1988

Level of critical thinking of Iowa secondary agriculture students

Timothy John Rollins
Iowa State University

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Level of critical thinking of Iowa secondary agriculture students

Rollins, Timothy John, Ph.D.

Iowa State University, 1988

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of Iowa secondary agriculture students

by

Timothy John Rollins

A Dissertation Submitted to the
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For the Graduate College

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1988
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INTRODUCTION

Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends constitutes reflective thought (Dewey, 1933, p. 9).

As educators face a growing body of complex information and knowledge, it is becoming apparent that the sheer amount of information needed by students to function in today's society is overwhelming. This "knowledge explosion" is growing so rapidly that many individuals risk becoming professionally obsolete unless they continually learn and update themselves. The emergence of technology associated with an information society demands that students possess the ability to process increasing amounts of complex information and knowledge in purposive and systematic ways.

Students of today must be prepared to cope with this world in order to effectively function in their future jobs and roles in society. No longer can students just be presented substantial amounts of factual information, general principles, and methods which they are expected to learn in order to prepare them for future endeavors. Glaser (1984) refers to this as "passive knowledge"—knowledge that students receive and express, but cannot use effectively for thinking and learning. Educational systems place the highest priority on skills with very general applicability: reading, writing, and mathematics. Skills in learning, reasoning, thinking, and general problem solving, however, are neglected.

Furthermore, knowledge alone is of very little value to competent human functioning without the reasoning, thinking, and learning skills
needed to use such knowledge in diverse situations and problems. Certain skills that might have been appropriate two decades ago may no longer be needed in the repertoire that students need to succeed in our present and future society. The uncertain demands of a new, dynamic, and complex era of demographic and social change, new technology, and world-wide economic competition and interdependency will be resolved with innovative and unique solutions to the problems that are posed. It has become apparent that much of the value of a student's education will come later in life from whatever thinking and learning skills they have acquired, along with the specific knowledge that schools can impart.

Success for a student will not necessarily hinge on their knowledge and ability to observe and react to the environment surrounding them. Students need to possess the dispositions and thinking skills necessary to work with and solve problems; they must be capable of knowing, doing, and thinking. They must know how to apply everything they already know and feel, to evaluate their thinking, and to change their behavior as a result of this process.

Recognition of the importance of cognitive functioning—intelligent thinking and intellectual processes— to individual competence in education, the community, and the workplace has come to the forefront as a growing concern at all educational levels. Schmidt and Hunter (1981) indicated that basic cognitive skills and abilities were directly related to job performance. In a report from the National Academy of Sciences (1984), it was concluded that these abilities may account for as much as one-third of the productivity differences between workers.
Educators, psychologists, and philosophers have been concerned with the elements of thinking and learning dating back to ancient times when Socrates, Plato, and Aristotle discussed aspects of thinking and mental processes with their students (Wingo, 1974). Older theories of learning focused on simpler forms of learning and did not provide an understanding of the higher cognitive processes. Educational practices based on these theories resulted in improved instruction for fundamental skills. Less emphasis was given to exercising thinking and problem solving abilities in the course of schooling.

The disciplines of philosophy, psychology, and education have been primarily responsible for providing the current definitions and conceptualizations of thinking skills. The individual frameworks are not equally based in empirical research nor have they been sufficiently developed to be successfully incorporated into any one instructional design. Collectively, however, these theories are at a point where they are beginning to provide a useful foundation for instructional and curricular development, as well as student learning.

There are diverse and numerous terms which describe these thinking and cognitive processes: higher order thinking, critical thinking, problem solving, decision making, and practical reasoning. Sternberg (Quinby, 1985) indicated that in spite of the terminology used to describe these processes, people are saying the same thing using different words.

It should be an important goal of educators that students develop the higher cognitive skills of being independent learners and critical thinkers and use the knowledge they have acquired. There is increasing
evidence, however, that explicit instruction in these cognitive skills is not occurring and that any proficiency attained by students is inadequate. The higher goals of thinking, learning, and problem solving are a challenge to excellence that educators of today should be striving toward (National Commission on Excellence in Education, 1983).

Human beings differ from one another in a vast number of ways. The demands of a particular situation draw upon aptitudes that create individual differences in the person's response to the problem. A student's performance in education is a product of whatever mixture of predispositions they bring to that performance that interact with the educational tasks and situations presented.

It has often been suggested that intellectual competence depends on an individual's cognitive style, meaning various slow-changing characteristics that pervade a person's manner of thought and perception.... Such characteristics differ from strategies, as the term is used here, in that strategies are specific actions to be taken at specific points in a problem solving or other process. Indeed, the distinction between strategies and cognitive style is not always made. However, I want to urge that the distinction is worth making. Because strategies occur at particular points within an ongoing process, whereas cognitive-stylistic characteristics pervade the process, the dynamics of learning one or the other might be quite different. Also, which one or what synthesis best accounts for intellectual competence is an important question" (Perkins, 1985, p. 350).

Cognitive style is a concept that refers to individual differences in cognition—acquiring and processing information—which includes all of the processes by which knowledge is acquired: perception, thought, memory, and problem solving. Variations in one's style of cognition implies more than just degrees of skill or ability; it also implies the existence of
Individual differences and preferences in the actual manners of gaining, storing, processing, and using information. This leads one to conclude that there is both a qualitative and quantitative variation in mental functioning that underlies the concept of cognitive style.

A learning style consists of combinations of cognitive, affective, and physiological traits. Collectively, they are used to characterize how learners typically learn best. Learning style reflects individual differences in the way information is acquired, processed, and assimilated. Studies of learning style suggest that individuals tend to place themselves in and seek out situations and tasks which will allow them to use their preferred modes of bringing new information into their cognitive structures. Knowledge about learning styles is a fundamental new tool at the service of teachers and schools. It provides a deeper, more profound view of the learner than previously perceived, and is part of a basic framework upon which a sounder theory and practice of thinking, learning, and instruction may be built.

The effectiveness of a student’s critical thinking skills will be influenced by the predispositions they have towards acquiring and processing information—thinking and learning. This cognitive process is approached by individuals with varying styles of performance. Cognitive or learning styles are associated with the overlap between individual differences in intellectual abilities and personality characteristics. Research has shown that an individual’s propensity for a certain manner of work in a given situation is different from but constrained by one’s intellectual ability and their personality.
Over forty years ago in *Permanent Learning*, Lancelot (1929) described a person's knowledge and thinking ability as being of crucial importance for human efficiency and success in the then present age of science and technology. He attributed the success of solving problems encountered in life every day to a "general thinking ability."

Strong, Silver, and Hanson (1985) defined the five principal goals of education: mastery, understanding, synthesis, involvement, and cultural literacy. Each of these goals included a set of teaching strategies and a set of thinking and learning styles. Inherent within each of these factors are relationships between the learner, the teacher, and curriculum. The implications of each of these statements may seem awesome and overwhelming to educators, but the product is not diminished at the expense of the teaching method or process. Crunkilton (1984) stated that the significance of teaching students thinking skills was to develop an "intellectual autonomy" with which they could develop an attitude for identifying solutions to problems.

There are many models of thinking that have been successfully implemented and effectively utilized in classroom settings to teach students how to think and learn best. Research has shown that thinking strategies are most effective when taught in conjunction with the appropriate subject matter content. By teaching students how to think and learn independently, we increase their power to think and learn outside of the classroom. It is vital that knowledge and thinking skills become tools that can be used by students for the preservation and advancement of agricultural knowledge by present and future generations of this society.
The purpose of this study was to determine the ability of Iowa agriculture students to use critical thinking skills.

The specific objectives of this study were to:

1. Assess the critical thinking abilities of Iowa agriculture students as measured by a standardized test of critical thinking.

2. To compare the critical thinking abilities of Iowa agriculture students to established critical thinking values.

3. To assess and analyze levels of critical thinking related to learning style.

4. To analyze selected relationships associated with levels of critical thinking.
We are concerned in teaching with the improvement of thinking. Everybody agrees that such improvement is desirable (Smith, 1953, p. 129).

The following sections comprise a review of both the literature and the research pertinent to this investigation. This review was not meant to be all inclusive, but rather a compendium of the most relevant, significant, and valuable findings which will contribute to an understanding and appreciation of the current state of the art of "critical thinking."

Critical Thinking

B. Othaniel Smith (1953) began his treatise on critical thinking with the above quotation. Smith's concept of critical thinking was based on operations involved in determining the meaning of a statement and whether to accept or reject it. The psychological literature of that era termed this problem solving.

John Dewey's (1933) philosophical effort to define thinking—reflective thinking—was aimed toward improving an individual's thinking processes to "change his own personal ways until they become more effective; until...they do better the work that thinking can do and that other mental operations cannot do so well" (p. 3). Dewey also recognized the problem solving aspects of thinking in the second of his five phases of reflective thought.

Mental processes represent a difficult and complex subject for study. Much of the research during the middle of this century attempted to infer
from the observed behavior of the individual what their mental processes must have been. However, the research of Bloom and Broder (1950) revealed differences in the ways in which individual students approached and solved problems. They were convinced:

that a study of problem-solving processes is basic to an understanding of individual differences—their measurement and control. Systematic research in this psychological field should yield results fundamental to a qualitative as well as quantitative science of human behavior (p. 103).

Robert H. Ennis (1962) concluded that efforts to teach critical thinking had been deficient due to the fact that no one had attempted a comprehensive, detailed examination of what was involved in making judgments about the worth of statements or answers to problems. Although Ennis essentially supported Dewey's proposition on thinking, he felt that it provided only a psychological and not a logical criterion for the solution of the problem. In other words, the problem was solved when the thinker thought it was solved.

The early effort of Ennis (1962) to define critical thinking, "the correct assessing of statements," elaborated on Smith's definition by delineating skills that called for the application of formal and informal logic. Ennis (1964) characterized a critical thinker by their proficiency in judging whether:

1. A statement follows from the premises.
2. Something is an assumption.
3. An observation statement is reliable.
4. A simple generalization is warranted.
5. A hypothesis is warranted.
6. A theory is warranted.
7. An argument depends on an ambiguity.
8. A statement is overvague or overspecific.
9. An alleged authority is reliable (p. 287).
Since then, Ennis has expanded his concept of critical thinking to include thirteen dispositions:

1. Seek a clear statement of the thesis or question.
2. Seek reasons.
3. Try to be well-informed.
4. Use credible sources and mention them.
5. Take into account the total situation.
6. Try to remain relevant to the main point.
7. Keep in mind the original and/or basic concern.
8. Look for alternatives.
10. Take a position (and change a position) when the evidence and reasons are sufficient to do so.
11. Seek as much precision as the subject permits.
12. Deal in an orderly manner with the parts of a complex whole.
13. Be sensitive to the feelings, level of knowledge, and degree of sophistication of others (Ennis, 1985, p. 46).

Sternberg and Baron (1985) provided a crucial connection between critical thinking and problem solving when they described critical thinking skills as including the abilities to "define and clarify, judge information, and infer-solve problems and draw reasonable conclusions" (p. 42). Ennis (1985) believed that higher-order thinking skills were also incorporated in his definition of critical thinking because "deciding what to believe or do is a higher-order thinking enterprise, and most practical higher-order thinking activity is focused on deciding what to believe or do" (p. 47). The working definition of critical thinking by Ennis (1985) evolved into "reflective and reasonable thinking that is focused on deciding what to believe or do" (p. 45) and, as defined, involved both dispositions and abilities and is a practical activity.
Cognitive Science and Education

As the result of efforts in psychology, other disciplines, including education, entered the field of cognitive science and focused on the workings of the mind, or cognition. The strategy of this chapter was to examine two sets of literature dealing with the topic of critical thinking or problem solving. From the field of psychology, one can explore a body of knowledge which seeks to understand human problem solving in the laboratory and the real world. In education, the body of knowledge is focused on the systematic training and education of attitudes, abilities, and skills of people to become problem solvers.

Reif (1980) concluded that a significant gap exists between educators' and cognitive scientists' approaches to problem solving due to historical and sociological reasons. Educators are concerned with realistic teaching activities with human students; they use rules of thumb, and approach tasks in intuitive ways. Cognitive scientists, on the other hand, think analytically, conduct experiments to confirm their theories, and work with computer models.

Individuals, i.e., Newell, Simon, Bloom, Sternberg, et al., in the disciplines of cognitive science and education have emerged as significant leaders and contributors in this investigation of cognitive processes. The following paragraphs summarize the writings of these individuals and the contributions they have made to the effort of precisely defining and describing the thinking and intellectual processes comprising "critical thinking."
Cognitive science was defined by Reif (1980) as "a group of related disciplines characterized by a common approach to complex information-processing systems" (p. 43). Recent work in cognitive psychology has added much to what is known about the processes involved in the development of human intellectual activity and processes (Quellmalz, 1985; Resnick, 1981). Thomas and Litowitz (1986) alluded to the importance of cognitive science to vocational education when they stated:

These developments allow more precise definitions and concepts of thinking, more focused teaching of intellectual processes required in order to use knowledge, better structured curriculum that will result in better retained and more usable learning, and more comprehensive assessment that goes beyond rote memory and recall levels of intellectual functioning (p. 14).

The recent advent of cognitive psychology brought about a major conceptual shift from the behaviorist tradition which predominated educational thinking and curricular designs in the past. As Glaser (1984) stated:

Psychological knowledge of learning and thinking has developed cumulatively through S-R formulations, Gestalt concepts, information-processing models, and current knowledge-based conceptions (p. 95).

Some of the earliest research into problem solving stemmed from operant-behavior analysts and theorists who believed that complex behavior was not different from simple discrimination learning. Resnick (1983) stated "...radical behaviorists denied that a science of mental life was possible because mental events were not open to public observation" (p. 7).
In distinguishing between various psychological theories of problem solving, Davis (1973) concluded that despite their different emphases, all of the specific stimulus-response (heretofore referred to as S-R) learning theories assumed that problem solving and thinking obeyed the same powerful laws of conditioning as the simpler forms of learned behavior, with two important exceptions. In their effort to gain simplicity, S-R theorists sacrificed the complexity of the conscious, thinking, and feeling human being for simplicity. Secondly, there was no prescriptive value in the learning-based problem solving literature.

Davis (1973) also described "the distinguishing characteristic of the Gestalt and the more contemporary cognitive psychologist is his commitment to explain human behavior in its everyday, conscious, and strategic purposiveness" (p. 29). Instruction and assessment of student learning focused heavily on inputs to and products from mental processes rather than on the mental processes themselves. Behaviorists showed little interest in process; the learner was a passive medium through which information was consumed. Learning was controlled by sensory inputs from the immediate environment with either "mediating responses" or no intervention at all between the stimulus and response in problem solving situations (Green, 1966).

One area of interest of cognitive science research is on the Human Problem Solving Theory (Thomas and Litowitz, 1986) which focuses on the relationship between mental processes and conceptual knowledge. Currently, three major aspects of problem solving research and theory are being intensely investigated: the nature of the problem; problem solving
methods; and the individual problem solver. Even though an individual may possess a high level of general problem solving ability, research has shown that when a problem requiring specialized knowledge is presented, the individual may be unable to reach an appropriate solution (Greeno, 1980; Norman, 1980; Frederiksen, 1984).

"Well-defined" problems have been defined as those where a test already exists that can be performed with a small amount of processing to determine a proposed solution (Newell and Simon, 1972; Wickelgren, 1974). Many practical types of the problems confronted in life consist of situations where not all of the information has been explicitly described. There is no specified solution nor method of formally testing or determining the appropriateness of a solution if, indeed, a solution exists. "Ill-defined" problems (Newell and Simon, 1972) are those for which no such tests exist. Some examples might include most social and political problems and many scientific problems. In his effort to distinguish between formal and ill-defined problems, Wickelgren (1974) concluded that the latter type may have to be transposed into a formal problem and dealt with accordingly.

Within the field of cognitive science, research on problem solving has produced a general theory of problem solving which has four major steps with numerous sub-elements (Newell and Simon, 1972). The first step of this theory is representing the problem. It involves perceiving, defining, and organizing all of the various factors found in the problem situation, categorizing and establishing the context of the problem, and selecting an appropriate classification for the problem.
Chi, Feltovich, and Glaser (1981) have shown that the initial representation of a problem is different for expert physicists than for novices. When novices were asked to categorize physics problems on the basis of similarities in methods of solution, they tended to sort problems on very basic and surface levels. Experts with knowledge and experience, however, represented a problem in terms of fundamental principles containing both the factual and procedural knowledge of the solutions involved. Larkin, McDermott, Simon, and Simon (1980) have also shown that the process of solution is also different for novices and experts.

Problem solving for novices has been characterized as a "means-end analysis" in which they work backward from a goal. This process is contrasted by experts who seem to be working forward from the information given in the problem (Resnick, 1983). One example of this difference in processing may occur when medical doctors, as opposed to interns, diagnose symptoms and prescribe treatments for patients. The more experienced doctors will interrogate the patient in more depth to ascertain the true nature of the illness and will be less prone to make snap decisions.

Reducing the problem is the second step; it may also be referred to as constructing the problem space. This step is still concerned with finding and identifying the details of the problem but at a more specific level. In this step, defining key elements of cause and effect relationships, goals, and available resources in both the present and desired state of affairs occurs. Bransford and Stein (1984) concluded that "human beings seem to need to break complex problems into component parts in order to succeed" (p. 19). Frederiksen (1984) stated "the
quality of the solution to the problem will be determined by the adequacy of this representation of the problem" (p. 367).

The third step for solving the problem involves the selection of a method or methods to use in selecting the most appropriate approach to generate a solution within the problem representation. The two most general methods are: changing the problem representation, and changing the method within the particular representation.

The former involves reclassifying the original information. Within the latter one, however, there are three more specific approaches: using an algorithm, such as in mathematical computations; generating and testing each of all the possible solutions; and finding a solution path, such as heuristics used by Polya (1973) in the teaching of mathematics (Thomas and Litowitz, 1986). Different kinds of formal problems also have general problem solving methods which have been described by Wickelgren (1974).

The final step, generating and evaluating solutions, occurs when the problem solving method is applied and tested to discover whether the potential solution meets the criteria of the problem solver. Complications may occur for the problem solver when the criteria are formulated for solving ill-structured problems.

One particular process of problem solving has been characterized by Bransford and Stein (1984) in The IDEAL Problem Solver. They have encapsulated their five-step process into Identifying and Defining the problem; Exploring strategies; Actively applying these strategies; and Looking at the effects.
Another major viewpoint of the cognitive system is that it is primarily a Human Information Processing system. The initial effort of Newell and Simon (1972) produced the information-processing framework which was summarized and revised by Newell (Simon, 1978). The conceptual structure which provided the foundation for much of the work on information-processing models of cognition was derived from this model (Bower, 1975).

The Information Processing Theory describes how individuals collect, store, modify, and interpret information from their surroundings, retrieve and restructure previously-stored information, and how knowledge and information is used in every facet of human activity (Thomas and Litowitz, 1986). This theory is concerned with the ways in which knowledge is represented, coded for storage in human memory, and the internal mechanisms used for processing which ultimately determine behavior.

According to Newell, Shaw, and Simon (1958), a program that successfully models (or simulates, duplicates, imitates) the tricks, devices, and strategies of the human problem solver may be viewed as a theory that explains human behavior. They were primarily interested in the process of solving problems and based their theory on the concepts of information processing and computer programming. Each program, as a theory, attempted to explain the observable human problem solving behavior by specifying the needed information and an organized set of information-processing operations. A successful computer program could serve as an exact, unambiguous description of a problem solving sequence
that parallels, point by point, the strategic way an individual processes information to reach solutions.

The two major assumptions in this framework are (1) the individual problem solver is an information-processing system; and (2) problem solving is both a search process and a process of understanding. The information-processing framework assumes that a solution to a problem involves searching through a problem space which is the solver's representation of the task. This representation is constructed by understanding processes to make use of both general comprehension mechanisms and the solver's knowledge of a specific domain. Constructing this problem space increases the problem solver's understanding of how to solve the problem which, in turn, leads to the generation of a new problem space. The process repeats itself with search and understanding processes alternating in complex ways (Poison and Jeffries, 1985).

The information-processing model also assumes a short-term or working memory system that is distinct from the long-term memory system. The problem solving activity is assumed to take place in working memory, and long-term memory is used as a type of resource in the solving process. Working memory is considered to have a limited capacity, which means, in terms of the problem solving model, that only a few states of the problem can be held in working memory at any one time. The problem solver is thus presumed to move from state to state without much backtracking, primarily because of the difficulty of going back to states that are no longer in working memory. However, when a solver reaches a particular state and apparently cannot advance toward the goal from that state, the solver may
return to the problem representation and define a new or modified problem space (Voss, Tyler, and Yengo, 1983).

Calfee (1981) and others believed there are four major, process-oriented components of this information system. They are: (1) sensory input and perception; (2) memory representations; (3) control processes; and (4) output and response mechanisms.

Our five sensing organs receive messages from the surrounding environment either simultaneously or in stages. An individual's perception can be based either upon these sensory inputs which Laster (1985) termed bottom-up perception, or on higher level information from memory, termed top-down perception. Perception is a process of construction, correcting and creating reality as information is used from the environment and from memory. Both types of perception processes are used in differing degrees depending upon the input. This provides the essential link between memory and perception.

Memory can be portrayed as a continuously active and organized system of information that is composed of short-term memory (STM) and long-term memory (LTM), the latter containing permanent knowledge and skills (Frederiksen, 1984). When new situations arose, Doyle (1983) hypothesized that memorization produced knowledge that was not readily applicable. Repeating or rehearsing information did not seem to improve memory. Craik and Lockhart (1972) found that retention generally increased as the level of processing increased. Individuals who recognized patterns and meanings retained information longer than individuals who just analyzed the physical and sensory features of information. Gitomer and Pellegrino
(1985) concluded that differences in long-term memory retrieval were more likely due to differences in content, the importance of concepts and features, and to the use of active processing. Previously, it had been thought that these differences were due to differences in the stages of individual development.

Research into cognitive strategies and control processes has discovered two kinds of information processing: controlled and automatic (Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977). A controlled process, using one sequence at a time, requires the conscious attention of the individual and uses up the capacity of the working memory. Automatic processing is controlled by a particular input to the working memory rather than by the individual, resulting in more capacity of the working memory. Although it requires a great deal of training and practice, automatic processing can be used for the more routine elements of problem solving, leaving the controlled-processing resources for novel aspects of the activity (Frederiksen, 1984).

Learning Styles

The strategies previously referred to by Perkins—"specific actions to be taken at specific points in a problem"—have been identified as cognitive strategies (Kirby, 1979). Sternberg (1984) referred to these strategies as "metacomponents" which he described as "the higher order or executive processes that we use to plan what we are going to do, monitor what we are doing, and evaluate what we have done" (p. 40).

Various thinking or cognitive processes (Kirby, 1979) used to support and complement these cognitive strategies include "performance components"
(Sternberg, 1984) and learning (McCombs, 1981-82) or knowledge acquisition strategies (Sternberg, 1984). "Performance components" are used to actually solve the problem and do what the executive processes tell you to do (Sternberg, 1983). Learning strategies are used to learn new materials or procedures to do problem solving. Wagner and Sternberg (1984) concluded that the higher level, metacognitive strategies seem to be more transferable than study strategies or domain--or task-specific microstrategies when learning new materials or procedures.

Efforts to identify the cognitive components of competent and intelligent performance have been numerous and fruitful (Simon, 1980; Wagner and Sternberg, 1984; Larkin, 1980; Pellegrino, 1979). In comparisons of expert and novice problem solvers, Simon (1980) concluded that "there is no such thing as expertise without knowledge--extensive, accessible knowledge" (p. 82).

Two types of knowledge are necessary to solve problems well--procedural and conceptual (Glaser, 1984; Larkin, 1980). Whereas procedural knowledge represents "knowledge about the application of what they (individuals) know" (p. 99), conceptual knowledge is composed of facts, principles, and abstractions or concepts (Glaser, 1984). Novice and expert problem solvers differ in the way they organize knowledge in memory. Findings indicate that knowledge is more retrievable when it is grouped or clustered by conceptual categories or organized with familiar retrieval cues (Larkin, 1980).

Sternberg and Caruso (1985) defined practical knowledge as "procedural information that is useful in one's everyday life" (p. 134).
Practical knowledge must be procedural rather than declarative and the knowledge must be relevant to one's everyday life. It is stored in the form of condition-action sequences. If a certain condition is met, a certain action is performed. Practical knowledge is acquired in three ways—direct learning, mediated learning, and tacit learning—and can be applied through adaptation, shaping, and selection.

In addition to the differences cited between novices and experts in the amount and the way knowledge is organized to solve problems, different cognitive processes and strategies are used. When combined with knowledge, the most transferable of these general metacognitive executive skills appear to be planning; representation (Greeno, 1980); and self-monitoring, self-management skills (Brown, Campione, and Day, 1981). These three skills can be very important in deciding the best thing to do when solving different problems satisfactorily since there are many different types of problems requiring many different problem solving skills (Greeno, 1980).

Sternberg (1984) identified seventeen "principal abilities underlying intelligent behavior" which include metacognitive and performance components. Five of these skills may be categorized as planning activities:

1. Recognizing and defining the nature of a problem.
2. Deciding upon the processes needed to solve the problem.
3. Sequencing the processes into an optimal strategy.
4. Deciding upon how to represent problem information.
5. Allocating mental and physical resources to the problem (p. 40).
Within the fourth ability, deciding upon how to represent problem information, the second metacognitive executive skill of representation is found.

The third general metacognitive component, self-monitoring or self-management, also appears to be an essential skill for successful problem solving (Bloom and Broder, 1950; Whimbey, 1980; Brown, Campione, and Day, 1981). Many children and adults alike are not conscious of nor able to explain their problem solving and learning strategies (Wagner and Sternberg, 1984). However, those students who possessed this ability were able to learn and accurately solve problems in an effort to achieve the desired goal (Bloom and Broder, 1950; Whimbey, 1980; Brown, Campione, and Day, 1981).

These three general metacognitive executive skills—planning, representation, and self-monitoring or self-management—provide a foundation for evaluating student differences and needs. The use of this framework makes it possible to begin to identify important cognitive objectives for students.

Thomas and Litowitz (1986) cited findings from information processing research that reveal several factors which influence the storage, coding, retrieval, structuring, and application of knowledge by humans:

1. The context in which something is learned is important for the retrieval of that knowledge. Context-free knowledge may not transfer to other situations unless links by which that knowledge is learned and codes for its storage are explicit.

2. The existence and development of different memory systems are still being debated, but at least two have been identified: episodic
memory (personal memories, one's own past, etc.); and semantic memory (general knowledge).

(3) The relationship between knowing and doing involve declarative (facts, concepts, and principles) and procedural knowledge (performance and thinking skills) that are represented on a learning continuum from experts to novices.

(4) Knowledge that is already present influences what is learned, how it is stored, and its meaning and potential use to the individual. New knowledge is "learned" by combining what an individual already knows with the new information, leading to differences in problem-solving behaviors between novices and experts.

(5) Within the common processes and functions associated with information intake, storage, processing and application, there are also individual differences within these processes. Although relatively stable, learning style patterns may change as a result of exposure to different environments over time.

These authors also stated that this theory is significant for vocational education because of its usefulness in explaining differences in the meanings of problems to humans as well as how a problem is represented to individuals for identification and its ultimate solution.

The information processing model described by Costa (1985) can serve as a guide for educators to use in curriculum and instructional development. A comparison of the numerous thinking models examined by Costa revealed that there were more similarities than differences. Costa (1985) identified four basic thought clusters: (1) input of data through the senses and from memory; (2) processing those data into meaningful relationships; (3) output or application of those relationships in new or novel situations; and (4) metacognition (p. 62)
No matter what level of critical thinking skill a person possesses, it is of no practical benefit or importance unless the person is disposed to use these skills when they are appropriate (Sternberg, 1983). Norris (1985) described this critical spirit as having three requirements, the first being to employ critical thinking skills when reasoning about situations encountered in the world. Secondly, critical thinking must be turned upon itself—thinking critically about one's own thinking—to prevent it from being mere criticism and not a search for the truth. Thirdly, there must be a disposition to act in accord with the dictates of critical thought.

A lack of knowledge in the subject matter area in question cannot be compensated for by a well-developed set of critical thinking skills. To apply the principles of critical thinking requires a level of competency over and above knowledge of the principles themselves (Ennis, 1980; Norris, 1984). A knowledge of subject matter, experience in the area in question, and good judgment would seem to be essential for the application of critical thinking skills to be successful. This realization can lead to the conclusion that critical thinking is ideally taught within traditional subject matter areas rather than as a separate subject.

In their historical analysis of problem solving in agricultural education, Lass and Moss (1987) cite Bricker who, in 1916, advocated that:

a properly organized course in secondary agriculture must be primarily and fundamentally a series of laboratory and field exercises made up of carefully selected materials, pedagogically and systematically arranged, around which recitations, lectures, and reading will center as supplementary work (p. 277).
One of the earliest promoters of problem solving in agricultural education was William Lancelot (1929) who defined a problem as "merely a thought question of relatively broad scope" (p. 35) which would bring about inductive reasoning or judgment and creative thinking. Lancelot was responsible for developing the criteria for the presentation of problems when teaching subject matter. He stated that problems must represent real life situations, interest the students, be clearly defined, be of proper scope and difficulty, and call for superior thinking.

Hammonds and Lamar (1968) stressed the implications and applications of the psychology of learning to teaching and learning. "Sensing and solving problems are recognized functions in higher mental processes. Problem solving is a primary tool for learning" (p. 78). However, they stressed that problem solving is not synonymous with learning; the purpose of presenting problems in teaching is to promote understanding.

Some authors (Moore and Moore, 1984) have argued that "the problem-solving approach to teaching in vocational agriculture came about through historical accident" (p. 8). Dickerson (1984) stated that problem solving "has become almost synonymous with agricultural education" (p. 6). Regardless of one's viewpoint on the historical associations and perspectives of problem solving to agricultural education, Crunkilton (1984) submitted:

> There is no single teaching technique or approach that will with a 100% effectiveness transfer the ability to think and solve problems from one person to another, teacher to student. But, the best foundation discovered to date that captures all of the rudimentary elements of education into one process for developing this reasoning and
problem-solving ability in students is through the problem-solving approach to teaching (p. 16).

Based upon literature and research that was reviewed, but not specifically cited, the following conclusions can be drawn:

(1) Instruments used to assess critical thinking skills must be improved to allow students a greater contextual basis and task format for appropriate evaluation.

(2) The incorporation of the essential skills for critical thinking into all subject matter areas can improve the cognitive abilities of students.

(3) Present-day curriculum can be infused with critical thinking abilities and dispositions without a great deal of technical difficulty.

(4) Systematic research has shown that most high school and college students do not perform extremely well on tasks associated with those competencies in critical thinking. Considerable evidence exists as to the serious consequences of this behavior.
METHOD OF PROCEDURE

The central problem for this investigation was to determine the ability of Iowa agriculture students to use critical thinking skills. Specific research methods and procedures were employed to fulfill this objective. This chapter describes the research methods and procedures used in this study. These procedures are described in the following paragraphs under the headings: Definition of Terms, Design, Selection of the Sample, Instrumentation, Collection of Data, and Analysis of Data.

Definition of Terms

Some of the terms used throughout this text have meanings which were unique to this investigation. The definitions for the terms presented below are meant to avoid ambiguity and to prevent misunderstanding concerning how these terms were used and applied in this study.

Learning Styles—the term is used to encompass four aspects of psychological makeup:

(1) cognitive style in the sense of preferred or habitual patterns of mental functioning: information processing, formation of ideas and judgments.
(2) patterns of attitudes and interests that influence what a person will attend to in a potential learning situation.
(3) a disposition to seek out learning environments compatible with one's cognitive style, attitudes and interests, and to avoid environments that are not congenial.
(4) a disposition to use certain learning tools and avoid others (Lawrence, 1984, p. 2).

Critical Thinking—"reflective and reasonable thinking that is focused on deciding what to believe or do" (Ennis, 1985, p. 45).
School—Iowa high schools in which the study was conducted. More specifically, in the context of this study, the term indicates agriculture classes in which this study was conducted.

Students—Iowa agriculture students in the 9th, 10th, 11th, and 12th grades participating in this study as a result of their enrollment in an agriculture class.

Agriculture instructors—group of instructors teaching in the schools selected for this study.

Design

The design for this study utilized descriptive research methodology. Some of the characteristics of descriptive studies described by Best (1981) are that they: (1) are non-experimental, dealing with non-manipulated variables in a natural setting, (2) involve hypothesis formulation and testing, (3) use inductive-deductive reasoning to arrive at generalizations, (4) often use randomization procedures, and (5) provide accurate descriptions of variables and procedures so replication studies are possible.

The justification for this particular methodology was presented by Van Dalen (1979) who stated:

Before much progress can be made in any field, scholars must possess descriptions of the phenomena with which they work...making accurate assessments of the incidence, distribution, and relationship of phenomena in the field.... Determining the nature of prevailing conditions, practices, and attitudes--seeking accurate descriptions of activities, objects, processes, and persons—is their objective (p. 284).
Selection of the Sample

The population of interest in this study consisted of agriculture students enrolled in Iowa high schools offering programs in agriculture. A list of 262 agriculture programs operating in the public high schools in Iowa for fiscal year 1987 was obtained from the Iowa Department of Education. The total enrollment of Iowa agriculture students in grades 9-12, based upon information obtained from the Iowa Department of Education, was determined to be 10,603.

Determination of the necessary sample size was only partially accomplished by a review of literature. Olejnik (1984) stated that:

To determine the necessary sample size for a hypothesis testing research study, four factors must be taken into consideration. These four factors are: criterion for statistical significance, level of statistical power, statistical analysis strategy, and the size of an effect judged to be meaningful (p. 41).

One solution to the sample size question was obtained from Oliver et al. (1983, 1985) after the effect size had been resolved. According to Oliver et al., effect size is essentially the acceptable difference between the sample mean and the population mean in standard deviation units. The researcher set the effect size at .20 based upon previous studies (Ennis and Millman, 1985). The implication was that a difference larger than the effect size, .20 of one standard deviation, would be needed in order for the rejection of the null hypothesis. The effect size for this study was determined from user norms found in the Cornell Critical Thinking Test Manual (Ennis and Millman, 1985).
The power of the statistical test is the probability that the test will lead to the rejection of the null hypothesis (Oliver et al., 1983, 1985). This power was set by the researcher at .95. The significance level (alpha) was set at .05.

In dealing with the finite population correction (fpc) factor, Cochran (1977) stated that:

> in practice the fpc can be ignored whenever the sampling fraction does not exceed 5\% and for many purposes even if it is as high as 10\%. The effect of ignoring the correction is to overestimate the standard error of the estimate (p. 25).

Cluster sampling was used because it was more convenient and feasible to select groups of individuals than it was to select individuals from a defined population. It was not practical nor possible to obtain a list of all members of the accessible population. In cluster sampling the unit of sampling is a naturally occurring group of individuals, not the individual (Borg and Gall, 1983).

Schaeffer et al. (1986) defined cluster sampling as a "simple random sample in which each sampling unit is a collection, or cluster, of elements" (p. 197). They also identified cluster sampling as the most economical method if the frame listing all of the population elements was not available. The population of 10,603 students was divided into non-overlapping groups of elements, in this case schools. Schaeffer et al. (1986) stated that "if these groups (schools) are considered to be clusters, then a simple random sample of groups is selected, and the sampled groups are then subsampled.... Cluster sampling does well when
the elements within each group are highly variable, and all groups are quite similar to one another" (p. 234).

Schaeffer et al. (1986) stated that:

the ultimate objective of statistics is to make inferences about a population from information contained in a sample.... The first step in statistics is to find a way to phrase an inference about a population or, equivalently, to describe a set of measurements.... The second step in statistics is to consider how inferences can be made about the population from information contained in a sample.... Knowledge of probability distributions associated with the sample allows us to choose proper inference-making procedures and to attach measures of goodness to such inferences (p. 5).

A compilation of the literature previously cited and the objectives of the study were presented to Dr. Harold D. Baker of the Statistical Laboratory and the Statistics Department at Iowa State University for analysis and design recommendations. It was determined from Oliver et al. (1983, 1985) that the minimum sample size should be 325 respondents. Dr. Baker recommended that this sample be increased by at least 50 percent to assure that the cluster sample adequately represented the population. Based upon his recommendations, a new minimum sample was generated consisting of 437 respondents. This sample represented approximately four percent of the 10,603 students enrolled in Iowa agriculture programs.

The number of schools needed to generate the minimum sample was based upon the state-wide average number of students in each program. Additional schools were selected due to the potential for instructors to decline to participate in the study or students not being able to complete all of the parts of the study. The goal of 437 respondents established as the baseline sample was exceeded.
A number was used to identify each of the secondary agriculture programs in the state. Using a computer-generated table of random numbers, 25 schools were initially selected for sampling. Telephone calls were made to the agriculture instructors of these schools in the sequence of their random selection to ascertain both their interest in cooperating in this study and to estimate the number of unduplicated students enrolled in their agriculture courses. Two instructors declined to participate in the study for various reasons.

Based upon the telephone interviews, 18 schools were selected for inclusion in this study. One of the instructors served two schools. Each of the 17 agriculture instructors was sent a letter explaining the purpose of the study and requesting their cooperation and participation.

Approximately one week later, a follow-up telephone call was made to confirm their participation. At that time, the total number of unduplicated 9th, 10th, 11th, and 12th grade students currently enrolled in these programs was ascertained. A total of 18 schools and 668 students participated in the study. The final sample represented approximately 6 percent of all the Iowa agriculture students.

Instrumentation

Descriptive data

An information sheet (Appendix A) was developed by the researcher to collect both specific demographic information as well as individual student preferences on how they learn in an agriculture course.

Eight questions on the instrument sought demographic information from the respondents in the following general areas: current grade level and
age, semesters in agriculture, years in the FFA (Future Farmers of America organization), leadership positions held, location of home, size of farm, and the highest grade level completed by parents. Nineteen questions were formulated from a review of literature and the researcher's own personal insight as to what data would provide for a more meaningful profile of how students learn best. The respondents were asked to indicate their preference for learning through various classroom teaching activities.

This instrument was reviewed by departmental faculty and staff for face validity. Based upon the recommendations of these groups, the instrument was revised and finalized for the study.

Prior to the collection of any data and the administration of any test materials, students read and signed a statement indicating their willingness to participate in the study. Iowa State University's Committee on the Use of Human Subjects in Research reviewed and approved each data collection instrument, test, and informed consent form (Appendix H). A formal agreement was sent for the instructor's and their school administrator's signatures.

The Cornell Critical Thinking Test Level X^R

The Cornell Critical Thinking Test Level X^R (Ennis and Millman, 1985) is a 71-item multiple-choice test intended to be taken in a 50 minute period. Each item has three choices and one keyed answer. Level X was designed primarily for evaluation and is aimed at fourth-through fourteenth-graders. Reliability estimates of Level X range from .67 to .90.
Aspects of critical thinking that have been incorporated into Level X include: induction, deduction, observation, credibility, and assumptions.

The test is divided into four parts:

Part I: Judging Whether a Fact Supports a Hypothesis
Part II: Judging Credibility of Observation Reports
Part III: Deciding What Follows
Part IV: Judging What Is Assumed in an Argument

The rationale for the selection of this instrument to measure critical thinking was based upon an extensive review of the literature. Two different tests were initially selected for possible use in this study. The publishers were contacted to explore the feasibility of providing the test materials required. John D. Baker, President of Midwest Publications of Pacific Grove, California, authorized the writer to use the Cornell Critical Thinking Test Level X® for the stipulated purposes of this study.

The Myers-Briggs Type Indicator™ (MBTI) (Form G)

The Myers-Briggs Type Indicator™ (MBTI) Form G (Briggs and Myers, 1977) was selected to measure the learning styles of students. The Indicator has no established time of completion. The authors did not encourage individuals to study each item before responding. The Indicator helps describe an individual's four mental processes—two perception processes (sensing and intuition) and two judgment processes (thinking and feeling) (Lawrence, 1982).

The MBTI was selected for administration primarily due to its application across broad population segments. It has also been used
extensively in research dealing with personalities and learning styles of high school students.

The MBTI identifies four individual preferences or strengths that persons use in gathering information and making decisions. These four preferences are selected from a set of eight variables which, stated in their simplest forms, are:

1. Extroversion (E) or Introversion (I): Extroverts (E) are continuously alert to events outside themselves, turning outward to pick up cues, ideas, values and interests, whereas Introverts (I) look inward for resources and cues, pursuing fewer interests more deeply.

2. Sensing (S) or Intuition (N): The Sensing (S) Intuition (N) preference reveals basic learning style differences. Sensing (S) students most often apply themselves to the literal meaning they find in concrete experiences, moving step-by-step using their senses, whereas Intuitive (N) students have their attention drawn to things that stimulate their imagination and not their senses.

3. Thinking (T) or Feeling (F): Thinking (T) students engage in logical analysis to the exclusion of illogical human factors, whereas the Feeling (F) student commits to a personal relationship and avoids situations which are not harmonious.

4. Judgment (J) or Perception (P): Judging (J) students are drawn toward closure, dislike unsettled situations, and want a specific work plan to follow, whereas Perceptive (P) students resist closure, fixed plans, and postpone decisions.
Using four of the eight factors, a person's learning style is derived from a possible combination of sixteen types. For example, the INFJ type would have an Introverted (I), Intuitive (N), Feeling (F), Judging (J) learning style.

Collection of Data

The following procedures were used in the collection of data for this investigation:

Agriculture instructors in each of the randomly-selected high schools were sent a letter on September 14, 1987 requesting their participation and cooperation in the research study. This letter also included basic information regarding the necessary time parameters and topic of investigation (Appendix B).

Follow-up telephone calls were conducted during the following weeks to discuss the instructor's questions and to explain the data collection methods which were to be utilized in the study. At this time, permission was received to conduct the study. A formal agreement was sent for the instructor's and their school administrator's signatures (Appendix C).

A package of school-coded test materials was forwarded to each of the 18 different schools participating in the study during the first week of October. This package included:

A. Information sheet (Appendix A).
B. Cover letter (Appendix D).
C. Instruction sheet (Appendix E).
D. Student data sheet (Appendix F).
E. General Purpose NCS® Answer Sheets.
F. Cornell Critical Thinking Tests—Level X®.
G. Myers-Briggs Type Indicator™ Form G.
H. #2 pencils for each student.
I. Instruction sheet for recording information from student's cumulative folder (Appendix G).
During the first day, instructors assigned each student a three digit identification number after they informed the students that their participation was voluntary. The students indicated their willingness to participate by signing the tear-off sheet at the top of the information sheet, which the instructors retained. The instructors then explained the purpose of the study and the steps of the process. Each student completed one information sheet and recorded their identification number on one NCS\textsuperscript{R} answer sheet for the Cornell Critical Thinking Test Level \textsuperscript{XR} on the following day.

Students were administered the Cornell Critical Thinking Test Level \textsuperscript{XR} during the prescribed 50 minute period of time.

Students were administered the Myers-Briggs Type Indicator\textsuperscript{TM} Form G during the length of the class period. In addition, instructors were to record information from the individual student's cumulative folders to the Student Data Sheets.

All test booklets, information sheets, NCS\textsuperscript{R} answer forms, student data sheets, and other data collected were returned to the researcher. This data collection procedure was designed to take no more than two to three weeks' time. However, due to uncontrollable circumstances (i.e. National FFA Convention, local chapter activities, etc.), this process was extended into the middle of December. Several follow-up telephone calls were conducted to encourage non-respondent agriculture instructors to complete the testing procedures. Other telephone calls were made to verify identification numbers, sex of the respondents, and to ascertain other data which were missing.
Analysis of Data

The step-by-step procedures followed in the analysis of data are described in the following paragraphs:

1. An identification number was assigned to each school and to each respondent to identify the participant by school and individual.

2. The returned instruments were coded as they were checked for illegible or incomplete data. If a respondent failed to identify their sex or provide sufficient information as to their identity, a follow-up telephone call was made to ascertain the appropriate information.

3. The data were keypunched directly from the completed information sheets and verified for accuracy by staff members in the Computer Science Department of Iowa State University. NCS answer sheets were machine scored and the data was transferred to disk storage on the AS/6 computer of the Iowa State University Computation Center.

4. The Myers-Briggs Type Indicator Form G was machine scored by a computer program developed by the Test and Evaluation Service at Iowa State University and the data was transferred to disk storage on the AS/6 computer of the Iowa State University Computation Center.

5. The Cornell Critical Thinking Test Level XR was machine scored by a computer program developed by the Test and Evaluation Service at Iowa State University and the data were transferred to disk
storage on the AS/6 computer of the Iowa State University Computation Center.

6. All analyses and manipulation of data were accomplished using the Statistical Package for the Social Sciences (SPSSX).

7. Descriptive statistical procedures used for data analysis included frequencies, percentages, means, and standard deviations on all of the items on the information and the student data sheet.

8. The Pearson product moment coefficient was calculated to determine if significant relationships existed between selected variables.

9. Inferential analyses were performed using a variety of procedures available in SPSSX. Tests for significant differences included group t-tests and one-way analysis of variance. The Scheffe post hoc test and Duncan's multiple range test was used to determine where differences existed when a significant difference was found and more than two groups were being compared.
FINDINGS

The purpose of this study was to determine the ability of Iowa agriculture students to use critical thinking skills. The specific objectives of this study were to: (1) assess the critical thinking abilities of Iowa agriculture students as measured by a normed test of critical thinking, (2) compare the critical thinking abilities of Iowa agriculture students to established critical thinking values, (3) assess and analyze levels of critical thinking related to learning style, and (4) analyze selected relationships associated with levels of critical thinking.

The findings of this chapter are presented under the following headings: (1) Descriptive Information, (2) Levels of Critical Thinking, (3) Critical Thinking Levels Compared to User Norms, (4) Learning Styles Related to Critical Thinking, (5) Selected Demographic Factors Related to Critical Thinking, and (6) Major Findings.

Descriptive Information

Descriptive information about the respondents (N=668) is provided in Table 1. A representative sample was taken from the total population of 10,603 Iowa vocational agriculture students. The tenth grade class composed the largest percentage of respondents (27.99), whereas the smallest percentage (21.86) of respondents was from the twelfth grade class.
Table 1. Description of respondents

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<th>Variable</th>
<th>Number</th>
<th>Percent</th>
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- \( ^a \) Missing cases = 37.
- \( ^b \) Missing cases = 2.
- \( ^c \) Missing cases = 33.
- \( ^d \) Missing cases = 224.
Table 1. Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Place of residence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grade level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Town</td>
<td>43</td>
<td>50</td>
</tr>
<tr>
<td>Farm</td>
<td>127</td>
<td>137</td>
</tr>
<tr>
<td>Total e</td>
<td>170</td>
<td>187</td>
</tr>
<tr>
<td><strong>Size of farm in acres</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-160</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>161-320</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>321-480</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>481-640</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>640-800</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>801 and larger</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Total f</td>
<td>465</td>
<td></td>
</tr>
<tr>
<td><strong>Highest grade level completed</strong>&lt;br&gt;by father (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>10-12</td>
<td>434</td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>15-17</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Total g</td>
<td>663</td>
<td></td>
</tr>
<tr>
<td><strong>Highest grade level completed</strong>&lt;br&gt;by mother (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>10-12</td>
<td>422</td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>15-17</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>Total h</td>
<td>662</td>
<td></td>
</tr>
</tbody>
</table>

^Missing cases = 2.
^fMissing cases = 32.
^gMissing cases = 5.
^hMissing cases = 6.
Almost equal percentages (26.78 and 28.53) of the respondents were 15 or 16 years of age. The next largest age group was 17 years of age (20.13%) followed by 14-year-olds (15.53%).

The largest category (40.24%) of respondents had been enrolled in either one or two semesters of vocational agriculture. The smallest category (11.41%) had been enrolled for seven semesters.

Nearly two-thirds of the respondents had been in the FFA for one or two years. The remaining one-third had completed three to four years of FFA membership.

Over half of the respondents had held one to two leadership positions while in high school and almost one-quarter more had held three to four positions.

Approximately three-fourths (74.62%) of the respondents lived on farms and over one-third (38.49%) of them lived on farms up to 160 acres in size. A substantial group (15.92%) of respondents lived on farms over 801 acres in size.

Almost two-thirds (65.46%) of the respondents indicated that their fathers had completed the twelfth grade. This value was almost identical (63.75%) to that of their mother's highest grade level completed. Almost one-third of the respondent's mothers had completed education beyond the high school level.

Levels of Critical Thinking

Contained in Table 2 are the means, standard deviations, F-ratio, and F-probability for levels of critical thinking of the respondents grouped according to grade level. The mean score for all respondents was 36.89.
Table 2. Critical thinking means, standard deviations, F-ratio, and F-probability by grade in school

<table>
<thead>
<tr>
<th>Grade</th>
<th>Level of critical thinking</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
<td>171</td>
<td>36.12</td>
<td>9.36</td>
<td>11.11</td>
<td>.0000</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>187</td>
<td>34.51</td>
<td>10.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>163</td>
<td>37.17</td>
<td>9.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>146</td>
<td>40.55</td>
<td>9.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>667</td>
<td>36.89</td>
<td>9.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aOne missing case.

The lowest level of critical thinking was observed for respondents in the tenth grade (mean = 34.51) and the highest level of critical thinking was observed for respondents in the twelfth grade (mean = 40.55). An analysis of variance test on these group means revealed that highly significant differences existed among group means. A Scheffe' post hoc test revealed differences among mean scores for grade 12 and all other grade level means.

Critical Thinking Levels
Compared to User Norms

Means, standard deviations, and percentile scores for respondents' levels of critical thinking compared to other high school students are presented in Table 3. Group XP was comprised of students randomly selected from a study hall in an upstate New York suburban school having a high proportion of college-bound students (Ennis and Millman, 1985). Group XQ was comprised of students completing a Biological Sciences Curriculum Study (BSCS) course of study (Ennis and Millman, 1985).
Table 3. Means, standard deviations, and percentile scores for levels of critical thinking compared to user norms

<table>
<thead>
<tr>
<th>Percentile rank</th>
<th>Iowa agriculture students</th>
<th>(XP)&lt;sup&gt;b&lt;/sup&gt; high school</th>
<th>(XQ)&lt;sup&gt;c&lt;/sup&gt; high school</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>56</td>
<td>57</td>
<td>56</td>
</tr>
<tr>
<td>95</td>
<td>52</td>
<td>54</td>
<td>52</td>
</tr>
<tr>
<td>85</td>
<td>47</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>75</td>
<td>44</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td>65</td>
<td>42</td>
<td>49</td>
<td>44</td>
</tr>
<tr>
<td>50</td>
<td>37</td>
<td>46</td>
<td>41</td>
</tr>
<tr>
<td>35</td>
<td>32</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>25</td>
<td>29</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>668</td>
<td>233</td>
<td>1673</td>
</tr>
<tr>
<td>Mean</td>
<td>36.89</td>
<td>45.3</td>
<td>40.6</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.91</td>
<td>6.8</td>
<td>7.9</td>
</tr>
</tbody>
</table>

<sup>a</sup>User norms from Cornell Critical Thinking Tests Level X and Level Z Manual (3rd edition).

<sup>b</sup>Students randomly selected from a study hall in an upstate New York suburban school having a high proportion of college-bound students (Ennis and Millman, 1985).

<sup>c</sup>Students completing a Biological Sciences Curriculum Study (BSCS) course of study (Ennis and Millman, 1985).

The respondents' mean (36.89) was observed to be the lowest among the three groups compared. The mean for Group XP was observed to be the highest (45.3), followed by the mean for Group XQ (40.6). Scores at the 99th percentile were approximately the same for all three groups. However, scores at the various percentile ranks for the respondents declined more rapidly when compared to the scores at various percentile ranks.
ranks for the other two groups. The standard deviation (9.91) for the respondents was the largest among the comparison groups.

Learning Styles Related to Critical Thinking

Tables 4, 5, and 6 provide data relative to the levels of critical thinking and learning styles of the respondents.

The Myers-Briggs Type Indicator TM was administered to each of the respondents to determine each respondent's learning style. Sixteen learning styles emerged as a result of this procedure and are described in Figure 1.

Contained in Table 4 are the means, standard deviations, F-ratio, and F-probability for the level of critical thinking classified by learning styles. Three learning styles were excluded from the statistical analysis of data due to insufficient cell sizes: ENFJ, INFJ, and INTJ. The learning style with the highest critical thinking mean score (41.84) was INFP, followed closely by ENFP (mean = 41.48). The ISTP learning style had the lowest mean score (33.67) and was closely followed by the ESTP style (mean = 35.19) and the ENTJ style (mean = 35.60). An analysis of variance test on the group means indicated that highly significant differences existed among the group means.

Data in Table 5 reveal the critical thinking mean differences among the learning style groups detected in Table 4. The Scheffe' test at the .05 level failed to locate the differences and, therefore, Duncan's multiple range test (.05 level) was employed for descriptive purposes. The mean difference (8.17) between learning styles INFP (mean = 41.84) and
Table 4. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by learning style

<table>
<thead>
<tr>
<th>Learning style</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>INFJ</td>
<td>2a</td>
<td>44.00</td>
<td>15.56</td>
<td>3.08</td>
<td>.0003</td>
</tr>
<tr>
<td>INFP</td>
<td>19</td>
<td>41.84</td>
<td>9.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENFP</td>
<td>42</td>
<td>41.48</td>
<td>10.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENFJ</td>
<td>7a</td>
<td>39.71</td>
<td>8.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISFP</td>
<td>28</td>
<td>39.71</td>
<td>9.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTP</td>
<td>46</td>
<td>39.02</td>
<td>8.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISFJ</td>
<td>19</td>
<td>38.42</td>
<td>7.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESFJ</td>
<td>20</td>
<td>38.20</td>
<td>9.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESFP</td>
<td>62</td>
<td>37.82</td>
<td>9.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISTJ</td>
<td>47</td>
<td>37.43</td>
<td>12.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENTP</td>
<td>63</td>
<td>37.08</td>
<td>9.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESTJ</td>
<td>61</td>
<td>36.54</td>
<td>10.19</td>
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<td></td>
</tr>
<tr>
<td>ENTJ</td>
<td>20</td>
<td>35.60</td>
<td>11.00</td>
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<td></td>
</tr>
<tr>
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<td>112</td>
<td>35.19</td>
<td>8.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>111</td>
<td>33.67</td>
<td>10.11</td>
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<td></td>
</tr>
<tr>
<td>INTJ</td>
<td>11a</td>
<td>29.64</td>
<td>11.20</td>
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</tr>
<tr>
<td>Total</td>
<td>668</td>
<td>36.86</td>
<td>9.93</td>
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<td></td>
</tr>
</tbody>
</table>

*aCell size insufficient for calculation.*
Table 5. Learning style groups with significantly different mean scores

<table>
<thead>
<tr>
<th>Learning style</th>
<th>Mean</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>41.48</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>7.81</td>
</tr>
<tr>
<td>ENFP</td>
<td>41.48</td>
<td></td>
</tr>
<tr>
<td>ESTP</td>
<td>35.19</td>
<td>6.29</td>
</tr>
<tr>
<td>ENFP</td>
<td>41.48</td>
<td></td>
</tr>
<tr>
<td>ESTJ</td>
<td>36.54</td>
<td>4.94</td>
</tr>
<tr>
<td>ENTP</td>
<td>37.08</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>3.41</td>
</tr>
<tr>
<td>ESFP</td>
<td>37.82</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>4.15</td>
</tr>
<tr>
<td>INFP</td>
<td>41.84</td>
<td></td>
</tr>
<tr>
<td>ESTP</td>
<td>35.19</td>
<td>6.65</td>
</tr>
<tr>
<td>INFP</td>
<td>41.84</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>8.17</td>
</tr>
<tr>
<td>INTP</td>
<td>39.02</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>5.35</td>
</tr>
<tr>
<td>ISFP</td>
<td>39.71</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>6.04</td>
</tr>
<tr>
<td>ISTJ</td>
<td>37.43</td>
<td></td>
</tr>
<tr>
<td>ISTP</td>
<td>33.67</td>
<td>3.76</td>
</tr>
</tbody>
</table>
Table 6. Pearson product moment correlations of levels of critical thinking with cumulative grade point average\(^a\) when grouped by learning style

<table>
<thead>
<tr>
<th>Learning style</th>
<th>N</th>
<th>r</th>
<th>Probability</th>
</tr>
</thead>
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<tr>
<td>ENFJ</td>
<td>4</td>
<td>.40</td>
<td>.595</td>
</tr>
<tr>
<td>ENFP</td>
<td>28</td>
<td>.43</td>
<td>.022</td>
</tr>
<tr>
<td>ENTJ</td>
<td>15</td>
<td>.61</td>
<td>.017</td>
</tr>
<tr>
<td>ENTP</td>
<td>48</td>
<td>.47</td>
<td>.001</td>
</tr>
<tr>
<td>ESFJ</td>
<td>14</td>
<td>.71</td>
<td>.004</td>
</tr>
<tr>
<td>ESFP</td>
<td>34</td>
<td>.51</td>
<td>.002</td>
</tr>
<tr>
<td>ESTJ</td>
<td>41</td>
<td>.54</td>
<td>.000</td>
</tr>
<tr>
<td>ESTP</td>
<td>74</td>
<td>.27</td>
<td>.020</td>
</tr>
<tr>
<td>INFJ</td>
<td>1</td>
<td>.07</td>
<td>.810</td>
</tr>
<tr>
<td>INFP</td>
<td>14</td>
<td>.48</td>
<td>.227</td>
</tr>
<tr>
<td>INTJ</td>
<td>8</td>
<td>.46</td>
<td>.030</td>
</tr>
<tr>
<td>INTP</td>
<td>22</td>
<td>-.17</td>
<td>.619</td>
</tr>
<tr>
<td>ISFJ</td>
<td>11</td>
<td>.40</td>
<td>.201</td>
</tr>
<tr>
<td>ISFP</td>
<td>28</td>
<td>.21</td>
<td>.281</td>
</tr>
<tr>
<td>ISTJ</td>
<td>66</td>
<td>.34</td>
<td>.005</td>
</tr>
<tr>
<td>ISTP</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>420(^b)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Cumulative grade point average was not available for 9th grade students.

\(^b\)Missing cases = 76.
<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISTJ</td>
<td>Linear learner with strong need for order. Likes direct experience. Likes audiovisuals; lectures. Enjoys working alone. Likes well-defined goals. Prefers practical tests.</td>
</tr>
<tr>
<td>ISFJ</td>
<td>Linear learner with strong need for order. Likes direct experience. Likes listening to lectures. Likes audiovisuals. Enjoys working alone. Likes practical tests.</td>
</tr>
<tr>
<td>ISTP</td>
<td>Linear learner; needs help in organizing. Likes direct experience; likes lectures, audiovisuals. Enjoys working alone. Wants logically-structured, efficient materials.</td>
</tr>
<tr>
<td>ISFP</td>
<td>Linear learner; needs help in organizing. Needs to know why before doing something. Likes group projects, class reports, team competition. Likes direct experience. Likes audiovisuals. May like lecture.</td>
</tr>
<tr>
<td>ESTP</td>
<td>Linear learner; needs help in organizing. Needs to know why before doing something. Likes group projects, class reports, team competition. Likes direct experience. Likes audiovisuals. May like lecture.</td>
</tr>
<tr>
<td>ESFP</td>
<td>Linear learner; needs help in organizing. Needs to know why before doing something. Likes group projects, team competition, class reports. Needs orderly, well-defined goals.</td>
</tr>
<tr>
<td>ESTJ</td>
<td>Linear learner with strong need for structure. Needs to know why before doing something. Likes group projects, class reports, team competition. Likes audiovisuals, practical tests. May like lecture.</td>
</tr>
<tr>
<td>ESFJ</td>
<td>Linear learner with strong need for structure. Needs to know why before doing something. Needs well-defined goals. Values harmonious group projects, team competition, class reports. Likes audiovisuals; practical tests. Likes direct experience.</td>
</tr>
</tbody>
</table>

Figure 1. Relating type to instructional strategies (People Type & Tiger Stripes, Lawrence, 1982)
INFJ
Can be global or linear
Wants to consider theory first, then applications
Enjoys working alone
Prefers open-end instruction
Needs harmony in group work

INFP
Global learner; may need help in organizing
Likes reading, listening
Wants to consider theory first, then applications
Needs harmony in group work
Prefers open-end instruction
Enjoys working alone
Likes autonomy

ENFP
Global learner; needs choices and deadlines
Likes seminars
Likes reading if can settle down long enough
Likes harmonious group projects, team competition, class reports
Likes autonomy
Needs help with organizing

ENFJ
Can be global or linear learner
Likes seminars
Likes reading if can settle down long enough
Likes harmonious group projects, class reports
Likes listening
Likes pencil-and-paper tests
Prefers open-end instruction
Wants to consider theory, then applications

INTJ
Can be global or linear
Wants to consider theory first, then applications
Enjoys working alone
Prefers open-end instruction
Good at paper-and-pencil tests

INTP
Global learner; needs help in coming to closure
Likes reading, listening
Wants to consider theory first, applications
Good at paper-and-pencil tests
Prefers open-end instruction
Enjoys working alone
Likes autonomy

ENTJ
Can be global or linear learner
Likes seminars
Likes reading if can settle down long enough
Likes group projects, class reports, team competition
Likes listening
Likes pencil-and-paper tests
Prefers open-end instruction
Wants to consider theory, then applications
ISTP (mean = 33.67) was the largest. This was followed closely by the difference in means (7.81) between the ENFP (mean = 41.48) learning style and ISTP (mean = 33.67). The two learning styles with the lowest significant mean difference (3.76) were ISTJ (mean = 37.43) and ISTP (mean = 33.67) learning styles.

Pearson product moment correlations between levels of critical thinking and cumulative grade point average when sorted by learning styles are presented in Table 6. Cumulative grade point averages were not available for ninth grade respondents, thus the difference in total N. Learning styles which had the highest r value were ESFJ (r = .71), ENTJ (r = .61), ESTJ (r = .54), and ESFP (r = .51).

Selected Factors Related to Critical Thinking

Table 7 contains the means, standard deviations, F-ratios, F-probabilities, grade level, and composite rankings of respondent preferences for "learning while in an agriculture course." It was observed that "learning in laboratories and shop activities" had the highest group mean. The composite mean (76.04) was the highest mean value observed in the table and was "much preferred" by all four groups. The tenth grade group mean (72.22) was the lowest mean and the eleventh grade group (79.34) was the highest mean for the above learning activity. The standard deviation of the tenth grade group (27.39) was much larger than that of the other three group standard deviations. An analysis of variance test on the group means revealed significant differences among
Table 7. Means, standard deviations, F-ratio, F-probability, and rankings for preferences in learning while in a vocational agriculture course

Learning activity

While in an agriculture course, I prefer to learn:
1. Using audiovisual materials (films, slides, TV, etc.)
2. In discussion groups with my classmates.
3. When the material is presented in a logical, orderly method.
4. When I can use a computer.
5. Giving reports on topics that are interesting to me.
6. Materials when I have to memorize facts.
7. While working on group projects with classmates.
8. When there are opportunities to be creative and original.

aMean = top line figure for each grade.
bStandard deviation = middle line figure for each grade.
cRanking = bottom line figure for each grade.
<table>
<thead>
<tr>
<th>Grade level</th>
<th>9th (N=172)</th>
<th>10th (N=187)</th>
<th>11th (N=163)</th>
<th>12th (N=146)</th>
<th>Composite</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>62.94^a</td>
<td>57.64</td>
<td>58.87</td>
<td>60.95</td>
<td>60.03</td>
<td>1.35</td>
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</tr>
<tr>
<td>26.95^b</td>
<td>28.92</td>
<td>26.91</td>
<td>22.46</td>
<td>26.63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7^c</td>
<td>5</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>57.60</td>
<td>55.40</td>
<td>62.58</td>
<td>65.19</td>
<td>59.86</td>
<td>4.68</td>
<td>.0030</td>
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</tr>
<tr>
<td>25.73</td>
<td>30.69</td>
<td>25.23</td>
<td>23.29</td>
<td>26.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55.17</td>
<td>51.76</td>
<td>56.17</td>
<td>66.25</td>
<td>56.88</td>
<td>8.55</td>
<td>.0000</td>
<td></td>
</tr>
<tr>
<td>25.80</td>
<td>28.42</td>
<td>28.61</td>
<td>22.99</td>
<td>27.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>11</td>
<td>6</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64.75</td>
<td>52.41</td>
<td>54.66</td>
<td>57.91</td>
<td>57.34</td>
<td>5.51</td>
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<td>28.75</td>
<td>32.83</td>
<td>30.47</td>
<td>28.61</td>
<td>30.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.53</td>
<td>32.24</td>
<td>37.77</td>
<td>42.20</td>
<td>39.44</td>
<td>6.76</td>
<td>.0002</td>
<td></td>
</tr>
<tr>
<td>31.77</td>
<td>30.62</td>
<td>33.03</td>
<td>29.81</td>
<td>31.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.77</td>
<td>22.57</td>
<td>29.20</td>
<td>31.11</td>
<td>28.17</td>
<td>4.20</td>
<td>.0059</td>
<td></td>
</tr>
<tr>
<td>25.35</td>
<td>26.14</td>
<td>27.66</td>
<td>24.25</td>
<td>26.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66.79</td>
<td>67.69</td>
<td>67.18</td>
<td>68.91</td>
<td>67.60</td>
<td>.2215</td>
<td>.8815</td>
<td></td>
</tr>
<tr>
<td>25.27</td>
<td>26.67</td>
<td>23.02</td>
<td>21.29</td>
<td>24.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66.41</td>
<td>56.97</td>
<td>64.20</td>
<td>69.05</td>
<td>63.80</td>
<td>7.0059</td>
<td>.0001</td>
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</tr>
<tr>
<td>25.73</td>
<td>29.05</td>
<td>25.40</td>
<td>21.27</td>
<td>26.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.67</td>
<td>36.54</td>
<td>42.26</td>
<td>49.57</td>
<td>43.40</td>
<td>7.1575</td>
<td>.0001</td>
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</tr>
<tr>
<td>27.89</td>
<td>28.59</td>
<td>27.54</td>
<td>25.96</td>
<td>27.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Continued

<table>
<thead>
<tr>
<th>Learning activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Learning reports on topics selected by other students.</td>
</tr>
<tr>
<td>11. By observing specific things and activities.</td>
</tr>
<tr>
<td>12. By formalized instruction (lectures, teacher assignments, homework).</td>
</tr>
<tr>
<td>13. By reading books and teaching myself things.</td>
</tr>
<tr>
<td>14. From demonstrations in class.</td>
</tr>
<tr>
<td>15. From personal relationships that are creative and original.</td>
</tr>
<tr>
<td>16. In laboratories and shop activities.</td>
</tr>
<tr>
<td>17. When someone takes a personal interest and involvement in me.</td>
</tr>
<tr>
<td>18. By following my own impulses and being flexible.</td>
</tr>
<tr>
<td>19. By thinking and reasoning by myself without others.</td>
</tr>
<tr>
<td>Grade level</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>46.03</td>
</tr>
<tr>
<td>26.67</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>61.46</td>
</tr>
<tr>
<td>24.82</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>37.02</td>
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<tr>
<td>29.03</td>
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<tr>
<td>18</td>
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<td>44.15</td>
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<td>30.42</td>
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<tr>
<td>17</td>
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<td>60.22</td>
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<tr>
<td>24.42</td>
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<tr>
<td>10</td>
</tr>
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<td>59.75</td>
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<td>24.29</td>
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<tr>
<td>11</td>
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<td>77.37</td>
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<td>21.93</td>
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<td>1</td>
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<td>64.01</td>
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<tr>
<td>25.81</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>63.00</td>
</tr>
<tr>
<td>25.86</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>61.63</td>
</tr>
<tr>
<td>25.96</td>
</tr>
<tr>
<td>8</td>
</tr>
</tbody>
</table>
means. A Scheffe' post hoc test revealed no significant differences among group means.

"Working on group projects with classmates" had the second highest composite mean. Although the ninth and tenth grade mean rankings among all activity means were identical (2nd), the eleventh grade mean ranked third and the twelfth grade mean ranked fourth among all activity means. The means of the four groups were closely clustered within two points of each other and indicative of "much preference." An analysis of variance test on the means revealed no significant differences among these means.

"Following my own impulses and being flexible" had the third highest composite mean (mean = 66.92) and was "much preferred" by the respondents. The eleventh and twelfth grade group means ranked second, whereas the ninth grade group mean ranked sixth and the tenth grade group mean ranked third among learning activities for this activity. The standard deviations of the four groups were widely spread. An analysis of variance test revealed a highly significant difference among group means. A Scheffe' post hoc test revealed significant differences between the twelfth grade mean (72.75) and the means of the ninth (63.00) and tenth grades (63.52).

Ranked next to last (mean = 34.15) and of "little preference" to the respondents was "learning by formalized instruction (lectures, teacher assignments, homework)." Although this learning preference ranked eighteenth for each of the four groups, the lowest mean (27.42) was observed for the tenth grade and the highest mean (39.05) was observed for twelfth grade groups. A highly significant difference among group means
was revealed in an analysis of variance test. A Scheffe' post hoc test revealed a significant difference among the tenth grade mean and the ninth and twelfth grade means.

It was anticipated that the lowest-ranked learning preference would result when students had "to memorize facts" (mean = 28.17). This preference ranked nineteenth for all four grades. The group means ranged from 22.57 (tenth grade) to 31.11 (twelfth grade). An analysis of variance test revealed a highly significant difference among group means. A Scheffe' post hoc test revealed a significant difference between the mean of the tenth grade group and the means of the ninth and twelfth grade groups.

Table 8 contains the means, standard deviations, F-ratio, and F-probability for levels of critical thinking compared by age of the respondents. The highest mean (39.22) was observed for 17-year-olds followed closely by 18-year-olds (mean = 38.75). The next highest mean score was observed for 14-year-olds (37.26). All three groups scored above the mean (36.86) for the sample. An analysis of variance test revealed highly significant differences among group means. A Scheffe' post hoc test revealed differences in levels of critical thinking between the 15- and 17-year-old groups and the 16- and 17-year-old groups.

Levels of critical thinking are compared by the number of semesters of vocational agriculture completed by the respondents in Table 9. The highest mean (41.15) was observed for respondents who had completed six to seven semesters of vocational agriculture. The lowest mean (35.54) was for respondents who had completed just one semester of vocational
Table 8. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by age of respondents

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>98</td>
<td>37.26</td>
<td>9.21</td>
<td>5.03</td>
<td>.0005</td>
</tr>
<tr>
<td>15</td>
<td>168</td>
<td>35.05</td>
<td>9.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>181</td>
<td>35.64</td>
<td>10.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>161</td>
<td>39.22</td>
<td>9.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>57</td>
<td>38.75</td>
<td>10.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>665*</td>
<td>36.86</td>
<td>9.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Missing cases = 3.

Table 9. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by number of semesters completed in vocational agriculture

<table>
<thead>
<tr>
<th>Semesters</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>246</td>
<td>35.54</td>
<td>9.50</td>
<td>8.96</td>
<td>.0000</td>
</tr>
<tr>
<td>2-3</td>
<td>194</td>
<td>35.70</td>
<td>9.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>140</td>
<td>38.18</td>
<td>10.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td>88</td>
<td>41.15</td>
<td>9.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>668</td>
<td>36.88</td>
<td>9.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

agriculture. An analysis of variance test on the group means revealed that highly significant differences existed between the group means. A Scheffe' post hoc test revealed differences in levels of critical thinking between those students completing six to seven semesters and those completing one semester. Additionally, the mean for students completing
six to seven semesters of vocational agriculture was found to be different from the mean for students completing two to three semesters.

Presented in Table 10 are the means, standard deviations, F-ratio, and F-probability for levels of critical thinking by number of years of FFA membership. The group with the highest mean score (41.43) had four years of membership and the group with the lowest mean score (35.32) was observed for those respondents who had one year of participation in FFA. An analysis of variance test on the group means revealed that highly significant differences existed between the group means. A Scheffe post hoc test revealed differences in levels of critical thinking among those students who had four years of FFA membership and those who had three, two, and one year of such membership.

Means, standard deviations, F-ratio, and F-probability are presented in Table 11 for levels of critical thinking by the number of high school leadership positions held by respondents. The group of respondents who had held seven or more leadership positions had a mean critical thinking score of 43.44. The group with the lowest mean score (35.90) had held one or two high school leadership positions. An analysis of variance test on the group means indicated that highly significant differences existed among the group means. A Scheffe post hoc test revealed differences in levels of critical thinking among the group of students who had held seven or more positions and each of the other three groups.
Table 10. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by the number of years of FFA membership

<table>
<thead>
<tr>
<th>Years</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>231</td>
<td>35.32</td>
<td>9.24</td>
<td>8.87</td>
<td>.0001</td>
</tr>
<tr>
<td>2</td>
<td>179</td>
<td>36.44</td>
<td>9.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>136</td>
<td>37.37</td>
<td>10.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>41.43</td>
<td>9.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>636</td>
<td>36.94</td>
<td>9.86</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Missing cases = 52.

Table 11. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by the number of high school leadership positions

<table>
<thead>
<tr>
<th>Leadership positions</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>223</td>
<td>35.90</td>
<td>9.40</td>
<td>13.9373</td>
<td>.0000</td>
</tr>
<tr>
<td>3-4</td>
<td>106</td>
<td>39.51</td>
<td>9.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>56</td>
<td>41.73</td>
<td>9.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 7</td>
<td>59</td>
<td>43.44</td>
<td>9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>444</td>
<td>38.50</td>
<td>9.74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Missing cases = 224.

Data in Table 12 compare the difference in mean level of critical thinking between those respondents who lived in town or on a farm. The highest mean (37.55) was observed for those respondents who lived on a farm, whereas those respondents who lived in town had a mean score (34.91) which was significantly lower at the .01 level.
Table 12. Test for difference in level of critical thinking of respondents living in town or on a farm

<table>
<thead>
<tr>
<th>Place of residence</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>t-value</th>
<th>t-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>On a farm</td>
<td>497</td>
<td>37.55</td>
<td>9.79</td>
<td>3.02</td>
<td>0.003</td>
</tr>
<tr>
<td>In town</td>
<td>169</td>
<td>34.91</td>
<td>9.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>666</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aMissing cases = 2.

Means, standard deviations, F-ratio, and F-probability for levels of critical thinking of respondents by the size of their home farms are presented in Table 13. Respondents from the largest farms, 801 acres and larger, had the lowest critical thinking mean score (36.01), whereas those respondents from farms of 481-640 acres had the highest mean (39.03) critical thinking score. No significant differences were discovered among means of these groups.

Table 13. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by size of respondent's home farm

<table>
<thead>
<tr>
<th>Acres</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-160</td>
<td>179</td>
<td>38.24</td>
<td>9.64</td>
<td>.7243</td>
<td>.6054</td>
</tr>
<tr>
<td>161-320</td>
<td>95</td>
<td>38.17</td>
<td>9.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>321-480</td>
<td>47</td>
<td>37.77</td>
<td>11.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>481-640</td>
<td>38</td>
<td>39.03</td>
<td>10.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>641-800</td>
<td>32</td>
<td>38.16</td>
<td>9.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>801 and larger</td>
<td>74</td>
<td>36.01</td>
<td>8.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>465</td>
<td>37.88</td>
<td>9.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aMissing cases = 30 (169 respondents lived in town).*
Presented in Table 14 are the means, standard deviations, F-ratio, and F-probability for levels of critical thinking by grade level completed by the respondent's father. Groups were categorized to reflect junior high school, senior high school, community college, and four-year college levels. The group whose fathers had completed 15-17 years of education had the highest mean score (37.87). The group whose fathers had completed the junior high school level of education had the lowest mean score (35.53). There were no significant differences found between the means of these groups.

Levels of critical thinking are compared to highest grade level completed by the respondent's mother in Table 15. The groups were categorized the same as that presented in Table 14. The group whose mothers had completed junior high school had the lowest mean score (32.08), whereas the group whose mothers had completed 15-17 years of

<table>
<thead>
<tr>
<th>Years</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-9</td>
<td>62</td>
<td>35.53</td>
<td>11.40</td>
<td>.7957</td>
<td>.4965</td>
</tr>
<tr>
<td>10-12</td>
<td>434</td>
<td>36.71</td>
<td>9.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>90</td>
<td>37.51</td>
<td>8.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-17</td>
<td>77</td>
<td>37.87</td>
<td>10.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>663a</td>
<td>36.84</td>
<td>9.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aMissing cases = 5.
Table 15. Means, standard deviations, F-ratio, and F-probability for levels of critical thinking by highest grade level completed by the respondent's mother

<table>
<thead>
<tr>
<th>Years</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F-ratio</th>
<th>F-probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-9</td>
<td>25</td>
<td>32.08</td>
<td>10.92</td>
<td>2.3515</td>
<td>.0712</td>
</tr>
<tr>
<td>10-12</td>
<td>422</td>
<td>36.96</td>
<td>9.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>108</td>
<td>36.61</td>
<td>9.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-17</td>
<td>107</td>
<td>37.87</td>
<td>9.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>662</td>
<td>36.86</td>
<td>9.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Missing cases = 6.*

education had the highest mean score (37.87). Again, there were no significant differences found among the means of these groups.

A stepwise regression procedure was employed to predict student critical thinking scores. Results of this procedure are presented in Table 16.

The Iowa Tests of Educational Development are measures of skills which include: understanding the meaning of a wide variety of words (Test V-vocabulary); recognizing the essentials of correct and effective writing (Test E-expression); solving quantitative problems (Test Q-quantitative thinking); critically analyzing discussions of social issues (Test SS-social studies); understanding nontechnical scientific reports and recognizing sound methods of scientific inquiry (Test NS-natural sciences); perceiving the moods and nonliteral meanings of literary materials (Test L-literature); and using a variety of sources of information (Test SI-sources of information). The Reading Total Score
Table 16. Stepwise regression analysis of variables on critical thinking scores

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable entered</th>
<th>B*</th>
<th>Multiple r</th>
<th>F-ratio^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reading total score (ITED subtest)</td>
<td>.531</td>
<td>.533</td>
<td>92.29</td>
</tr>
<tr>
<td>2</td>
<td>Cumulative grade point average</td>
<td>2.965</td>
<td>.553</td>
<td>51.23</td>
</tr>
<tr>
<td>3</td>
<td>&quot;Judgment&quot; score (MBTI)</td>
<td>.170</td>
<td>.571</td>
<td>37.19</td>
</tr>
<tr>
<td>4</td>
<td>Number of leadership positions in high school</td>
<td>.149</td>
<td>.585</td>
<td>29.84</td>
</tr>
<tr>
<td>5</td>
<td>&quot;When material is presented in a logical, orderly method&quot; (learning preferences)</td>
<td>.051</td>
<td>.594</td>
<td>24.97</td>
</tr>
<tr>
<td>6</td>
<td>&quot;When someone takes a personal interest and involvement in me&quot; (learning preferences)</td>
<td>-.043</td>
<td>.606</td>
<td>22.01</td>
</tr>
<tr>
<td></td>
<td>Constant = 8.399</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Constant = 8.399  Multiple R^2 = .3668

^Regression coefficients for the final prediction equation.

F_{1,233,.05} = 3.84.

(RT) is based on exercises that require analysis of reading selections and include sections from the natural sciences, social sciences, and literature tests.

The Myers-Briggs Type Indicator™ contains four separate indices which reflect one of four basic preferences directing the use of an individual's perception and judgment. The four preferences are:

Extraversion or Introversion (E or I); Sensing perception or Intuitive perception (S or N); Thinking judgment or Feeling judgment (T or F); and
Judgment or Perception (J or P). Each of the preferences directs the use of perception and judgment, affecting not only what people attend to in any given situation, but also how they draw conclusions about what they perceive.

Six student characteristics entered the prediction equation which accounted for 36.68 percent of critical thinking variance. The Reading Total Score, a subtest from the Iowa Tests of Educational Development, was the first variable to be entered into the equation, followed by cumulative grade point average, the "judgment" score from the Myers-Briggs Type Indicator™, the number of leadership positions held in high school, and two of the nineteen learning preferences, "when material is presented in a logical, orderly method" and "when someone takes a personal interest and involvement in me."

F-ratios reported were for the step in which each variable entered the prediction equation. Although the six variables included were highly significant beyond the .05 level, the resulting equation accounted for only slightly more than one-third of the variance associated with critical thinking scores. Other variables did not add significantly to the prediction equation (p>.05) and were, therefore, not included.

The Reading Total Score accounted for approximately 28 percent of the critical thinking score variance. Cumulative grade point average added slightly more than 2 percent, "judgment" slightly less than 2 percent, and each of the remaining three variables added between one and 2 percent to the total variance explained by the prediction equation. Residual
variance could not be explained by remaining variables at the established level of significance.

Regression analysis was again employed to identify variables, exclusive of the learning styles obtained from the Myers-Briggs Type Indicator™, which significantly influence the predictability of critical thinking scores. Results of this analysis are presented in Table 17. Most notably, the first variable to enter the prediction equation was Use of Sources of Information, a subtest from the Iowa Tests of Educational Development. This variable accounted for 27.97 percent of the variance associated with critical thinking scores.

Two other variables had significant F-ratios and entered the prediction equation in subsequent iterations. Cumulative grade point average (2.834%) and Literacy Materials (1.695%), a subtest of the Iowa Tests of Educational Development, entered in steps two and three, respectively. After each significant predictor variable was entered, the full equation (with all significant variables entered) was able to account for 32.49 percent of the critical thinking scores. Residual variance could not be attributed to the remaining variables on a statistical basis.

A factor analysis of the variables in this study provided 13 different factors. The highest factor loadings were observed for all nine subtests of the Iowa Tests of Educational Development, cumulative grade point average, and critical thinking scores. The second highest factor loadings were composed of grade level, years in FFA, semesters of vocational agriculture, and age.
Table 17. Stepwise regression analysis of all variables excluding MBTI™ on critical thinking scores

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable entered</th>
<th>( b^a )</th>
<th>Multiple r</th>
<th>F-ratio(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of sources of information (ITED subtest)</td>
<td>.333</td>
<td>.529</td>
<td>90.07</td>
</tr>
<tr>
<td>2</td>
<td>Cumulative grade point average</td>
<td>2.847</td>
<td>.555</td>
<td>51.41</td>
</tr>
<tr>
<td>3</td>
<td>Literary materials (ITED subtest)</td>
<td>.337</td>
<td>.570</td>
<td>36.90</td>
</tr>
</tbody>
</table>

Constant = 22.43 Multiple \( R^2 = .3249 \)

\(^a\)Regression coefficients for the final prediction equation.

\(^b\)\( F_{1,233,.05} = 3.81. \)

It is interesting to note that the subscores of the Myers-Briggs Type Indicator™ loaded as predicted. Each of the four preferences (E or I; S or N; T or F; and J or P) direct the use of perception and judgment, affecting not only what people attend to in any given situation, but also how they draw conclusions about what they perceive. The Extraversion or Introversion (EI), Sensing perception or Intuitive perception (SN), Thinking judgment or Feeling judgment (TF), and Judgment or Perception (JP) preferences had high factor loadings.

Major Findings

The following statements briefly summarize the major findings important to this investigation.
1. The critical thinking mean score measured in the sample of Iowa agriculture students (36.89) was lower than the mean scores (45.3 and 40.6) measured in the two comparison groups.

2. Levels of critical thinking measured in the tenth grade group of respondents (mean = 34.51) was the lowest of the four grades observed.

3. The level of critical thinking measured in 15- and 16-year-old respondents (means = 35.05 and 35.64 respectively) was significantly lower than the level measured in 17-year-old respondents (mean = 39.22).

4. Levels of critical thinking measured in respondents who had completed one or two to three semesters of agriculture (means = 35.54 and 35.70 respectively) were significantly lower than critical thinking levels observed for respondents who had completed more than six semesters of agriculture (41.15).

5. A significant difference in critical thinking mean scores was observed for respondents who had completed four years of membership in FFA (mean = 41.43) and those who had completed one, two, or three years of membership (means = 35.32, 36.44, and 37.37 respectively).

6. Respondents who had held more than seven leadership positions had significantly higher mean scores for levels of critical thinking.

7. The difference observed in the mean levels of critical thinking scores of respondents living in town (34.91) and respondents living on farms (37.55) was highly significant.
8. There were no significant differences discovered in the mean scores of respondents' levels of critical thinking and their parent's educational level.

9. Two subtests from the Iowa Tests of Educational Development, the Reading Total Score and Uses of Sources of Information, proved to be the two greatest predictors of levels of critical thinking.

10. The Myers-Briggs Type Indicator™ did not substantially contribute to predicting the level of critical thinking in respondents.

11. Respondents unanimously and overwhelmingly preferred to learn in laboratories and shop activities while in an agriculture course.

12. As a collective group, respondents preferred to learn in an agriculture course while working on group projects with classmates.

13. A significant difference existed in the means of respondents in the twelfth grade and the ninth and tenth grades in their preference to learn while following their own impulses and being flexible.

14. Levels of critical thinking for the two largest groups of respondents described by the learning styles "ESTP" and "ISTP" from the Myers-Briggs Type Indicator™ were below the mean observed for the sample.
DISCUSSION

The central purpose of this study was to determine the ability of Iowa agriculture students to use critical thinking skills. More specifically, this study was designed to: (1) assess the critical thinking abilities of Iowa agriculture students as measured by a normed test of critical thinking, (2) compare the critical thinking abilities of Iowa agriculture students to established critical thinking values, (3) assess and analyze levels of critical thinking related to learning style, and (4) analyze selected relationships associated with levels of critical thinking.

The overall design of the study proved to be effective in accurately assessing the critical thinking skills of secondary agriculture students. The ability to make inferences to the general population of secondary agriculture students was a major consideration throughout the design of this study. An underlying objective from the inception of this investigation was to infer results obtained to the entire population of Iowa agriculture students. The cluster sampling procedure was determined from research and consultation to be the most effective and economical while simultaneously insuring the possibility of making valid inferences.

Another strength of the design utilized in this study was the efficiency with which the instructor and students utilized class time for data collection. Specific instructions were designed, evaluated, and recommended to the agriculture instructors in order to facilitate the collection of data. Two commercial instruments and a respondent
information sheet were completed in less than three hours of student class time.

One major problem in fulfilling specific objectives of the study was identifying, obtaining, and evaluating instruments appropriate for use at the secondary level. The overall study could have been strengthened by a wider assortment of appropriate instruments from which to select for the measurement of both critical thinking and learning styles.

The Cornell Critical Thinking Test used to assess the critical thinking skills of the respondents did not lend itself to factor analysis. The aspects of critical thinking that are purported to be measured in this instrument—induction, deduction, observation, credibility, and assumptions—could not be examined individually to ascertain which of these criteria or skills were lacking in the respondents. This statistical technique could have proven very beneficial in identifying which of these factors do, in fact, contribute substantially to the enhancement of critical thinking. Merely being able to assess a weakness or lack of skill in the critical thinking ability of an individual without accurately identifying its root causes is a testimonial to the current state-of-the-art of critical thinking research and evaluation.

Mindful of this fact, the first objective of this study was to assess the abilities of secondary agriculture students to perform critical thinking. The Cornell Critical Thinking Test (Ennis and Millman, 1985) is a 71-item test that, when corrected for examples given in the test booklet, yielded a maximum correct answer score of 66. For the tenth grade group (mean = 34.51), approximately 53 percent of the questions were
answered correctly, whereas for the twelfth grade group (mean = 40.55), 61 percent of the questions were answered correctly. The mean score for all respondents (36.89) indicated that approximately 56 percent of the questions were correctly answered.

Whereas the eleventh and twelfth grade means were observed to be above the group mean, the ninth grade mean was less than one point below the group mean. It is significant to note that the mean for the tenth grade respondents was almost two and one-half points below the group mean. The tenth grade group mean was observed to be the lowest group mean. The largest standard deviation for critical thinking for all grade levels was noted for the tenth grade group. This observation suggests that more variability was present in the levels of critical thinking for this grade level.

Highly significant differences were observed among the mean scores for critical thinking of the twelfth grade respondents and the respondents of the other three grade levels. When a comparison of the differences between critical thinking mean scores for all four grade categories were analyzed, differences among these means become more revealing. The difference in mean scores between the eleventh grade (37.17) and the ninth grade (36.12) was 1.61. This difference was identical to the mean score difference observed between the ninth grade (36.12) and the tenth grade (34.51) groups.

Comparable results were observed when levels of critical thinking were examined by age of the respondent. It was discovered that the most significant differences were noted among the means for the 15- and
16-year-old respondents which were lower than the means measured in their 17-year-old counterparts. The two groups which scored below the group mean were the 15- and 16-year-old groups. These two age groups would likely comprise the bulk of the tenth grade class. Again, when a comparison of the differences between critical thinking mean scores of all five age categories are examined, a trend may be emerging.

The discernible pattern which may be evolving was that the tenth grade group studied in this investigation differed in their critical thinking ability from the remainder of the sample. Although this investigation did not attempt to discover causal relationships, these findings may suggest a number of explanations for the results obtained.

Whereas a more complete description of the two comparison groups was unavailable, it was likely that the groups were comprised of more nearly-equal proportions of males and females than were represented in this study. Although more than two-thirds of the respondents in this study were male, this composition of male to female students is representative of the secondary population of agriculture students in Iowa.

One feasible explanation may lie in certain physiological and sociological processes that are occurring in tenth grade students 15 and 16 years of age. Apparently, these two factors have been either overlooked or neglected in the research and the literature relevant to critical thinking. It may be conceivable these factors exert a powerful influence over individuals of this age, regardless of their gender. Mental processing of sensory inputs dominated by a student's physiological
needs and social environment may not be entirely conducive for the development of a high level of critical thinking at this stage in the developmental process of individuals.

Another plausible explanation may be confirmed by further investigation of this topic in a longitudinal study. The data clearly revealed that students enrolled in ninth grade vocational agriculture courses had a higher level of critical thinking ability than did those students who were in tenth grade agriculture courses. One implication might be that ninth grade students with high levels of critical thinking ability are not being retained in agriculture courses for the succeeding years. This factor may also be confounded by the inference made in the previous paragraph.

The levels of critical thinking observed in the respondents is indicative that some level of proficiency in this skill is indeed present. It may be even more important to note that much variability in this proficiency exists in the diverse characteristics of the respondents. Based upon the literature reviewed, the levels of critical thinking observed in the respondents might be characterized as being equivalent to that of novices.

The second major objective of this investigation was to compare the levels of critical thinking observed in the respondents to levels measured in two comparison groups. The groups selected for comparative purposes in this investigation were uniquely different from the respondents in several important ways. Group XP was comprised of senior high school students from a suburban school with a high proportion of college-bound students.
Senior high school students comprising Group XQ had completed a college-preparatory course of study in science.

Although the respondents' scores at the 99th percentile ranking were essentially identical to Group XP and Group XQ, a rapid decline in the respondents' scores occurred below this level. At the 50th percentile rank, the respondents' mean score of 37 was highly different from the mean scores of Group XP (46) and Group XQ (41). The differences remained uniform among all three groups to the lowest percentile ranking reported. One conclusion that may be drawn from this observation is that those respondents who scored above the 90th percentile ranking possessed levels of critical thinking equal to or above those individuals scoring at the same percentile ranking in Groups XP and XQ.

An additional illustration, however, may serve to explain and illuminate the differences surfacing among these groups. The standard deviation of the respondents' scores was two points larger than the standard deviation of Group XQ and more than three points greater than the standard deviation of Group XP. This measure of dispersion describes the variability present in the respondents' scores measuring levels of critical thinking. It may be concluded that there was a great deal of variation in individual levels of critical thinking within the respondents studied in this investigation.

The aforementioned qualitative and quantitative differences may still not satisfactorily explain differences observed in the levels of critical thinking between the three groups. One relationship often associated with vocational agriculture and vocational education, in general, is the appeal
it has to the less academically-oriented student. If this correlation is true, then the differences discovered in this investigation may be partially attributed to this fact.

Data were not gathered which would have indicated the respondents' plans for college. However, since a majority of the respondents were 16 years of age and under, it might be surmised that most of the respondents would not have made plans to attend a post-secondary institution. Increased requirements for high school graduation and college admission would most likely preclude a majority of these students enrolled in vocational agriculture from being described as college-bound.

A cursory observation may lead one to initially conclude that the mean levels of critical thinking observed in Iowa agriculture students are lower than the mean levels of the two comparison groups used in this investigation. A review of the literature and the research in critical thinking did not reveal any investigations dealing with the unique respondent group selected in this study. Accordingly, the data disclosed in this study should serve as a foundation or basis from which to compare similar respondents.

Comparisons made between the results obtained in this study to research cited in the review of literature may be inappropriate. Imminent authorities in the fields of education and cognitive psychology have not prescribed quantitative or benchmark criteria from which to base judgments about desirable levels of critical thinking. The nature of critical thinking currently precludes anything more tangible than a curriculum
based upon a conceptual model of the desirable cognitive skills that research has shown to increase the critical thinking abilities of students.

Regardless, the levels of critical thinking discovered in these respondents may be inadequate. Vocational agriculture students must have more than some vaguely defined minimum level of competency in critical thinking to function in today's society. It appears that agricultural educators may not be as effective in teaching critical thinking as they could be. As a result, a deficiency in the respondents' levels of critical thinking may be recognized from the data presented in this study.

The third major objective of this study was to assess and analyze levels of critical thinking related to learning style. Learning style, as previously defined in Methods of Procedure, encompasses four aspects of an individual's psychological makeup: (1) cognitive style or information processing habits, (2) patterns of attitudes and interest, (3) compatible dispositions to one's cognitive style, and (4) dispositions to use or not use certain learning tools. The sixteen learning styles shown in Figure 1 are not evenly distributed in the school population. There were no data available to compare the distribution of types at different educational levels because each had their own characteristically different type distributions. The distribution might be different for elective courses, such as an agriculture course, because students' learning styles or types influence their choices of electives. However, a general population distribution percentage can provide insights into the learning styles of
the respondents studied in this investigation. Myers and McCaulley (1985) cited data which revealed that 70 percent of the population preferred Extraversion (E) while 30 percent preferred Introversion (I). Sensing (S) was preferred by 70 percent of the population and 30 percent preferred Intuition (N). Thinking (T) and Feeling (F) were preferred almost equally as were Judgment (J) and Perception (P). This would supposedly mean that more students are ESFJ than INFJ and more are ENFJ than INFJ. The Sensing (S) and Intuition (N) preference reveals basic learning style differences.

As previously reported, the learning style with the highest critical thinking mean score (41.84) was INFP followed closely by ENFP (mean = 41.48). It is interesting to note that the four highest critical thinking mean scores were all -NF- types. According to Myers and McCaulley (1985), the intuitive (N) person has insight into complex, abstract, symbolic, and theoretical relationships. They may be attracted to learning environments where they can work with theory and imagination more than dealing with tangibles. Feeling types (F), however, seek out environments where understanding and communication with people are needed. Interpersonal skills are more important than the technical skills.

Although the -NF- groups comprised only ten percent of the sample studied, this observation may represent an anomaly if the generalizations previously cited are considered in the context of an agriculture course. It may be an indication that there are other aspects of vocational education, apart from knowledge acquisition and skill development, which attracted students to the courses. The high levels of critical thinking observed in these four groups may very well confirm the theoretical
constructs of critical thinking alleged by the authors which were tested for in the Cornell Critical Thinking Test.

The two largest groups of respondents in this study were described by the learning styles ESTP (N=112) and ISTP (N=111). These two groups comprised almost one-third of the total sample of respondents. It was surprising to observe that Introverts (I) composed a greater than expected percentage of the total population. According to Myers and McCaulley (1985), the percentage for this group was almost one-third higher than expected.

An almost equal percentage of respondents preferred Thinking over Feeling (70%) and Perceiving over Judging (72%) in their learning styles. Again, these percentages were not representative of the general population and were, in fact, almost half-again as large as expected.

Besides having identical preferences for thinking and perceiving, TP, the ISTP and ESTP groups were identical in their preferences for the Sensing (S) learning style indicated by S-. The Sensing-with-Thinking (ST-) student focuses their practical outlook on aspects readily subject to logical analysis—objects, machinery, and the more impersonal transactions of life.

This evidence suggests that the most predominant learning style preference was Sensing (S). This fact should not be surprising because one goal of agricultural education is to prepare students for occupations in agriculture which may require psychomotor skill development. This opportunity could also enhance problem-solving strategies, described by
Sternberg (1984) as "metacomponents," to plan, monitor, and evaluate what the student has done.

The critical thinking mean scores of the ESTP (35.19) and ISTP (33.67) groups were observed to be the lowest mean scores analyzed for any group and were below the mean score observed for the sample (36.86). The mean scores for these learning styles (ESTP and ISTP) were significantly different from the mean scores of the INFP (41.84) and the ENFP groups (41.48).

The accounting provided for students who preferred the Sensing-with-Thinking (-ST-) learning style may not provide direct evidence to explain the critical thinking mean scores for these two groups. However, it does provide sufficient descriptive information to make a supposition about the ISTP and ESTP learning styles of the respondents and their levels of critical thinking.

Three of the four Sensing (-S-) learning style mean scores of the respondents (43%) were below the mean score for the sample. The four groups comprised approximately 57 percent of the total sample. Based upon the evidence presented, it would seem evident that four of every ten respondents who were predominantly inclined to use the Sensing (S) learning style in an agriculture course were at a distinct disadvantage when levels of critical thinking were being evaluated.

The implications from these observations should strengthen the instructional precepts of vocational agriculture. The majority of the respondents who favored the Sensing (S) learning style also preferred to learn through a variety of instructional techniques, many of which are
unique to agricultural subject matter. Supervised agricultural experience, team competition, laboratory and shop exercises, and practical tests which include relevant problem-solving activities provide instructional strategies that should be utilized with these respondents. Literature previously cited (Sternberg and Caruso, 1985) alluded to the importance of practical knowledge as it pertains to everyday relevancy. Glaser (1984) and Larkin (1980) also stated that procedural knowledge, or how to apply this knowledge, is just as important as conceptual knowledge for individuals to solve problems well.

Respondents were asked to rate their preference for nineteen different learning activities while in an agriculture course. Learning "in laboratories and shop activities" was unanimously and overwhelmingly preferred by all four grades. Although there was no significant difference observed among the group means, it was significant to note that the tenth grade group mean (72.22) was the lowest of the grade group means, whereas the tenth grade standard deviation (27.39) was the largest variation noted among the grade groups. This observation remained consistent with the disparity noted in the tenth grade group throughout this study.

This result was anticipated in light of the experiential principles upon which the vocational agriculture curriculum is purported to be founded. In light of the findings related to the ISTP and ESTP learning styles prevalent among the respondents, the high level of preference given to this activity over other learning activities might have been anticipated.
"Working on group projects with classmates" had the second highest composite mean and was a much preferred learning activity by all grade levels. The unanimity expressed by the respondents in the form of the four group means being separated by less than two points was unexpected. Myers and McCaulley (1985) expected this learning activity to be preferred by the EN— learning styles which are represented by one-fourth of the respondents. In this instance, the respondent's dominant learning style may have become transient or dynamic and shifted towards a learning activity that is a trademark of socially-interactive learning typified in vocational agriculture and FFA activities.

The third most preferred learning activity of the respondents was "following my own impulses and being flexible." This learning activity is a characteristic endeavor of the Perceptive (P) learning style. Although three-fourths of the respondents were represented in this category, it is evident that the ninth and tenth grade student did not prefer this activity as highly as the eleventh and twelfth grades. The standard deviations of the ninth (25.86) and tenth grade (27.54) students were also highly indicative of the mixed feelings toward this learning activity by the ninth and tenth grade students. According to Myers and McCaulley (1985), the perceptive learning style is associated with creativity, spontaneity, and curiosity which may be more evident in the latter stages of high school.

"Learning by formalized instruction (lectures, teacher assignments, homework)" was of little preference to the respondents and ranked next to last. The learning activity lowest-ranked was when respondents had "to
memorize facts." Both of these learning activities were unanimously and overwhelmingly of little preference to students in all four grades.

The low preferences given these two learning activities may have serious consequences for the instructional techniques used in vocational agriculture classrooms. It may be surmised that these two learning activities may be the least preferred because they are, in fact, the predominant instructional techniques the respondents have directly observed being used in the educational system they have progressed through. If these learning activities—"learning by formalized instruction" and "memorizing facts"—are utilized to a great extent in an agriculture course, the respondents may elect to enroll in another course which is more conducive and appropriate to their interests and their learning styles.

It was anticipated that significant differences would be observed in the levels of critical thinking for respondents who had completed one, two, or three semesters of agriculture and those respondents completing more than six semesters. It may be illustrative of an age factor that the means of these three groups were significantly different. However, the difference in mean scores of almost six points was higher than expected.

Again, an age factor may be implicitly responsible for the significant mean differences which were observed for those respondents completing four years of FFA membership and respondents with one, two, or three years of membership in the FFA. Although not directly measured, the quality and quantity of experiences obtained while a member of the FFA may have inextricably accounted for the significantly higher levels of
critical thinking observed for the respondents who had completed four years of membership.

Similar results were obtained when critical thinking levels were compared to the number of high school leadership positions held by the respondents. These findings may be attributed to those same factors discussed in the previous paragraph.

A group t-test revealed a notable finding of this study. It was observed that the level of critical thinking of respondents who lived on a farm was significantly higher (p>.01) than respondents' critical thinking levels who lived in town. Analyses of other variables measured in this study that might have revealed what factors accounted for this difference were not fruitful. It is conceivable that respondents who lived on a farm were actively engaged in processing, storing, understanding, and utilizing information crucial to their agricultural livelihood and rural way of life. This problem-solving activity becomes more personal and has more relevancy and utility when it becomes necessary to solve a myriad of problems not necessarily encountered by those respondents who lived in town. It is also of importance to note that almost three times as many respondents lived on farms as lived in town.

Two stepwise regression procedures yielded results of relative importance in the ability to predict critical thinking scores. The initial regression analysis utilized all the variables measured in this study. The Reading Total Score test from the Iowa Tests of Educational Development was identified as accounting for approximately 28 percent of the critical thinking score variance. A subsequent regression analysis
was performed without the eight variables from the Myers-Briggs Type Indicator™, and another subtest from the Iowa Tests of Educational Development, Use of Sources of Information, accounted for almost an identical amount of critical thinking score variance.

The results of the regression analysis indicated that the best predictor of critical scores in this study were two subtests of the Iowa Tests of Educational Development. The use of the Myers-Briggs Type Indicator™ in similar studies to predict critical thinking scores may not be justified on a cost-benefit basis.

Based on the findings of this investigation, the following major conclusions were drawn.

The availability and suitability of instruments used to measure and analyze critical thinking skills was severely limited which hampered this investigation.

Given the basic tenets of agricultural education, its problem-solving approach to instruction, and the evidence provided in this investigation, one can conclude that agriculture students in Iowa are developing critical thinking skills but at surprisingly low levels of development.

Secondary agriculture students in Iowa had lower and more diverse levels of critical thinking than high school students in the comparison groups.

The level of critical thinking in a secondary agriculture student in Iowa is related to their level of academic and educational achievement and their predominant learning style.

Iowa agriculture students overwhelmingly preferred interactive and experiential learning activities.

Conventional instructional techniques met with much disfavor among Iowa agriculture students.

Based on the findings and conclusions identified in this study, several recommendations were made which may impact agriculture students,
agriculture instructors, school administrators, teacher educators, state supervisors, and test and curriculum development personnel. These recommendations are suggested in an attempt to improve the quality of evaluation instruments, curriculum materials, and instruction in Iowa agriculture classes. These recommendations may be generalized to all agriculture programs in Iowa. School administration personnel should examine the potential benefits which may be derived as a result of the implementation of these suggestions in the programs which they are responsible for supervising.

Curriculum materials have been designed, produced, and tested that will increase the levels of critical thinking. Test and evaluation materials currently in use should be evaluated and, if necessary, redesigned to parallel those aspects of critical thinking that are included in critical thinking instruction. This may substantially increase the uniformity and reliability of measuring definable aspects of critical thinking.

Instructional materials incorporating critical thinking skills should be diffused into the agriculture curriculum. Teacher educators should develop instructional materials for use by agriculture instructors which will allow instruction in critical thinking principles to take place in all agricultural subject matter. This will not necessitate new curriculum materials per se. It will, however, require reorganization of and emphasis on different aspects of the curriculum which is already in place.

Pre- and in-service education should be provided to student teachers and agriculture instructors to facilitate the process of diffusing
critical thinking principles into the curriculum. Pre- and in-service education should not only include the curriculum development aspects of critical thinking, but also the instructional techniques found to be most appropriate for increasing levels of critical thinking in agriculture students.

Differences observed in students are not just quantitative differences that may be expressed in terms of a higher or lower level of mental ability. There are qualitative differences which account for a student's different needs, interests, motivations, and degrees of success in school.

Educators are being held accountable, now more than ever before, for a student's knowledge and skills. Student learning styles provide an additional assessment tool which educators can use to become more proficient in identifying and attending to the individual needs of students.
The purpose of this study was to determine the ability of Iowa agriculture students to use critical thinking skills. More specifically, this study was designed to: (1) assess the critical thinking abilities of Iowa agriculture students as measured by a normed test of critical thinking; (2) compare the critical thinking abilities of Iowa agriculture students to established critical thinking values; (3) assess and analyze levels of critical thinking related to learning style; and (4) analyze selected relationships associated with levels of critical thinking.

The design for this study utilized descriptive research methodology. The population in this study consisted of agriculture instructors and students enrolled in Iowa high schools offering programs in agriculture. The sample consisted of 668 students from 18 Iowa secondary schools. The cluster sampling technique was used because of the feasibility of selecting individuals from a defined population.

Agriculture instructors were contacted and requested to cooperate in this study. An information sheet was developed to collect demographic information and student preferences on learning activities in agriculture courses. The Cornell Critical Thinking Test (Ennis and Millman, 1985) was administered to students to collect data on levels of critical thinking. The Myers-Briggs Type Indicator™ was also administered to students to collect data relative to their learning styles.

The following statements briefly summarize the major findings important to this investigation.
The critical thinking mean score measured in the sample of Iowa agriculture students was lower than the mean scores measured in the two norm-referenced groups. Levels of critical thinking measured in the tenth grade group of respondents was the lowest of the four grades observed. Levels of critical thinking were highest for the twelfth grade group of respondents.

The level of critical thinking measured in 15- and 16-year-old respondents was significantly lower than the level measured in 17-year-old respondents. Levels of critical thinking measured in respondents who had completed one or two to three semesters of agriculture were significantly lower than critical thinking levels observed for respondents who had completed more than six semesters of agriculture.

A significant difference in critical thinking mean scores was observed for respondents who had completed four years of membership in FFA and those who had completed one, two, or three years of membership. Respondents who had held more than seven leadership positions had significantly higher mean scores for levels of critical thinking.

The difference observed in the mean levels of critical thinking scores of respondents living in town and respondents living on farms was highly significant. There were no significant differences discovered in the mean scores of respondents' levels of critical thinking and their parents' educational level.

Two subtests from the Iowa Tests of Educational Development, the Reading Total Score and Uses of Sources of Information, proved to be the two greatest predictors of levels of critical thinking. The Myers-Briggs
Type Indicator™ did not substantially contribute to predicting the level of critical thinking in respondents. Levels of critical thinking for the two largest groups of respondents described by the learning styles "ESTP" and "ISTP" from the Myers-Briggs Type Indicator™ were below the mean observed for the sample.

Respondents unanimously and overwhelmingly preferred to learn in laboratories and shop activities while in an agriculture course. As a collective group, respondents preferred to learn in an agriculture course while working on group projects with classmates. A significant difference existed in the means of respondents in the twelfth grade and the ninth and tenth grades in their preference to learn while following their own impulses and being flexible.

Based on the findings of this investigation, the following major conclusions were drawn.

Given the basic tenets of agricultural education, its problem-solving approach to instruction, and the evidence provided in this investigation, one can conclude that agriculture students in Iowa are developing critical thinking skills but at surprisingly low levels of development. Secondary agriculture students in Iowa had lower and more diverse levels of critical thinking than high school students in the comparison groups.

The level of critical thinking in a secondary agriculture student in Iowa is related to their level of academic and educational achievement and their predominant learning style. Iowa agriculture students overwhelmingly preferred interactive and experiential learning activities.
Conventional instructional techniques met with much disfavor among Iowa agriculture students.

The following statements briefly summarize the major implications resulting from the findings of this investigation.

The current state-of-the-art of critical thinking research and evaluation merely allows an assessment of critical thinking skills to be performed without establishing minimum competencies for this skill.

As a result of the low levels of critical thinking observed in the sample of Iowa secondary agriculture students, agricultural educators must incorporate principles of critical thinking and problem-solving into their curriculum.

The use of the most appropriate instructional methods to stimulate students with various learning styles will enhance student learning and their levels of critical thinking.

The authors of the Cornell Critical Thinking Test alluded to the important qualification that students were able to read well enough. The results of the two regression analyses may verify the authors' inference that a student's reading comprehension is a strong indicator of their level of critical thinking ability as measured by this test.

It may seem that less academically-inclined students, which the respondents may have represented, would be at a distinct disadvantage in comprehending the logical nature of this test. Does this test reliably measure the ability of students to think critically or does it measure their ability to think logically?
The user norms provided in the test booklet shed little light on the characteristics of students previously tested. More pertinent and revealing information for the student populations previously studied would provide researchers with valuable insight. User norms lacked the suitable scope necessary for their suitability and general applicability to the respondents in this study.

Has the incorporation of vital aspects of critical thinking been allowed for in the author's definition? Have all of the different perspectives of critical thinking been accounted for? Does this definition realistically reflect the critical thinking that is necessary to formulate an all-encompassing operational definition necessary for vocational education?

Psychomotor activity and skill development is affected and determined by the cognitive activity inherent in critical thinking. Development of critical thinking activities beyond "deciding what to believe and do" is essential for agricultural education.

This study did not attempt to determine specific contributions made to levels of critical thinking in agriculture students by aspects of the agriculture curriculum. Nor did this study attempt to determine the most effective instructional strategies or techniques necessary to induce or establish critical thinking abilities in agriculture students. It is conceivable that the levels of critical thinking observed in the respondents are contributions of the total curriculum in Iowa secondary schools.
BIBLIOGRAPHY


Whimbey, A. 1980. The key to higher order thinking is precise processing. Educational Leadership 42:66-70.


ACKNOWLEDGEMENTS

It is with the deepest, heartfelt feelings that I take this opportunity to express my love, gratitude, and appreciation to my family who helped make what was once an insurmountable dream a reality.

To my father who, in his own special way, provided me with the spirit, the will, and the strength to achieve the goals that I have placed before me.

To my mother who, with her wisdom and concern, intentionally planted the seed for this investigation with the thought-provoking quip, "Think about it."

To my son Kevin who shared the joys and sorrows, the happiness and the ordeals, and helplessly observed his father's transformation into a graduate student.

To my son Bryan who illuminated the long path with the brilliant sparkle in his eyes and relinquished a father for three formative years.

To my son Darren who taught the teacher much about creativity, independence, and persistence and also relinquished a father for three formative years.

I also extend a debt of gratitude which can never be fully repaid to the following individuals:

To Dr. Alan Kahler who served as co-chairman of my committee and from whom I received honest advice, self-confidence, enthusiastic encouragement, and invaluable assistance.
To Dr. Wade Miller who served as co-chairman of my committee and from whom I learned about pragmatic teaching, perceptive research, and introspection.

Special recognition is also given to my committee members Dr. Anton Netusil, Dr. John Wilson, Dr. Richard Gladon, and Dr. Jack Weigle for their support and time in guiding my graduate program.

To those "special" friends who were there for me when support, advice, and comraderie was needed, I extend a warm thank you.
APPENDIX A. INFORMATION SHEET
Dear Agriculture Student:

During the next several days your agriculture instructor will be asking for your cooperation in collecting some very important information. This information consists of three parts: an information sheet which will ask you some general questions; a test which will measure your critical thinking ability; and an instrument which will describe how you learn best. Your instructor will also be recording other factual data about your school work. All of this information will only have an identification number (I.D. NO#). Your name will not appear anywhere on this information.

Your participation in this project is strictly VOLUNTARY. Please SIGN your name above if you agree to participate in this project. The I.D. NO# assigned to you by your instructor should be recorded in the space above. If you have questions about anything on these or other pages, please ask your instructor to assist you.

+++ INFORMATION SHEET ++++

1. Circle your current grade level.  9  10  11  12
2. Circle your current age.  14  15  16  17  18
3. Including this semester, how many semesters of vocational agriculture have you completed? (Check one answer only)
   ___1   ___2   ___3   ___4   ___5   ___6   ___7
4. Including this year, how many years have you been in F.F.A.? (Check one answer only)
   ___1   ___2   ___3   ___4
5. How many different leadership positions have you been involved in during high school (i.e. class/club officers, committee member)? _____
6. Check ONE area below which most closely describes where you live:
   _____ in town      _____ on a farm     if on a farm, how many acres? _____
7. The highest grade level completed by my FATHER is (check ONE that applies):
   ___7   ___8   ___9   ___10   ___11   ___12   ___13   ___14   ___15   ___16   ___17
8. The highest grade level completed by my MOTHER is (check ONE that applies):
   ___7   ___8   ___9   ___10   ___11   ___12   ___13   ___14   ___15   ___16   ___17
The following questions have no "right" or "wrong" answers. The answers you give show how you prefer to learn things in school and everyday activities.

INSTRUCTIONS: Below are listed some of the ways in which you learn. As you read each statement, please respond to each item as you feel about it using the 1 to 99 scale described below.

<table>
<thead>
<tr>
<th>No Preference</th>
<th>Some Preference</th>
<th>Very Much Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 10 20 30 40 50 60 70 80 90 99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 = No Preference  
25 = Little Preference  
50 = Some Preference  
75 = Much Preference  
99 = Very Much Preference

EXAMPLE: I prefer to learn:

* 72 by studying facts, facts, and more facts.

While in an agriculture course, I prefer to learn:

1. _____ using audiovisual materials (films, slides, TV, etc.).
2. _____ in discussion groups with my classmates.
3. _____ when the material is presented in a logical, orderly method.
4. _____ when I can use a computer.
5. _____ giving reports on topics that are interesting to me.
6. _____ materials when I have to memorize facts.
7. _____ while working on group projects with classmates.
8. _____ when there are opportunities to be creative and original.
9. _____ through independent study.
10. _____ hearing reports on topics selected by other students.
11. _____ by observing specific things and activities.
12. _____ by formalized instruction (lecture, teacher assignments, homework).
13. _____ by reading books and teaching myself things.
14. _____ from demonstrations in class.
15. _____ from personal relationships that are creative and original.
16. _____ in laboratories and shop activities.
17. _____ when someone takes a personal interest and involvement in me.
18. _____ by following my own impulses and being flexible.
19. _____ by thinking and reasoning by myself without others.
APPENDIX B. INTRODUCTORY LETTER
Dear Agriculture Instructor:

You are probably aware of the nation-wide movement to increase the emphasis in teaching critical thinking, problem solving, and decision making. Recently, the Iowa legislature prescribed standards to develop and establish the instruction of these skills in schools throughout Iowa.

Vocational agriculture is a prescribed part of the total educational program in the comprehensive high school curriculum. As such, we are responsible for teaching these higher order thinking skills in our programs. Historically, we educators in vocational agriculture have taken pride in using the decision making and problem solving approaches to teaching our students. These approaches constitute a major part of the higher order thinking skills program currently mandated.

You have been randomly selected to participate in a study we are planning on conducting this fall. We would like to solicit your participation in this project which will entail you and your students taking a critical thinking test, a personality type indicator, and completing a general information questionnaire. This process is anticipated to take approximately three days. You will also be requested to supply data from your students' cumulative folders which will provide additional data for the study.

The data you provide will be used for research purposes and will result in professional publication. All data we receive from you will be anonymous and kept in strict confidence.

We would like to strongly urge your participation in this important study. We will contact you sometime during this next week to discuss this study with you, answer any questions you may have, and seek your permission to include you in the investigation.

We wish you the best as you start the new school year, much success in accomplishing your goals, and look forward to working with you on this project.

Sincerely,

Timothy J. Rollins
Teaching Assistant

Alan A. Kahler
Professor

W. Wade Miller
Associate Professor
APPENDIX C. FORMAL AGREEMENT
I understand the importance of this research and agree to the conditions under which this research project will be conducted in the school and department. I understand my role in the conduct of this project and accept the responsibilities inherent in my part as the test administrator.

INSTRUCTOR SIGNATURE ____________________________ DATE __________

I understand the importance of this research and agree to the conditions under which this research project will be conducted in the school.

ADMINISTRATOR SIGNATURE ____________________________ DATE __________

TITLE ____________________________ SCHOOL ____________________________

The completion of this form signifies your understanding and agreement to cooperate in the conduct of this research project. When signed and dated, please return this form to:

Agricultural Education Department
Iowa State University
223 Curtiss Hall
Ames, Iowa 50011
c/o Tim Rollins
APPENDIX D. COVER LETTER
Dear ________________,

Your consent to cooperate in this research project means additional responsibilities for you as well as your students and high school staff members. As one of the few programs to be selected for inclusion in this project (from over two hundred and fifty in Iowa), you are a member of a select group.

One of the functions of this applied, educational research is to learn more about the teaching and learning processes. It is hoped that the results of this research will provide new insights into how students think and learn best in the classroom and improve the teaching processes for agriculture instructors, as well as educators in general.

The success of this research project cannot be measured solely by the results obtained, however. Success is very dependent, in this case, upon your cooperation and the manner in which you seek student participation. Having taught agriculture for eleven years, and getting to know many Iowa agriculture instructors through my responsibilities as a graduate student, supervisor of student teachers, and workshop instructor, I am confident that you will continue to do your utmost to improve agricultural education.

To permit all of the schools selected to participate in this study, it is very important that you complete the administration of this research project within the dates noted below. These materials must be circulated to other schools to avoid conflicts in scheduling and activities of other agriculture programs. The other agriculture instructors and I would very much appreciate if you would maintain the schedule noted below.

You will have five school days to complete the administration of these materials. If you anticipate being unable to accomplish this within the allocated time, please inform me. If you have any questions, please do not hesitate to call me at (515)294-0901. I will return your call as soon as possible to answer your concerns.

Again, let me take this opportunity to express my appreciation to you for the efforts you, your students, and staff members are about to undertake. I am confident that we will successfully accomplish this task.

Respectfully,

Tim Rollins
APPENDIX E. INSTRUCTION SHEET
PLEASE READ
THese INSTRUCTIONS PRIOR TO
ADMINISTERING THE INSTRUMENTS
112
INSTRUCTIONS

READ AND FOLLOW THESE
DIRECTIONS FOR ADMINISTERING INSTRUMENTS

Much of the success of this research project depends to a great extent on the accuracy
with which you carry out the procedures for administering these instruments. Therefore, it
is vital that the following instructions be adhered to as closely as practicable. The
procedures to be followed in administering these instruments are detailed below and are
accompanied by a recommended schedule. Although only "recommended", the schedule should be
adhered to as closely as possible to ensure that the entire population of students being
tested receives duplicate testing procedures and to allow all students adequate time to
complete the instruments.

Each student in your program is to be assigned ONE I.D. NO#. No student is to be
tested more than once. For example, if a student is in two classes, they should be tested
only once during the designated class period.

******************************************************************************

APPROXIMATE TIME REQUIRED FOR THIS ACTIVITY—15 MINUTES.

DAY ONE

Distribute one of the "GOLDENROD" instruments to each of the students in your
agriculture classes. Also distribute one of the NO.2 pencils enclosed in your packet of
information to each student.

READ ALOUD to the students in each of your classes the two paragraphs on the front
page of the "Information Sheet":

Dear Agriculture Student:

During the next several days your agriculture instructor will be asking for your
cooperation in collecting some very important information. This information consists of
three parts: an information sheet which will ask you some general questions; a test which
will measure your critical thinking ability; and an instrument which will describe how you
learn best. Your instructor will also be recording other factual data about your school
work. All of this information will only have an identification number (I.D. NO#). Your
name will not appear anywhere on this information.

Your participation in this project is strictly VOLUNTARY. Please SIGN your name above
if you agree to participate in this project. The I.D. NO# assigned to you by your
instructor should be recorded in the space above. If you have questions about anything on
these or other pages, please ask your instructor to assist you.

It is important for your students to understand:

a. the information they are providing will only be identified with a
   number (I. D. No#). They will remain totally anonymous.

b. you do not have access to the answers of any of the questions
   that are being asked. You will be participating in this project.

c. that they answer each of the questions to the best of their
   ability, and as truthfully and honestly as possible.

d. they will need to be in attendance for the next three successive
days. Absences and tardiness to class will prevent them from
   having sufficient time to complete the three parts.

e. there should be no talking while taking these three instruments
   so they can answer the questions to the best of their ability.
f. that they should not write on any of the test booklets and only on the answer sheets provided. The material will be scored by machine and other students will be using these booklets.

Your students may ask questions related to the project at this time and you should answer them based upon your knowledge, and the information and materials received from the researcher.

If they agree to participate in this project, have them SIGN their name neatly in the space provided at the top of the front page.

--- APPROXIMATE TIME REQUIRED FOR THIS ACTIVITY---20 MINUTES ---

The students should then answer the questions on the "Information Sheet". The directions for each of the questions are to be followed exactly as stated. If there are some questions that they are unsure of, have the student estimate the answer as close as possible.

When the students have completed all of the questions on the "Information Sheet", have them return the I.D. NO# (example: Z-023) you have pre-selected and pre-recorded for them in the two places provided on the front of the information sheet.

REMEMBER THE STUDENT TO MEMORIZE THEIR I.D. NO# FOR FUTURE USE.

Carefully remove the front page portion which has the student's signature and I.D. NO# on it. Keep these separate from the "Information Sheet". Keep the upper portion on file. Retain the signed forms with the student's I. D. NO# to refer to when transferring cumulative folder information to the data sheets. The lower portion of the "Information Sheets" are to be returned to I.S.U.

--- APPROXIMATE TIME REQUIRED FOR THIS ACTIVITY---10 MINUTES ---

Hand each student one "GENERAL PURPOSE-NCS-ANSWER SHEET. Have them turn to SIDE 2 and you should read aloud "IMPORTANT DIRECTIONS FOR MARKING ANSWERS". Turn the page over to SIDE 1 and have them fill in their I.D. NO#. They will only be able to use three numbers (example, 233) of their I.D. NO#, under the boxes labeled "IDENTIFICATION NUMBER" in the bottom portion of side 1. Use columns A, B, and C only. Instruct them to carefully darken in the appropriate bubbles below each of the columns they have filled in with three numbers. An example would appear as shown below (this may be drawn on the chalkboard if necessary)

<table>
<thead>
<tr>
<th>BIRTH DATE</th>
<th>IDENTIFICATION NUMBER</th>
<th>SPECIAL CODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO.</td>
<td>DAY</td>
<td>YR.</td>
</tr>
<tr>
<td>1950</td>
<td>02</td>
<td>03</td>
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<tr>
<td>1950</td>
<td>02</td>
<td>03</td>
</tr>
</tbody>
</table>

You should check the answer sheets for accuracy and completeness prior to collecting them from each student. ENSURE THAT THE STUDENT'S I.D. NO# IS CORRECT and that they are completed correctly to ensure the accurate transfer of data. ASSIGN YOURSELF THE I.D. NO# (USE THE NUMBER ___-001), AND FILL IN THE "GENERAL PURPOSE NCS ANSWER SHEET" WITH YOUR I.D. NO#.

Collect the answer sheets and the pencils from each student. These will be used tomorrow for the next step in the project--the Cornell Critical Thinking Test.

CONGRATULATIONS--ONE-THIRD OF THE WAY COMPLETED!!!!!
DIDAY TWO

APPROXIMATE TIME REQUIRED FOR THIS ACTIVITY---60 MINUTES.*****

*****This may require you to make special arrangements with your principal or
administrator. If necessary, please do so ahead of time.

*****THIS TEST IS TIMED TO BE FINISHED IN 50 MINUTES*****

***PLEASE TRY TO ASSURE THAT ALL STUDENTS HAVE THIS LONG***

Distribute one copy of the Cornell Critical Thinking Test (WHITE), one #2 pencil, and
the individual "GENERAL PURPOSE NCS ANSWER SHEET" that the student completed yesterday.

When the students are ready, say:

READ THE INSTRUCTIONS ON PAGE ii OF THE TEST BOOKLET TO
YOURSELVES WHILE I READ THEM ALOUD: "EXPLORING IN NICOMA.
THE YEAR IS (YOU READ THE MATERIAL ON THE FRONT OF THE TEST
BOOKLET)..." DO YOU HAVE ANY QUESTIONS? NOW WAIT UNTIL
YOU ARE ASKED TO BEGIN.

When students are ready to begin the test, say:

REMEMBER TO BASE YOUR ANSWERS ON THE INFORMATION GIVEN, AND
DO NOT GO BACK TO A PROBLEM IN THE FIRST TWO PARTS ONCE YOU
HAVE PASSED IT.

ALTHOUGH THE INSTRUCTIONS IN THE TEST TELL YOU TO STOP AND WAIT
AT CERTAIN POINTS, YOU SHOULD GO RIGHT ON TO THE NEXT PART AT
THese POINTS. DO NOT WAIT UNTIL YOU ARE INSTRUCTED TO GO ON.

ANSWER ALL QUESTIONS ON THE ANSWER SHEET. DO NOT MARK IN THE
TEST BOOKLETS. USE THE ANSWER SHEETS YOU HAVE BEEN PROVIDED.

Next, say:

BEGIN.

You should also take the test at this time. Be observant of the time and you may
announce to the class periodically how much time remains.

After 50 minutes, say:

STOP. THE TEST IS OVER.

Collect the test booklets, pencils, and the "GENERAL PURPOSE NCS ANSWER SHEET" from
each student.

ALL OF THE TEST BOOKLETS AND ANSWER SHEETS ARE TO BE RETURNED TO I.S.U.

WELL DONE--TWO DOWN AND ONE MORE TO GO!!!!

******************************************************************************
Distribute one copy of the "Myers-Briggs Type Indicator—Form G" booklet, one #2 pencil, and another "GENERAL PURPOSE NCS ANSWER SHEET" to each student. Have them turn to SIDE 2 and you should read aloud "IMPORTANT DIRECTIONS FOR MARKING ANSWERS". Turn the page over to SIDE 1 and have them fill in their I.D. NO#. They will only be able to use three numbers (example, _233) of their I.D. NO# under the boxes labeled "IDENTIFICATION NUMBER" in the bottom portion of SIDE 1. Use columns A, B, and C only. Instruct them to carefully darken the appropriate bubbles below each of the columns they have filled in with three numbers. At the top of SIDE 1, under SEX, please have them fill in the appropriate bubble to indicate their sex. The accuracy of this test requires that the student indicate their sex. ONLY THEIR I.D. NO# AND SEX IS ABSOLUTELY REQUIRED.

When the students are ready, read aloud the directions found on the front page of the booklet. Remind the students that they SHOULD NOT fill in their names on the answer sheets; they MUST indicate their I.D. NO# and sex, however.

When the directions have been read, remind the students that they should finish answering all the questions by the end of the class period. They will be asked to stop at the end of the class period.

When the students are finished, they should return the answer sheet, with their sex and I.D. NO# filled in accurately, and the booklet. The pencils may be kept by each student completing this project—a small token of your gratitude for their cooperation in this project. You should also express the researcher's gratitude and appreciation for the efforts they have put forth.

ALL OF THE TEST BOOKLETS AND ANSWER SHEETS ARE TO BE RETURNED TO I.S.U.

CONGRATULATIONS—YOU HAVE ACCOMPLISHED A MAJOR FEAT!!!!!
APPENDIX F. STUDENT DATA SHEET
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<th>CODE</th>
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<td>ID NO</td>
<td>CLASS RANK</td>
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PERSON RECORDING DATA ________________ TELEPHONE NO#( ) ____________________
NAME
APPENDIX G. INSTRUCTION SHEET FOR RECORDING DATA FROM STUDENT'S CUMULATIVE FOLDER
INSTRUCTIONS FOR RECORDING DATA FROM THE STUDENT'S CUMULATIVE FOLDER

This very important part of the project will conclude your valuable assistance in this research effort. You will need the "DATA SHEETS" supplied in the packet of information you received and the student I. D. #’s you have pre-assigned your students. This task will be immensely easier if there is a staff member in the counseling office whom you can both persuade and rely upon to record this important data ACCURATELY AND PRECISELY. BEGIN THIS PROCESS IMMEDIATELY--IT IS TIME CONSUMING AND ACCURACY IS VITAL.

On the Student Data Sheets, record the student I. D. #’s in alpha-numerical order down the far left hand column. Locate the student’s cumulative folder which corresponds to their I. D. # and LEGIBLY record the information requested. The person recording the data should print their name and telephone number at the bottom of the Data Sheet.

DIRECTIONS

Some of these data will not be available to you. Please be as thorough as possible in completing this data sheet and provide as much of the requested information as possible.

Column 1—Class Rank
Record the class rank of the individual IF it is available from their cumulative folder or from other school sources. It may be indicated as shown in the following example:

   68    indicates that this individual ranks sixty-eighth
   110   in the class of one hundred and ten.

Column 2—Percentile Rank
Record the percentile rank of the individual IF it is available from their cumulative folder or from other school sources.

Column 3—Cumulative Grade Point Average
Record the Cumulative Grade Point Average of the individual student in this column. This will vary depending upon the total number of courses the individual student has completed in high school (grades 9–12). The GPA is based on a 4.0 basis.

Column 4—Level I or Level II
Record the level of the ITED series of tests which your high school administered. IF this is NOT APPLICABLE, enter n/a in the column for each student to which it applies. IF ninth grade students have no ITED test scores, enter n/a.

Columns 5 through 12—ITED Battery Scores
From the Individual Profile which should be found in the student's cumulative folder, record the STANDARD SCORE for each of the subtests shown on the Student Data Sheet in the columns shown below:

Column 5—Correctness and Appropriateness of Expression—TEST E
Column 6—Quantitative Thinking—TEST Q
Column 7—Analysis of Social Studies Materials (Part I & 2)—TEST SS
Column 8—Analysis of Natural Science Materials (Part I & 2)—TEST NS
Column 9—Literary Materials—TEST L
Column 10—Vocabulary—TEST V
Column 11—Uses of Sources of Information—TEST SI
Column 12—Reading Total Score—TEST RT

Column 13—ITED Composite Score
Record the ITED Composite Score from the Individual Profile which should be found in the student's ITED results within their cumulative folder.

Column 14—Date of Test
Enter the date (month and year) in which the ITED Battery of Tests were most recently administered to the individual students.

**9th Grade students who do not yet have ITED scores may be ignored. PLEASE NOTE THEM WITH A "N/R"—NO RECORD.
APPENDIX H. HUMAN SUBJECTS CONSENT FORM
1. Title of project (please type): An Analytical Study of Critical Thinking and Learning Styles of Iowa Agriculture Students

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are properly protected. Additions to or changes in procedures affecting the subjects after the project has been approved will be submitted to the committee for review.

Timothy J. Rollins 9-21-87
Typed Named of Principal Investigator Date Signature of Principal Investigator

223 Curtiss Hall 294-0901
Campus Address Campus Telephone

3. Signatures of others (if any) Date Relationship to Principal Investigator

W. Wade Miller 9-21-87 Co-Chair/Major Professor

4. ATTACH an additional page(s) (A) describing your proposed research and (B) the subjects to be used, (C) indicating any risks or discomforts to the subjects, and (D) covering any topics checked below. CHECK all boxes applicable.

☐ Medical clearance necessary before subjects can participate
☐ Samples (blood, tissue, etc.) from subjects
☐ Administration of substances (foods, drugs, etc.) to subjects
☐ Physical exercise or conditioning for subjects
☐ Deception of subjects
☐ Subjects under 14 years of age and/or Subjects 14-17 years of age
☐ Subjects in Institutions
☐ Research must be approved by another institution or agency

5. ATTACH an example of the material to be used to obtain informed consent and CHECK which type will be used.

☐ Signed informed consent will be obtained.
☐ Modified informed consent will be obtained.

6. Anticipated date on which subjects will be first contacted: 10 21 87
   Anticipated date for last contact with subjects: 11 25 87

7. If Applicable: Anticipated date on which audio or visual tapes will be erased and/or identifiers will be removed from completed survey instruments:

   Month Day Year

8. Signature of Head or Chairperson Date Department or Administrative Unit

9. Decision of the University Committee on the Use of Human Subjects in Research:

   ☑ Project Approved ☐ Project not approved ☐ No action required

   Name of Committee Chairperson Date Signature of Committee Chairperson

Revised 6/78