire.

For each of the statements in this part, CIRCLE the number which best indicates the extent to which you have had the listed learning activities in your horticulture class. Five numbers are indicated below:

1 = ALMOST NEVER or NEVER
2 = SOMETIMES but less than half of the time
3 = ABOUT HALF of the time
4 = FREQUENTLY -- more than half of the time, but not nearly always
5 = ALMOST ALWAYS or ALWAYS

EXAMPLE:

I participate in class discussion 1 2 3 4 5

This student indicates that he/she sometimes (less than half of the time) participates in class discussion.

Now, respond to the statements beginning on the next page.
In my horticulture class...

<table>
<thead>
<tr>
<th></th>
<th>Almost never</th>
<th>Sometimes</th>
<th>About half of the time</th>
<th>Frequent</th>
<th>Almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What we study in class is based on the horticultural problems that we have in our laboratory activities.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>What we study in class is based on the horticultural problems that we have in our out-of-school supervised occupational experience program (SOEP).</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>At the beginning of a unit of study, the teacher lists for us topics that we need to study in class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The teacher gives examples of horticultural situations for us to identify what problems exist in the situations.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>We are required to study real horticultural situations (from the laboratory, SOL, field trips etc.) to identify what problems exist in the situations.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The teacher tells me all the information I need when I have to find answers to horticultural problems.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>At the beginning of a unit of study, the teacher asks us to list horticultural problems which we need to be able to answer.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>The teacher shows us by examples that more than one answer may be possible for a given problem.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>The teacher requires us to think about more than one possible answer to a given problem before we decide on the best answer.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
reminder:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>almost never</td>
<td>sometimes</td>
<td>about half</td>
<td>frequently</td>
<td>almost always</td>
</tr>
<tr>
<td>or never</td>
<td>of the time</td>
<td>or always</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. When I need to find more information about horticultural problems, the teacher lets me decide what reference materials I should use.

11. When I find reference materials related to horticultural problems, the teacher lets me decide what information in the references should be used.

12. I use more than one source of information before I decide on the best answers to problems.

13. The teacher requires us to conduct experiments to help us get answers to problems.

14. The teacher requires us to discuss our experiences from out-of-school SOE projects to find answers to problems.

15. When we students come up with more than one possible answer to a problem, the teacher helps us decide on our best answer.

16. At the end of a unit of study, the teacher makes sure that we come up with the best answers to the problems which we have studied.

17. The teacher asks us to give reasons for the best answers we choose for the problems.

18. The teacher gives tests which basically ask us to recall specific details of what we have studied.

19. We use in our laboratory work the answers to the problems which we have studied.

20. I write plans of practice for my out-of-school SOE projects that include making use of the answers to the problems I have studied.
21. I use what I have learned about horticultural problems to solve problems in my out-of-school SOE projects.

22. When I have horticultural problems in my work (in the laboratory or in my SOE projects), my teacher asks me to bring up the problems for discussion in class.

23. When I have horticultural problems in my work, my teacher helps me come up with my best solutions.

24. We analyze our laboratory experiences to see whether our problem solutions work well.

25. I analyze my horticultural record books to see whether my problem solutions work well.

26. The teacher gives exercises or tests which require us to solve problems in horticulture (similar to the test we have just worked on today).

PART II: SUPERVISED OCCUPATIONAL EXPERIENCE PROGRAM (SOEP)

1. Mark X for any type of supervised occupational experience program (SOEP) listed below which you have had since the beginning of your study in horticulture.

☐ In-school laboratory
☐ Home improvement project
☐ Job placement or cooperative program
☐ Other types of SOEP (indicate): ___________________________

2. How many times since last summer has your teacher visited your supervised occupational experience program?

Home project ______ time(s).

Job placement or cooperative program ______ time(s).
PART III: FFA PARTICIPATION

This section is to be completed by the FFA members only. If you are not an FFA member, do not answer the questions.

Listed below are FFA activities at the chapter, district, state, and national levels.

MARK any activity which you have participated at each level.
MARK "none at all" if you have not participated in the activities at that level.

1. I have attended chapter meetings
   ☐ Regularly (attended almost or all meetings)
   ☐ Sometimes (attended about one-half of the meetings)
   ☐ Once in a while (attended a few meetings)

2. The office I have held in the chapter is/are (mark those which apply)
   ☐ A regular chapter office
   ☐ An assistant to a regular chapter office
   ☐ The FFA class office (such as Junior FFA, Vocational Agriculture II class, Ornamental Horticulture, and others)
   ☐ None at all

3. I have participated in chapter committee work as (mark those which apply)
   ☐ A member of a program of activities committee (standing committee)
   ☐ A chairperson of a program of activities committee
   ☐ A member of other committees
   ☐ A chairperson of other committees
   ☐ None at all
4. I have participated in the following CHAPTER activities
   (mark those which apply)
   ☐ Creed public speaking
   ☐ Extemporaneous public speaking
   ☐ Prepared public speaking
   ☐ Parliamentary procedure
   ☐ BOAC (Building Our American Communities Program)
   ☐ Other activities, indicate:__________________________
   ☐ None at all

5. I have participated in the following DISTRICT activities
   (mark those which apply)
   ☐ Extemporaneous public speaking
   ☐ Prepared public speaking
   ☐ Parliamentary procedure (a contest team)
   ☐ FFA Agriculture Proficiency Awards (district applicant)
   ☐ Other activities, indicate:__________________________
   ☐ None at all

6. I have participated in the following STATE activities
   (mark those which apply)
   ☐ Extemporaneous Public speaking
   ☐ Prepared public speaking
   ☐ Parliamentary procedure (a contest team)
   ☐ FFA floriculture judging contest
   ☐ FFA nursery and landscape judging contest
   ☐ FFA Agriculture Proficiency Awards (state applicant)
   ☐ Chapter delegate to state convention
   ☐ Attending state FFA convention
   ☐ Attending state FFA camp
   ☐ Candidate for state FFA office
   ☐ None at all

GO ON NEXT PAGE
7. I have participated in the following **NATIONAL** activities
   (Mark those which apply)
   □ Attending national FFA convention
   □ Extemporaneous public speaking
   □ Prepared public speaking
   □ FFA floriculture judging contest
   □ FFA nursery and landscape judging contest
   □ FFA Agriculture Proficiency Award (national applicant)
   □ **None at all**

**BACKGROUND INFORMATION**

Including this year, how many years have you been enrolled in agriculture or horticulture or both? (Include both at your JVS and your home school)

____ year(s).

Name ________________________________  First  Last  

Thank you for completing this questionnaire.
APPENDIX D

SOE SCORING INSTRUMENT
Instructions for Evaluating Supervised Occupational experience of Students

Using the attached score sheet, please score the level of SOE involvement for the academic year 1985-86 for each student in your horticulture class. The criteria and the scoring procedure are described below.

Criteria

1. Opportunity (for out-of-school SOEP)
   1.1 Opportunity for students to engage in out-of-school SOEP
   1.2 Extent to which the opportunity has been used by the student

2. Quality (for any type of SOEP), the extent to which the student:
   2.1 has taken part in planning the SOEP
   2.2 has participated in decision making about the SOEP (for example, making decisions when confronted with problems)
   2.3 has used approved practices learned in class in the SOEP
   2.4 has kept accurate records of the SOEP
   2.5 has evaluated his/her projects
   2.6 has, overall, demonstrated time and managerial commitment to the SOEP

Scoring Procedure

1. The possible scores range from 1 to 5, as follows:

   1  2  3  4  5
   very low low moderate high very high

2. When scoring any individual student, it is very important that the student be compared to the rest of the class on each criterion.
**Score Sheet for SOE Involvement**

**Reminder:**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>very low</td>
<td>low</td>
<td>moderate</td>
<td>high</td>
<td>very high</td>
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</table>

Student name

<table>
<thead>
<tr>
<th>Example:</th>
<th>John Doe</th>
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<table>
<thead>
<tr>
<th></th>
<th>Having opportunity in SOEP</th>
<th>Using SOEP</th>
<th>Planning SOEP</th>
<th>Keeping SOEP records</th>
<th>Using approved practices in SOEP</th>
<th>Decision-making in SOEP</th>
<th>Overall time and managerial commitment to SOEP</th>
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<tbody>
<tr>
<td>1.</td>
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APPENDIX E

TEACHER QUESTIONNAIRE
TEACHER QUESTIONNAIRE

In the following few pages you will find questions concerned with classroom and laboratory activities in your class.

The term "problem" as used in these questions refers to agricultural situations which require systematic thoughts rather than the mere listings of facts to come up with answers or solutions.

Please CIRCLE the number which best indicates the extent to which you have each of the listed activities in your class. Five numbers are indicated below:

1 = ALMOST NEVER or NEVER
2 = SOMETIMES but less than half of the time
3 = ABOUT HALF of the time
4 = FREQUENTLY -- more than half of the time, but not nearly always
5 = ALMOST ALWAYS or ALWAYS

EXAMPLE:
I involve students in planning for laboratory work (1) 2 3 4 5

This teacher indicates that he/she almost never (or never) involve students in planning for laboratory work.

Please turn to the next page to respond to the statements.
In my classroom and laboratory teaching...

1. I use specific horticultural problems that students have encountered or may encounter in their SOE program (other than the school laboratory) to determine what to teach.  
2. I use specific horticultural problems that students have encountered or may encounter in the school laboratory to determine what to teach.  
3. At the beginning of each unit of instruction, I present to students a list of topics to be studied.  
4. I use examples of real horticultural situations (e.g. from SOE, laboratory, field trips, etc.) for students to identify what problems the situations present.  
5. I have students observe real horticultural situations (e.g. from SOE, laboratory, field trips, etc.) to identify what problems the situations present.  
6. I tell students all the information they need to know in order to come up with their answers to problems.  
7. At the beginning of a unit of instruction, I involve students in developing a list of problems that determine what is taught in the classroom.  
8. Through examples of horticultural situations, I demonstrate to students that more than one possible answer may be generated for any given problem.
9. For any given problem, I require students to come up with more than one possible answer before a conclusion is made.

10. I let students decide what reference materials to use to find answers to problems.

11. I let students decide what specific information they should look for in reference materials to find answers to problems.

12. I require students to get information from more than one source before making conclusions about the answers to problems.

13. I require students to conduct experiments to find answers to problems.

14. I require students to analyze their SOE experiences (other than the school laboratory) to find answers to problems.

15. When students come up with more than one possible answer to a problem, I help them decide on their best answer.

16. At the conclusion of a given unit of instruction, I make sure that students know the best answers to the problems they have studied.

17. At the conclusion of a given unit of instruction, I make sure that students understand the reasons underlying the best answers to the problems.

18. I give tests which basically require students to recall specific information that I teach in class.

19. I require students to develop plans of practice for their laboratory work which use the answers to the problems they have studied.
reminder:
1. almost never
2. sometimes
3. about half of the time
4. frequently
5. almost always
or never
or always

20. I require students to develop plans of practice for their SOE projects which use the answers to the problems they have studied.

21. When students encounter horticultural problems in the laboratory or in their SOE projects, I encourage them to bring up the problems for discussion in class.

22. When students encounter horticultural problems in the laboratory or in their SOE projects, I make sure that they come up with their best solutions.

23. I require students to analyze their SOE experiences to determine whether their problem solutions work well.

24. I require students to analyze their laboratory experiences to determine whether any of the problem solutions work well.

25. I give exercises or tests which require students to apply their knowledge in solving horticultural problems (e.g. tests similar to the problem-solving test used in this research).

Thank you for completing this questionnaire.
APPENDIX F

SCALE FOR SCORING FFA PARTICIPATION
SCALE FOR SCORING FFA PARTICIPATION

<table>
<thead>
<tr>
<th>Activity</th>
<th>Weighted Score</th>
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</thead>
<tbody>
<tr>
<td><strong>A. Office held in chapter</strong></td>
<td></td>
</tr>
<tr>
<td>Regular officer</td>
<td>4</td>
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<tr>
<td>FFA class officer</td>
<td>3</td>
</tr>
<tr>
<td>Assistant to regular officer</td>
<td>2</td>
</tr>
<tr>
<td>Did not hold an office</td>
<td>0</td>
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<tr>
<td><strong>B. Chapter committee work</strong></td>
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<tr>
<td>Chairperson of program of activities</td>
<td>4</td>
</tr>
<tr>
<td>Chairperson of other committees</td>
<td>3</td>
</tr>
<tr>
<td>Member of program of activities</td>
<td>2</td>
</tr>
<tr>
<td>Member of other committees</td>
<td>1</td>
</tr>
<tr>
<td><strong>C. Chapter activities (for each activity)</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>D. District activities (for each activity)</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>E. State activities (for each activity)</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>F. National activities (for each activity)</strong></td>
<td>4</td>
</tr>
</tbody>
</table>

Adapted from the scale developed by Welton and Warmbrot (Welton, 1971).