EFFECT OF PROBLEM-BASED LEARNING ON CRITICAL THINKING ABILITY AND CONTENT KNOWLEDGE OF SECONDARY AGRICULTURE STUDENTS

A Dissertation
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Doctor of Philosophy

by
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The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled:

EFFECT OF PROBLEM-BASED LEARNING ON CRITICAL THINKING ABILITY AND CONTENT KNOWLEDGE ACQUISITION OF SECONDARY AGRICULTURE STUDENTS

Presented by Scott Burris

A candidate for the degree of Doctor of Philosophy

And hereby certify that in their opinion it is worthy of acceptance.

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I dedicate this work to the memory of my

parents, Dale and Lynda Burris.

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ABSTRACT

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship between critical thinking ability and content knowledge among selected secondary agriculture students in Missouri.

The target population for this study was identified as secondary agriculture students in Missouri. Twelve Missouri secondary agriculture teachers were selected based on criteria established by the researcher. The resulting sample (n = 140) consisted of 77 students in the PBL treatment group and 63 students in the supervised study treatment group.

The study employed a quasi-experimental, non-equivalent comparison group design. The treatment consisted of two instructional strategies: problem-based learning or supervised study. Analysis of covariance indicated a treatment effect on critical thinking ability and content knowledge.

Students in the supervised study treatment group produced higher scores on critical thinking ability. While this difference was statistically different, there was no practical difference between the two groups.

The supervised study treatment group outperformed the PBL group on content knowledge. The difference was both statistically and practically significant. From the findings related to content knowledge, it can be concluded that students in supervised study classes tended to score higher on content knowledge assessments than students in PBL classes.

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CHAPTER I
INTRODUCTION

"Whether our focus is on classical education, the new math, or basics, the ultimate goal of education has been to teach children to think critically and independently" (Sternberg & Baron, 1985, p 40). The origins of critical thinking can be traced back to the early philosophies of Plato and Aristotle. The importance of critical thinking was evident in the beginning of the modern era of education in the writings of Dewey (1909, 1997), who described the ability to think critically as a way to find meaning in the world in which we live.

Initiatives of reform in education have further solidified the concept of critical thinking as a requisite goal of education. The report of the National Commission on Excellence in Education, A Nation at Risk (1983), sounded an alarm concerning faltering attempts to foster critical thinking, higher-order thinking and problem solving in our nation's schools. The Secretary's Commission on Achieving Necessary Skills (1991) ranked competencies in critical thinking, decision making, problem solving, and reasoning as imperative for high performing workplaces. An emphasis is now being placed on the student's ability to understand and use information, not just merely posses it (Richardson, 2003).

Missouri, in an effort to meet the challenges facing education, developed standards outlining the knowledge, skills and abilities, which graduates of its public school systems should be able to perform (Missouri Department of Elementary and Secondary Education, 1996). The outcome of this effort, the Show-Me Standards, identified 33 performance standards classified under four broad goals. Many of these standards placed an emphasis on students' abilities to think, analyze and solve problems.

Educators are constantly emphasizing the importance of developing critical thinking skills that are transferable from the classroom to life experiences. But what exactly is critical thinking? Critical thinking has been paralleled with the scientific method of discovery (Staib, 2003). A more widely referenced definition was developed by Facione as a result of a collaborative effort with the American Philosophical Association (APA). Facione defined critical thinking as:

> "the process of purposeful, self-regulatory judgment, which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological or contextual consideration upon which that judgment is based. (Facione, 1990, p. 3)

Almost unanimously, educators believe the development of critical thinking ability should be a primary goal of education (Pithers & Soden, 2000). However, the actions of educators would suggest otherwise. "Three-quarters of a century of educational literature suggests the main emphasis in schools has been teaching students facts, even though teachers and curriculum designers have attested to the importance of teaching students to think" (Cano, 1990, p 46). Concerns have been expressed over instructional methodologies that allow students to assume a passive, rather than active role (Rollins, 1990). Students have become familiar with the process of passing knowledge back and forth without inquiring into how this information applies to the real world (Black & Deci, 2000). While the importance of acquisition and recall of basic knowledge remains important, the development of critical thinking has emerged as being equally important. Can we find a balance with instructional strategies that facilitate the acquisition of basic knowledge yet develop and nurture critical thinking?

The problem-solving approach has been widely accepted as a preferred method for teaching agriculture (Boone & Newcomb, 1990). It has been frequently cited in literature as the most effective instructional approach for teaching agriculture (Flowers & Osborne, 1988; Osborne & Hamzah, 1989; Boone & Newcomb, 1990). Additionally, it has been recommended in agricultural education texts (Binkley & Tulloch, 1981; Crunkilton & Krebbs, 1982; Phipps, 1988; and Newcomb, McCracken & Warmbrod, 1993).

Newcomb, McCracken, and Warmbrod described six steps to the problem-solving process that mirror Dewey's (1909, 1997) steps to reflective thinking. Step one is an interest approach designed to create a provocative situation. Step two is to identify group objectives and step three is to identify questions to be answered. Step four, problem situation, combines the third and fourth step for Dewey's model. The fifth step in the problem-solving approach is to test solutions through application. The final step is to evaluate proposed solutions.

Current recommended curriculum for agriculture courses in Missouri exists in the form of lesson plans developed by the Instructional Materials Laboratory (IML) at the University of Missouri. The format for the lessons was recommended by the Agricultural Education Division of the Missouri Department of Elementary and Secondary Education (DESE). This format is best described as the supervised study technique as outlined by Newcomb, Warmbrod and McCracken (1993). Newcomb, et al. identified supervised study as one of several techniques for delivering content within the problem-solving approach. A four part sequence is described to successfully implement this method of instruction: planning the supervised study, conducting the supervised study, terminating the supervised study, and developing conclusions based on the supervised study.

Current trends in education favor a more constructivist approach (Hickey, Moore, & Pellegrino, 2001). Constructivist views encourage a learning environment where students explore their world, discover knowledge, reflect, and think critically (Brooks & Brooks, 2001). Constructivism emphasizes the importance of the teaching context, student prior knowledge, and active interaction between the learner and the content to be learned (Hausfather, 2001). Constructivism represents how people solve real-life, complex problems in society by working with others to make thoughtful decisions, taking initiative and solving problems (Jonassen, 1997).

These tenets of constructivism are addressed in classroom situations with the use of problem-based learning (PBL)(Savery & Duffy, 2001). PBL is characterized by learners encountering a messy, ill-structured problem. This encounter occurs prior to any instruction in the content area. Students seek out information and create unique solutions to the problems encountered.

PBL has gained in popularity as an instructional strategy over the past 30 years (Fenwick & Parsons, 1998). Early models of PBL arose from medical school programs (Barrows, 2000). More recently, newer PBL models have been adapted to fit a variety of different programs at a multitude of levels. Proponents of the method claim that PBL promotes student-centered learning and lifelong learning (Maxwell, Bellisimo, & Mergendoller, 2001), is more nurturing and enjoyable than traditional methods of instruction (Albanese & Mitchell, 1993), and improves student motivation and teamwork

(Vernon, 1995). Other studies have indicated that PBL is effective in improving problem-solving and critical thinking abilities (Hmelo, 1998; Gallagher, 1997; Dods, 1997; Ball & Knobloch, 2004). In addition to critical thinking, PBL also emphasizes student understanding and learning how to learn (White, 1996).

Theoretical Framework

Dunkin and Biddle (1974) provided a conceptual model in which variables related to learning may be examined. The model is an adaptation of Mitzel's (1960) Model of Teaching. While this model is somewhat dated, it provides a classification of variables impacting student learning. Dunkin and Biddle asserted that these variables were broadly classified into four categories: presage, context, process, and product variables. Figure 1 displays the Theoretical Model for Classroom Teaching.

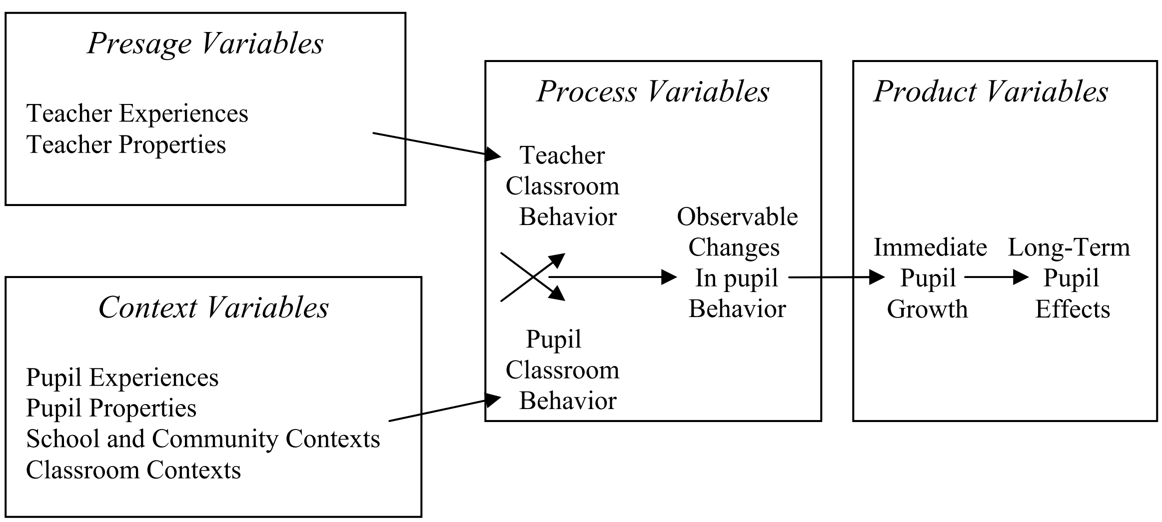


Figure 1. Theoretical Model for the Study of Classroom Teaching

Presage variables are teacher characteristics that have an effect on the teaching process including the formative experiences of teachers, the teacher preparation experiences, and teacher characteristics. Context variables represent conditions to which the teacher must adjust including the population of students and the characteristics of the students, classroom, school, and community. Process variables are the actual activities of classroom teaching. These variables represent the interactions of the teacher and students. The instructional activities planned and carried out in the classroom are categorized as process variables. Finally, product variables include commonly investigated variables such as subject-matter learning and attitude toward the subject. Other product variables of interest include knowledge acquisition and critical-thinking ability.

Arrows in the model represent causative relationships. According to the model, the formative experiences of a teacher (presage) have a causative effect on classroom events. As indicated by the model, the classroom behavior of the teacher, as well as teacher-student interaction, play a significant role in student outcomes. This study will investigate the effect of instructional strategy (process variable) on content knowledge and critical thinking ability (product variables). The design of the study will control for presage and context variables.

Need for the Study

Buriak and Shinn (1993) identified a structure for research in agricultural education. Their structure specifically identified critical thinking and problem solving as an area for future research, implicating its importance and echoing the current sentiments in education. As state standards in secondary education emphasize the importance of problem solving skills and critical thinking abilities, educators are challenged to provide insight into best practices for creating and developing critical thinking skills.

Problem-based learning (PBL) has emerged as an alternative to more traditional methods of instruction. An overwhelming majority of the research on PBL follows its origins in medical programs (Norman & Schmidt, 1992). Fewer studies have been conducted on problem-based learning in other programs and at other levels, particularly at the secondary level (Herman & Knobloch, 2004; Mergendoller, Maxwell, & Bellisimo, 2000; Dods, 1997).

While there are elaborate descriptions of using PBL in various settings, there is little empirical evidence as to what students are learning and how (Hmelo-Silver, 2004). Herman and Knoblock (2004) recommended that future studies investigate the use of constructivist PBL approaches to determine effects on learning outcomes in agriculture classrooms.

Agricultural education has long valued the importance of problem solving (Brown, 1998). In turn, the problem-solving approach has been touted as the most effective method for teaching (Osborne & Hamzah, 1989). Research validating this claim has been inconclusive. While the problem-solving approach and problem-based learning share common educational goals, the two have very different philosophical origins. Few studies (Herman & Knobloch, 2004) have sought to identify the impact of PBL in secondary agriculture classrooms.

Research on critical thinking, particularly in agricultural education, is not a new concept. Previous studies in agricultural education have investigated factors associated with critical thinking ability (Myers & Dyer, 2004; Rudd, Baker, & Hoover, 2000; Torres & Cano, 1995; Cano & Martinez, 1991; and Rollins, 1990). However, a limited amount of research has focused on the effects of instructional methodology on critical thinking (Ricketts & Rudd, 2003).

Results from this study will serve to answer these concerns, in part, and contribute to the knowledge base of teaching and learning as a process in education in general and specifically in the field of agricultural education. Furthermore, findings from this research will inform practicing teachers of alternative strategies that can be used in the classroom to meet the expectations established at the state and national level as well as help inform teacher preparation programs as to what instructional strategies should be taught at the undergraduate level.

Statement of the Problem

According to Carroll (2000), the emphasis on knowledge and skill standards in our current educational paradigm reflects the goal of learning as knowledge conservation rather than knowledge construction. Traditional approaches to teaching focus on transmitting knowledge from the teacher to the student without any connection to real world applications. Students process information at lower levels and are not encouraged to think critically about the content learned.

Recent legislation has called for reform in schools to develop and improve the critical thinking ability of students. As a result, teachers are faced with the challenge of implementing alternative instructional strategies that create more stimulating environments and build critical and creative thinking skills. Does the strategy used for instruction, specifically problems-based learning, affect content knowledge acquisition and critical thinking ability?

Purpose of the Study

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship between critical thinking ability and content knowledge among selected secondary agriculture students in Missouri. The following research objectives and hypotheses were generated to focus and guide the direction of the study.

Research Objectives and Hypotheses

1. Describe subjects on gender, grade classification, and academic aptitude (7th grade science MAP index).

2. Describe the critical thinking ability of students before and after instruction in a quail management unit.

3. Describe the content knowledge of students before and after instruction in a quail management unit.

4. Compare the effect of instructional strategy (problem-based learning versus supervised study) with regard to secondary agriculture students' critical thinking ability and content knowledge.

   H_1: Students taught using the problem-based learning instructional strategy will demonstrate a greater improvement in critical thinking than students taught using the supervised study instructional strategy.

   H_2: A significant difference exists in content knowledge for students taught using the problem-based learning instructional strategy and students taught using the supervised study strategy.

5. Describe the relationships between critical thinking ability and content knowledge.

Definition of Terms

Content knowledge: The amount of information students are able to recall after instruction. For this study, content knowledge is operationally defined as the score on a unit assessment administered immediately after instruction (post-test).

Critical thinking: Critical thinking is a composite of attitudes, knowledge, and skills which includes: (1) attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true; (2) knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined; and (3) skills in applying the above attitudes and knowledge.

Critical thinking ability: Critical thinking ability is operationally defined as a composite score on the Watson-Glaser Critical Thinking Appraisal® (WGCTA®).

Constructivism: Theoretical approach to learning characterized by a focus on knowledge structure and knowledge formation (Seater, 2003). Learning is embedded in authentic tasks encountered by learners. This approach provides a theoretical support for problem-based learning.

Supervised study: Supervised study is a technique described by Newcomb, Warmbrod, and McCracken (1993) in which students use basic reference materials to find information on their own. Newcomb, et. al. suggest a four part sequence to successfully implement this method of instruction; planning the supervised study, conducting the supervised study, terminating the supervised study, and developing conclusions based on the supervised study. The structure of recommended agriculture curriculum in Missouri follows the supervised study format.

Problem-solving approach: The problem-solving approach is the most recommended approach to instruction in agricultural education. It is described by Newcomb, McCracken, and Warmbrod (1993) as a six step process; 1) interest approach, 2) group objectives, 3) questions to be answered, 4) problem situation, 5) test solutions through application, and 6) evaluate proposed solutions. While a dominant approach, problem-solving is not an instructional strategy.

Problems-based learning: Instructional strategy in which students confront contextualized, ill-structured problems and strive to find meaningful solutions (Rhem, 1998). PBL is characterized by learners encountering a messy, ill-structured problem. This encounter occurs prior to any instruction in the content area. Students seek out information and create unique solutions to the problems encountered.

Strategy/technique/methods: These terms are used interchangeably by various authors to indicate a distinct method of delivering content.

Assumptions

For this study, the following were assumed to be true.

1. Teachers in the study carried out the assigned treatment as designated in the orientation session and in the teaching materials provided.
2. Subjects provided true and accurate responses, to the best of their ability, on data collection instruments.

Limitations

1. Participants in the study were selected by the qualifying characteristics of the instructor and remained in intact classroom groups. While groups were randomly assigned to a treatment, the design of the study lacked random selection. The sample in the study approximates the target population; however, caution should be used when generalizing beyond participants.
2. The sample was limited to students of selected agriculture teachers. Cost and time prohibited the study of a larger sample.

CHAPTER II

REVIEW OF LITERATURE

Purpose of the Study

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship among critical thinking ability and content knowledge among selected secondary agriculture students in Missouri.

Educational Trends

Education has long focused on teaching students to give a correct answer. Students often complete assignments, do well on tests and get good grades; yet, do not learn to think critically (Brooks & Brooks, 2001). According to Brooks and Brooks (2001), teachers too often ask students to recite, define, describe, or list facts. Students are less frequently asked to analyze, infer, connect, synthesize, evaluate, think and rethink. Students have become familiar with this process of passing knowledge back and forth without inquiring into how this information applies to the real world (Black & Deci, 2000). The concern over development of critical thinking skills, or lack there of, has led to a renewed focus of education.

The current educational climate reflects the importance of learning not only content information, but also developing skills for thinking critically (Pithers & Soden, 2000). The need for instructional design to improve the thinking process has been substantiated in numerous reports over the last 25 years (Halpern, 2003). In recent years, more emphasis has been placed in the student’s ability to understand and use information, not to merely posses it (Richardson, 2003). College faculty identified critical thinking, along with problem solving, as skills necessary for every college graduate (Diamond, 1997).

A Nation at Risk (National Commission on Excellence in Education, 1983) questioned the faltering achievement of American students and called for investigations into existing educational structures. The National Commission on Excellence in Education specifically identified concerns about students' lack of ability in critical thinking, higher-order thinking and problem solving skills. This concern over students' ability to think critically was further substantiated by Norris (1985), who indicated that critical thinking was lower than expected in the United States at every stage of schooling.

The importance of critical thinking has been reinforced by industry expectations. The Secretary's Commission on Achieving Necessary Skills (SCANS) (1991) addressed this issue in their report entitled *What Work Requires of Schools*. The commission found that high performance workplaces required competencies in critical thinking. Among those critical thinking competencies identified were creative thinking, decision making, problem solving, and reasoning (SCANS, 1991).

Support for the development of critical thinking skills has also been apparent in the expectations of student performance in Missouri public schools. As a result of legislation, the Missouri Department of Elementary and Secondary Education (DESE) (1996) developed the Show-Me Standards outlining expectations of Missouri students. These standards were a result of Senate Bill 380, "The Outstanding Schools Act" (1993), which called for the Missouri State Board of Education to adopt performance standards. The Show-Me Performance Standards target the development of critical thinking skills.

The standards are categorized into four goals. Goal one of the Show-Me Standards (DESE, 2004) states, “Students in Missouri public schools will acquire the knowledge and skills to gather, analyze, and apply information and ideas”(p. 3). In addition, Goal Three of the Show-Me Standards posits, “Students in Missouri public schools will acquire the knowledge and skills to recognize and solve problems”(p. 3). Finally, Goal Four asserts, “Students in Missouri public schools will acquire the knowledge and skills to make decisions and act as responsible members of society”(p. 3). The importance of critical thinking skills is evident by the references to analysis, problem solving, and decision making in three of the four goals.

The literature suggests a common goal in education: to develop critical thinking abilities in students of all ages. While there have been attempts to teach critical thinking in separate courses outside of a context area, Ruggiero (1988) argued that the explicit teaching of critical thinking does not depend on what is taught, rather in how it is taught. The only significant change required to teach critical thinking is a change in teaching methodology. Effects of teaching methodology on critical thinking skills have been well documented (Whittington, Stup, Bish, & Allen, 1997; Burback, Matkin, & Fritz, 2004; Elliot, Oty, McArthur, & Clark, 2001).

In summary, the ability of students to think critically is becoming increasingly important. While the concept of thinking critically is not new, only in the last 25 years has there been a call for reform in education to improve upon students’ ability to think critically. This reform is a result of efforts at both the national and state level. The literature suggests the most effective way to improve the ability of students to think critically is through appropriate teaching methodologies.

Theoretical Framework

Dunkin and Biddle (1974) provided a conceptual model in which variables related to learning may be examined. The model is an adaptation of Mitzel's Model (1960) of Teaching. While this model is somewhat dated, it provides a classification of variables impacting student learning. Dunkin and Biddle asserted that these variables were broadly classified into four categories: presage, context, process, and product variables. Figure 1 displays the Theoretical Model for Classroom Teaching.

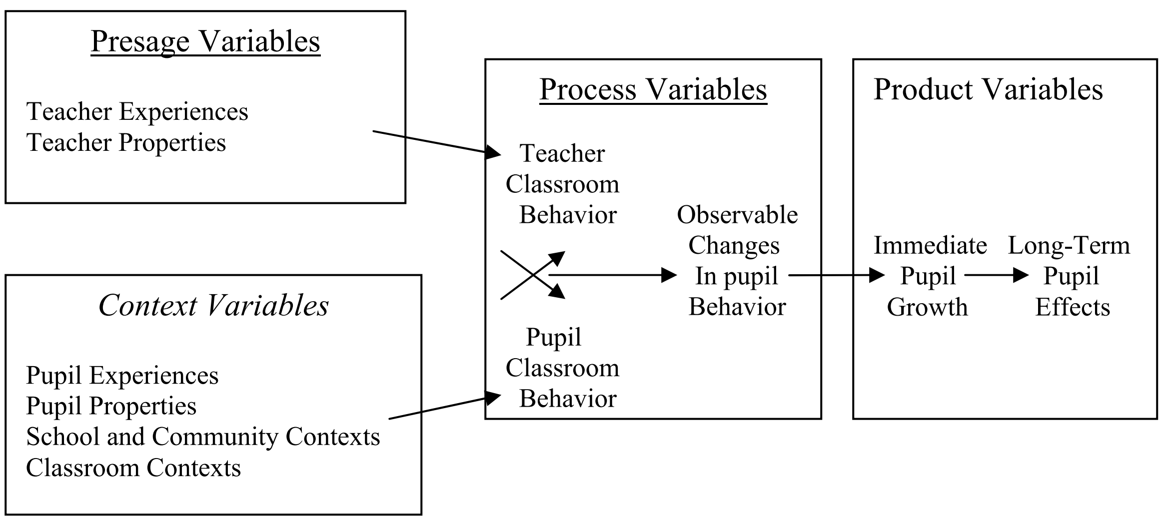


Figure 1. Theoretical Model for the Study of Classroom Teaching.

Presage variables are teacher characteristics that have an effect on the teaching process. Variables often studied in this category reflect the formative experiences of teachers, the teacher-training experiences, and teacher properties such as teaching skills, intelligence, motivations, and personality traits. Administrators and teacher educators potentially have some control over these variables as teachers are often hired or selected based on their previous experiences in the field or performances in teacher preparatory programs (Dunkin & Biddle, 1974).

The second category of variables addressed by the model was the category of context variables. In contrast to presage variables, context variables are typically outside of the control of teachers and administrators, particularly in public education. Included in this category is the population of students, of which are highly influenced by their own experiences and characteristics. These variables represent conditions to which the teacher must adjust. Other context variables include the characteristics of the classroom, school, and community.

Dunkin and Biddle (1974) described process variables as the actual activities of classroom teaching. Process variables include behaviors of teachers in the classroom and pupil classroom behavior as well as the interactions between them. Most simply explained, these variables are what teachers and pupils do in the classroom. Dunkin and Biddle suggested that students' observable behaviors are influenced by other students as well as the teacher. The instructional activities planned and carried out in the classroom are categorized as process variables.

Finally, product variables "concern the outcomes of teaching – those changes that come about in pupils as a result of their involvement in classroom activities with teachers and other pupils" (Dunkin & Biddle, 1974, p. 46). Although most often thought of in positive terms, such as student growth or achievement, product variables may also represent undesirable outcomes such as anxiety or isolation. By far, the most commonly investigated variables in this category relate to positive student outcomes such as subject-matter learning and attitude toward subject. Specific product variables of interest for this study are critical thinking ability and content knowledge.

Arrows in the model represent possible causative relationships. Dunkin and Biddle (1974) described the arrows as possible sources of hypotheses. Regarding this study, with presage and context variables held constant, instructional strategy (process variable) is hypothesized to have an effect on knowledge acquisition and critical thinking skills (product variables).

In summary, Dunkin and Biddle's model for the study of classroom teaching provided four categories of variables: presage, context, process and product. Presage variables are those that influence teachers and their teaching behaviors. Context variables are those variables contributed by the students. Process variables describe the interaction of teacher and student in the teaching and learning process. The instructional strategy utilized by teachers in the classroom is a process variable. Product variables include student outcomes as a result of teaching. Product variables include critical thinking ability and content knowledge. For this study, the model suggests that with presage and context variables held constant, instructional strategy (process variable) will effect knowledge acquisition and critical thinking skills (product variables).

Critical Thinking

While there appears to be unanimous agreement regarding the importance of developing students' critical thinking skills, there is much less agreement on exactly what constitutes critical thinking. This ambiguity is evident in the definition of critical thinking proposed by Richard Paul, director of the Center for Critical Thinking. Paul

(1992) described critical thinking as "the art of thinking about your thinking while you are thinking in order make your thinking better…" (p. 643). While others have provided a more concrete description, a single definition of critical thinking has not been agreed upon. The literature suggests multiple views of what actually constitutes critical thinking (Halpern, 1996; Burden & Byrd, 1994; Pascarella & Terenzini 1991; Stahl & Stahl, 1991; Simon and Kaplan, 1989; Beyer, 1987; Ennis, 1962).

The concept of critical thinking was reflected in the teaching of Greek philosophers such as Socrates, Plato and Aristotle (Staib, 2003; Burbach, Matkin, & Fritz, 2004). Dewey (1909, 1997) described critical thinking as the suspension of judgment and healthy skepticism. More recently, Ennis (1985) described the most commonly used definition of critical thinking as: "reflective and reasonable thinking that is focused on deciding what to believe or what to do" (p. 45).

In recent years, the subject of critical thinking has been investigated and defined by researchers in many different ways. Many researchers have conceptualized critical thinking in terms of skills (Bailin, S., Case, R., Coombs, J. R., & Daniels, L.B., 1999; Halpern, 1996; Beyer, 1987; Burden & Byrd, 1994; Ennis, 1962). Beyer (1987) identified skills required for effective critical thinking. Beyer's critical thinking skills are outlined as follows:

1. Distinguishing between verifiable facts and value claims.
2. Distinguishing relevant from irrelevant information, claims, and reasons.
3. Determining factual accuracy of a statement.
4. Determining credibility of a source.
5. Identifying ambiguous claims or arguments.

6. Identifying unstated assumptions.
7. Detecting bias.
8. Identifying logical inconsistencies in a line of reasoning.
9. Recognizing logical inconsistencies in a line of reasoning.
10. Determining the strength of an argument or claim.

Some or all of these skills can be found in other definitions of critical thinking. Simon and Kaplan (1989) described critical thinking as the formation of logical inferences. Other similar definitions have included: developing careful and logical reasoning (Stahl & Stahl, 1991), deciding what action to take or what to believe through reasonable reflective thinking (Ennis, 1985), and purposeful determination of whether to accept, reject, or suspend judgment (Moore & Parker, 1994). Pascarella and Terenzini (1991), in an effort to provide a more comprehensive definition of critical thinking, compiled the following:

> …critical thinking has been defined and measured in a number of ways, but typically involves the individual's ability to do some or all of the following: identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions from information or data provided, interpret whether conclusions are warranted on the basis of the data given, and evaluate evidence or authority. (p. 118).

Other definitions of critical thinking encompassed more than merely listing skills. Some researchers have linked critical thinking with higher order thinking or even used the terms interchangeably. A common framework for analyzing the cognitive level of instruction is Bloom's Taxonomy of Education Objectives (Bloom, Engelhart, Hill, & Krathwohl, 1956). Bloom, et al. described six levels of cognition: Knowledge, Comprehension, Application, Synthesis, Analysis, and Evaluation.

Knowledge, according to Bloom, et al. (1956), represents "the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting" (p. 201). Comprehension represents "a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications" (p. 204). Application is described as the "use of abstractions in particular and concrete situations" (p. 205). Analysis is described as "the breakdown of elements into its constituent parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit" (p. 205). Synthesis is defined as "the putting together of parts so as to form a whole" (p. 206). Finally, Evaluation consists of "judgments about the value of material and methods for given purposes" (p. 207). The levels of knowledge and comprehension are most commonly considered as lower order thinking (Miller, 1990). Application, analysis, synthesis, and evaluation are generally regarded as higher order thinking (Miller, 1990; Ennis, 1985). While knowledge and comprehension remain foundational goals in education, emphasis on development of higher order thinking has increased.

The link between critical thinking and higher-order thinking is evident in the descriptions utilized in previous studies. Burden and Byrd (1994) described critical thinking as a higher-order thinking activity that required a set of cognitive skills. Whittington, Stup, Bish, and Allen (1997) used critical thinking interchangeably with levels of cognition. Others have suggested that while critical thinking most certainly encompasses aspects of higher-order thinking, the two concepts should not be used synonymously (Ennis, 1985; Facione, 1990). Facione (1990) described critical thinking, along with problem solving, creative thinking, and decision-making as members of a family of closely related forms of higher order thinking. Similarly, Ennis (1985) stated that critical thinking incorporated a good deal of higher-order thinking.

The discrepancies among researchers in defining critical thinking led the American Philosophical Association, in 1987, to initiate a Delphi project of which one of the outcomes was a consensus definition of the concept of critical thinking. The result, in part, defined critical thinking as follows:

> We understand critical thinking to be a purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment was based (Facione, 1990, p 3).

According to Bailin, Case, Coombs and Daniels (1999), the role of attitude in critical thinking is equally important as skills and knowledge. Siegel (1988) referred to this aspect of critical thinking as the critical spirit. Accounting for each of these components, perhaps the most comprehensive definition of critical thinking was provided by Watson and Glaser (1994). It is this definition that is embraced by this study. Watson and Glaser proposed the following definition:

> Critical thinking is a composite of attitudes, knowledge, and skills which includes: (1) attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true; (2) knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined; and (3) skills in applying the above attitudes and knowledge.

Instruction and Critical Thinking

There is a body of evidence suggesting that critical thinking can be influenced by the instructional strategies utilized in the teaching-learning process. Lundy, Irani, Ricketts, Eubanks, Rudd, Gallo-Meagher, and Fulford (2002) studied the ability of college students to think critically as a result of a course in biotechnology. Their mixed methods study compared male and female students as well as honors and non-honors students on critical thinking disposition as measured by the California Critical Thinking Dispositional Inventory (CCTDI). It was found that all students, regardless of gender or academic status, showed gains in their disposition toward critical thinking. Lundy, et al. concluded from these findings that critical thinking was a skill that can be acquired and developed in all students by utilizing critical thinking instructional techniques. The authors, however, stopped short of describing these techniques.

Mabie and Baker (1996) studied the impact of experiential instructional strategies on the development of science process skills. The science process skills of observing, communicating, comparing, ordering, relating, and inferring were considered to be the building-blocks of critical thinking. A total of 147 fifth and sixth grade students were randomly assigned by class group to either the treatment or control. The treatments for this study were two experiential units of instruction. Findings from this study showed improvements of subjects in the treatment groups on science process skills. The authors concluded that experiential learning activities can lead to increased critical thinking skills.

Burbach, Matkin, and Fritz (2004) used the Watson-Glaser Critical Thinking Appraisal® (WGCTA®) to determine the critical thinking abilities of 80 students enrolled in six sections of a college introductory leadership course. The course was specifically designed to teach critical thinking by incorporating reflective journal writing, service learning, small groups, scenarios, case study and questioning. The pre-test, post-test design indicated that the active-learning strategies utilized in the course resulted in improved critical thinking skills.

Using the same instrument (WGCTA®), Elliot, Oty, McArthur, and Clark (2001) compared the critical thinking abilities of college freshmen enrolled in an integrated algebra for the sciences course to a traditional college algebra course. The integrated math/science design utilized scientific examples to provide a contextual background for mathematical operations. Students in the integrated course scored higher on the WGCTA®. It was concluded that the integrated approach increased critical thinking ability.

In summary, critical thinking has been defined by many different researchers in a variety of ways. Critical thinking is most often viewed as both a set of skills and as a disposition. Although not synonymous with higher-order thinking, critical thinking and higher-order thinking are interrelated. Previous studies indicate that instructional strategies within the classroom can increase critical thinking ability.

Approaches to Teaching and Learning

Problem-Solving Approach

Problem-solving approaches to teaching have been an integral part of agricultural education programs (Brown, 1998; Ball, Knobloch, & Settle, 2003). The problem-solving approach has often been recommended as the primary approach to instruction in agricultural education (Flowers & Osborne, 1987). Several agricultural education texts have indicated that the problem-solving approach is the most effective method of teaching agriculture. Among those text book authors are Binkley and Tulloch (1981), Crunkilton and Krebbs (1982), Phipps (1988) and Newcomb, McCracken and Warmbrod (1993). Ball and Knobloch (2003) found that Methods of Teaching Agriculture (Newcomb, et al., 1993) was the most frequently required reading resource among teacher educators in agriculture.

Newcomb, McCracken and Warmbrod (1993) described the problem-solving approach in comparison to Dewey's (1909, 1997) steps of reflective thinking. According to Dewey, the natural process of learning consists of six steps. The first step was experiencing a provocative situation. This provocation is what motivates a person to want to learn more about a particular subject. The second step in the process is to define a problem or identify questions to be answered. According to Dewey, it is not enough to simply become interested. Step three consists of seeking out data and information in preparation for step four, formulate possible solutions. The fifth step is to test the proposed solutions and the final step is to evaluate the results.

Newcomb, McCracken, and Warmbrod (1993) argued that if people learn through these steps, classroom instruction could be designed using these steps as well. They described a six step process of instruction that mirrors Dewey's steps to reflecting thinking. Step one is an interest approach designed to create that provocative situation. Step two is two identify group objectives and step three is to identify questions to be answered. Step four, problem situation, combines the third and fourth step for Dewey's model. The fifth step in the problem-solving approach is to test solutions through application. The final step is to evaluate the proposed solutions. Figure 2 compares Dewey's steps to reflective thinking and Newcomb, McCracken, and Warmbrod's model for problem-solving instruction.

Dewey's Steps to Reflective Thinking	Problem-Solving Approach
1. Experience a provocative situation;	1. Interest approach;
2. Defining a problem;	2. Group objectives;
	3. Questions to be answered;
3. Seek data and information;	4. Problem situation;
4. Formulate possible solutions;	
5. Testing proposed solutions;	5. Test solutions through applications;
6. Evaluating results.	6. Evaluation of solution.

Note. This figure appears in Newcomb, McCracken, & Warmbrod (1993) *Methods of Teaching Agriculture.*

Figure 2. Comparison of Reflective Thinking and Problem-Solving Instruction.

While Newcomb, McCracken, and Warmbrod (1993) strongly advocated the problem-solving approach to instruction, they also advocated that instruction be accomplished through techniques for teaching. It is important to understand that problem-solving, as described by Newcomb, et al., is an approach and not a technique or strategy for teaching. The approach serves as a framework or guide for planning instruction; however, various techniques or strategies become the tools for teaching. Newcomb, et al. grouped teaching techniques into two categories: group teaching techniques and individual teaching techniques. Table 1 displays the categories and techniques described by Newcomb, et al.

Table 1

Teaching Techniques for Problem-Solving Instruction

Group Teaching Techniques	Individual Teaching Technique
Lecture	Supervised Study
Discussion	Experiments
Demonstration	Independent Study
Field Trips	
Role Playing	
Resource People	

Techniques identified by Newcomb, McCracken, and Warmbrod (1993) were not intended to be an exhaustive list of techniques for instruction. Instead, the authors presented techniques that could be used to effectively plan instruction in agricultural education, specifically using the problem solving approach. However, Ball and Knobloch (2003) found that the predominant number of teaching methods taught in methods courses in agricultural education programs appeared to be directly from Newcomb, et al.'s book.

Curriculum in Missouri

Currently recommended curricula for secondary agriculture courses in Missouri are a result of a longstanding relationship between the Missouri Department of Elementary and Secondary Education (DESE) and the University of Missouri's Instructional Materials Laboratory (IML). The Agricultural Education Division of DESE has recommended curricula topics and instructional design since the 1960's. IML has produced this curriculum in a consistent format. This format provides content information and teaching instructions in lesson plan form. The instructional strategy specified in these lesson plans is best described as the supervised study method, as described by Newcomb, McCracken and Warmbrod (1993)..

Newcomb, McCracken, and Warmbrod (1993) described supervised study as a method of teaching in which students use basic reference materials to find information on their own. Newcomb, et al. suggested a four part sequence to successfully implement this method of instruction: planning the supervised study, conducting the supervised study, terminating the supervised study, and developing conclusions based on the supervised study.

The planning phase consists of developing an interest approach designed to create student interest about the topic and developing study questions. In conducting supervised study, teachers are responsible for directing the students, keeping students productively involved, and observing and monitoring student progress. Teachers are responsible for terminating the supervised study when they feel that most students have had an opportunity to answer a majority of the study questions. Newcomb, McCracken, and Warmbrod (1993) acknowledged this design as often a judgment call based on the teacher's experience. The final phase, developing conclusions, provides an opportunity for the teacher clear up misconceptions, elaborate on crucial concepts, and synthesize class findings (Newcomb, McCracken, & Warmbrod, 1993). This step is accomplished through the facilitation of a group discussion.

Problem-Based Learning

Problem-based learning (PBL), developed at McMasters University, is a strategy of instruction in which students confront contextualized, ill-structured problems and strive to find meaningful solutions (Rhem, 1998). PBL embodies the tenets of constructivist pedagogy and applies them directly to classroom situations. McCombs (2001) acknowledged that education was in need of a shift from what we need to *teach*, to what content and skills must be *learned*. This acknowledgement is consistent with constructivist views that knowledge is constructed, not transmitted or absorbed (Seatter, 2003). Phillips (1995) identified this concept as the common thread among constructivist views. Constructivism represents how people solve real-life, complex problems in society by working with others to make thoughtful decisions, taking initiative and solving problems (Jonassen, 1997).

There are several ideological tenants that separate constructivist philosophy from other viewpoints. Most notably, knowledge is constructed from experiences of the learner (Doolittle & Camp, 2002; Hausfather, 2001), not transmitted or absorbed (Seater, 2003). Savery and Duffy (2001) stated that according to constructivist viewpoint, understanding is in our interactions with the environment. Learning is a function of content as well as context, learner actions and learner goals.

Savery and Duffy (2001) additionally posited that the cognitive conflict of puzzlement is the stimulus for learning and determines the organization and nature of what is learned. Finally, knowledge evolves through social challenge (Savory & Duffy, 2001). Social interaction provides learners with opportunities to test and defend their own understandings as well as enrich and expand our understanding by examining the views of others (Richardson, 2003).

Savory and Duffy (2001) expanded on constructivist philosophy by providing eight principles of instruction embodying the goals of constructivist pedagogy. Their work provides a structure for guiding instruction in the classroom. Those principles of constructivist pedagogy are as follows:

1. Anchor all learning activities to a larger task or problem.
2. Support the learner in developing ownership for the overall problem or task.
3. Design an authentic task.
4. Design the task and learning environment to reflect to complexity of the environment they should be able to function in at the end of learning.
5. Give the learner ownership of the process used to develop a solution.
6. Design the learning environment to support and challenge the learner's thinking.
7. Encourage testing ideas against alternative vies and alternative contexts.
8. Provide opportunity for and support reflection on both the content learned and learning process.

Problem-based learning (PBL) has gained in popularity as an instructional strategy over the past 30 years. Early models of PBL arose from medical school programs (Barrows, 2000). Founders of the McMasters program sought to find innovative approaches for students who had become disenchanted with traditional approaches to medical education. Since its inception, adaptations of the traditional medical school problem-based model have been included in a variety of different programs at a multitude of levels. The success of PBL has led to its incorporation into professional programs (Fenwick & Parsons, 1998). Most recently, PBL has gained popularity in pre-service teacher education programs (Hmelo-Silver, 2004).

Proponents of PBL claim that it promotes student-centered learning and lifelong learning (Maxwell, Bellisimo, &Mergendoller, 2001), is more nurturing and enjoyable than traditional methods of instruction (Albanese & Mitchell, 1993), and improves student motivation and teamwork (Vernon, 1995). Other studies have indicated that PBL is effective in improving problem-solving and critical thinking abilities (Hmelo, 1998; Gallagher, 1997; Dods, 1997; Ball & Knobloch, 2004).

In addition to critical thinking, PBL also emphasizes student understanding and learning how to learn (White, 1996). PBL, according to Barrows and Kelson (1995), was designed to help students meet the following goals: 1) construct an extensive and flexible knowledge base; 2) develop effective problem-solving skills; 3) develop self-directed, lifelong learning skills; 4) become effective collaborators; and 5) become intrinsically motivated to learn.

PBL is an instructional strategy for teaching grounded in the philosophy of experiential learning first subscribed to by Kilpatrick and Dewey (Hmelo-Silver, 2004). In PBL, students learn by solving problems and reflecting on their experiences (Barrows & Tamblyn, 1980). PBL situates learning in real-world problems, making students responsible for their learning and promoting active learning. The process places emphasis on both helping learners develop strategies and constructing knowledge (Hmelo & Ferrari, 1997).

Several characteristics of PBL make it uniquely attractive in the development of curriculum. PBL is often interdisciplinary (Putnam, 2001). Knowledge and skills needed to solve real world problems are not acquired in a compartmentalized fashion. Solutions developed by students in a problem-based format have multiple outcomes. Rarely do problems encountered in real life have only one narrowly defined solution. Students learn skills that overlap in competency areas often integrating writing and math into developing their solutions. Finally, PBL emphasizes metacognitive or higher-order skills (Putnam, 2001). Students develop problem-solving and critical thinking skills as they work toward the solution of the real world problem.

PBL is set apart from other strategies by the type of problem focused on in instruction. The traditional problem-solving methods have been characterized by the existence of a clearly defined problem (Newcomb, McCracken, & Warmbrod, 1993; Stewart, 1950). Problem-based learning, in contrast to traditional problem-solving approaches, is characterized by the inclusion of a messy, ill-structured problem (Jonassen, 1997). According to Lohman (2002), ill-structured problems have the following characteristics:

1. The exact nature of the problem is unclear and some information, but not enough to solve the problem, is provided.
2. More than one way to solve the problem exists.
3. The problem does not have a single right answer.

Ill-structured cases in PBL are prototypical of problems regularly found in practice (Lohman & Finkelstein, 2000). This messy and ill-structured nature creates a constructivist learning environment in which learners ground their learning experiences and seek to develop and construct their own understanding.

Structure of Problem-Based Learning

Although PBL was developed originally for medical schools, the problem-based design has been adapted and used successfully in a variety of settings from middle-school to professional education (Barrows, 2000; Barrows & Kelson, 1995; Barrows & Tamblyn, 1980; Hmelo-Silver, 2000). PBL begins with a problem situation, the basis for learning, in which the students encounter before any preparation or study has occurred (Maxwell, Bellisimo, & Mergendoller, 2001). Students encounter the problem in the same manner they would in the real world.

Students often work in groups with the help of a tutor or facilitator. Needed areas of learning are identified and used as a guide to individualize study. Students must identify what they know and don't know and go beyond their textbooks to pursue knowledge in other resources (White, 1996). Knowledge and skills that are learned in the process are applied to the problem to evaluate the effectiveness of learning and to reinforce and contextualize learning (Maxwell et al. 2001). Finally, learning that has occurred is integrated into the student's existing knowledge base.

The role of the teacher takes on a much different form in PBL as compared to more traditional instructional strategies. Most often, the teacher will assume the role of a facilitator, guide, or coach. The facilitator maintains the focus on learning, guides the process, meters the challenge, and provides appropriate feedback to each student and group (Gordon, Rogers, Comfort, Gavula, & McGee, 2001). Gallagher and Stepien

(1995) described the teacher in PBL as a metacognitive coach indicating that teachers guide the students in problem solving as opposed to teaching content.

Arends (2004) described five major phases that can typically be found in PBL. Table 2 identifies those phases along with teacher behaviors during each phase of instruction. According to Arends, the process begins with orienting students to the problem, a phase where the teach establishes the direction of the lesson and creates motivation. This phase is followed by organizing students for study. At this time, the teacher serves as a guide to direct students to appropriate tasks essential to solving the problem.

Table 2

Syntax for Problem-Based Learning (Arends, 2004)

Phase		Behavior
Phase 1	Orient students to the problem	Teacher goes over the objectives of the lesson, describes important logistical requirements, and motivates students to engage in self-selected problem-solving activity.
Phase 2	Organize students for study	Teacher helps students define and organize study tasks related to the problem.
Phase 3	Assist independent and group investigation	Teacher encourages students to gather appropriate information, conduct experiments, and search for explanations and solutions.
Phase 4	Develop and present artifacts and exhibits	Teacher assists student in planning and preparing appropriate artifacts such as reports, videos, and models and helps them share their work with others.
Phase 5	Analyze and evaluate the problem-solving process	Teacher helps students to reflect on their investigations and the processes they used.

Arends (2004) theorized that Phase 3 is characterized by students' efforts to gather and acquire information related to possible solutions. The teacher continues to coach and guide, suggesting or directing students to appropriate activities but allowing students to formulate their own strategies. The fourth phase encompasses the development and presentation of solutions. Student solutions are showcased in a variety of ways. Finally, the process concludes with an evaluation of the experience. Students reflect on the strategies employed to solve their problem and discuss suggested improvements to the process.

Multiple conceptual models exist for teaching using PBL. Most models contain similar processes. The major difference can usually be found in the delineation of the individual steps. Kain (2003) described steps to the PBL process which are similar to the actions identified in Arend's (2004) five phases. Kain (2003) contended that the process begins with defining the problem. Others refer to this step as "problem finding" (Bridges & Hallinger, 1995; Gallagher, Rosenthal, & Stepien, 1992). Step two, according to Kain (2003), consists of seeking information. Learners generate answers to three key questions: What do we know? What do we need to know? How can we find out?

From information gathered, students enter into Kain's (2003) third step, which is to generate options and select a solution. This step often requires students to conduct more research after a solution has been decided upon. In real world problem solving, the next step would be to implement the solution. In PBL activities, those solutions are not always possible. Instead, PBL consists of a presentation of a solution. The presentation can take unlimited forms. The final step, as outlined by Kain (2003), is to debrief the experience. Students meet within their problem-solving group as well as the entire class to assess their performance. This step is critical in developing problem-solving skills.

While the two previously mentioned models are similar, Ryan and Millspaugh (2004) proposed a more elaborate model consisting of fourteen steps to the process. Their model was developed for PBL in undergraduate education, but the structure is applicable to secondary education as well. Figure 3 displays the fourteen steps of this model in relation to the steps of phases of both the Arends model and Kain model.

<table>
<tr><th>Arends Model</th><th>Kain Model</th><th>Ryan and Millspaugh Model</th></tr>
<tr><td>*</td><td rowspan="3">*</td><td>1. Explain why Problem-Based Learning is used.</td></tr>
<tr><td rowspan="5">Phase 1</td><td>2. Establish teams and assign team member roles</td></tr>
<tr><td>3. Present “case” to students</td></tr>
<tr><td>Step 1</td><td>4. Identify problem and stakeholders. Identify information to be learned.</td></tr>
<tr><td rowspan="5">Step 2</td><td>5. Provide additional/background information related to the case.</td></tr>
<tr><td>6. Identify formal learning objectives</td></tr>
<tr><td>Phase 2</td><td>7. Assign individual responsibilities</td></tr>
<tr><td rowspan="3">Phase 3</td><td>8. Provide instructional activities to assist in interpreting and understanding information</td></tr>
<tr><td>9. Report on learning objectives within teams</td></tr>
<tr><td rowspan="2">Step 3</td><td>10. Relate learning objectives to case solution</td></tr>
<tr><td rowspan="2">Phase 4</td><td>11. Exchange ideas among teams</td></tr>
<tr><td>Step 4</td><td>12. Prepare/Present case resolutions</td></tr>
<tr><td rowspan="2">Phase 5</td><td rowspan="2">Step 5</td><td>13. Debrief the case</td></tr>
<tr><td>14. “Generalize” from case experience through discussion</td></tr>
</table>

**steps not represented in model*

Figure 3. Comparison of Models of Problem-based Learning.

Each of the three models advocate a step process ultimately leading to solution of the problem and concluding with an evaluation or reflection of the process. However, the three models define each step or phase differently according to the tasks that make up the particular step. When compared to the Ryan and Millspaugh model, the Arends model begins at the corresponding step 2 and the Kain model begins at the corresponding step 4. The structured and specific nature of the model proposed by Ryan and Millspaugh begins with logistical considerations necessary for PBL that are not addressed in, to the same degree, in the other two models. Although originally intended for use at the post-secondary level, the structure provided by this model can be helpful in designing PBL activities for the secondary level.

In summary, PBL is a constructivist approach to instruction that revolves around a real-world, ill-structured problem. The method promotes both the acquisition of content knowledge and the development of thinking skills and strategies. Teachers typically take on the role of the facilitator and students become responsible for information learned. This method typically ends with a presentation of solutions and an evaluation of the process used in solving the problem. Originally developed for medical schools, PBL has been effective in increasing student performance in academic achievement, problem-solving ability and critical thinking in a variety of programs.

Problem-Based Learning and Student Outcomes

PBL was designed with several important goals (Barrows & Kelson, 1995). It was designed to help students:

1. Construct an extensive and flexible knowledge base
2. Develop effective problem-solving strategies

3. Develop self-directed, lifelong learning skills
4. Become effective collaborators
5. Become intrinsically motivated to learn

PBL emphasizes critical thinking skills, understanding, learning how to learn, and working cooperatively with others. There has been considerable research on the contribution of PBL to knowledge acquisition, development of problem solving skills, and self-directed learning skills. While much of the research in PBL comes from the medical field, some efforts have focused on PBL in other programs and at other levels.

In a review of evidence in the medical field, Norman and Schmidt (1992) compared findings of previous studies to the goals of PBL. They concluded that PBL curricula may enhance both the transfer of concepts to new problems and integration of basic science concepts into clinical problems. Additionally, they found that intrinsic interest in the subject matter and student self-directedness was enhanced through PBL.

Albanese and Mitchell (1993) conducted an extensive review of literature on PBL in the medical field. Their work is one of the most frequently cited studies on PBL and related student outcomes. Their meta-analysis of over 100 studies yielded information related to student outcomes. Albanese and Mitchell indicated one of the most consistently mentioned outcomes from PBL was lower basic test scores. Findings from their meta-analysis indicated that the expectation that PBL students will not do as well as conventional students on basic science tests is generally true, but not always true. The authors noted that variations of PBL produced students who performed as well on basic exams.

In contrast to basic information tests, Albanese and Mitchell (1993) found that PBL students scored higher on clinical exams. These clinical exams are closely associated with problem solving and utilize critical thinking skills. Furthermore, the meta-analysis revealed that clinical scores for PBL students tended to be more clustered to the middle, while traditional students often scored on extreme ends of the scale. When compared on ratings given by clinical supervisors, PBL students outperformed traditional students in each study included in the meta-analysis.

Albanese and Mitchell (1993) also concluded that PBL students were less likely to study for short-term recall and were more likely to analyze what they needed to know when compared to traditional students. PBL students also perceived their learning environment in a more favorable light than students of conventional curricula.

Vernon and Blake (1993) conducted a similar meta-analysis. Studies in the medical field were identified and included based on methodological criteria. Data from 22 research reports on 19 different PBL programs were included in the analyses. Twelve types of outcome variables were grouped into four general areas: program evaluation, academic achievement, academic process, and clinical functioning. According to Vernon and Blake, data regarding program evaluation appear to consistently favor PBL. With regard to academic achievement, Vernon and Blake concluded that traditional students have an advantage in knowledge exams. However, the authors could not conclude this advantage was due solely to program design. Most of the previous studies on academic performance have been static group designs. These designs lacked randomization and presented threats to internal validity as a result of selection bias.

Vernon and Blake (1993) found that previous studies on academic processes, while limited, supported the PBL goals of placing greater emphasis on in-depth understanding and self-directed study and less emphasis on rote learning and memorization. Studies on clinical functioning suggested that clinical performances and skills of students exposed to PBL are superior to those of students educated in a traditional curriculum.

Both Albanese and Mitchell (1993) and Vernon and Blake (1993) concluded that on basic knowledge type assessments, students taught using PBL performed at the same level (Albanese & Mitchell) or at lower levels (Albanese & Mitchell, Vernon & Blake). This discrepant outcome was the focus of a comparative study of program models at the University of the West Indies (Alleyne, Shirley, Bennett, Addae, Walrond, West, & Pereira, 2002). In this study, scores of students from a PBL program were compared to scores of students from a traditional program on three discipline areas. Students were compared on scores consisting of three components; theory, clinical and orals. No differences were found between PBL students and traditional students in any of the discipline areas. It was concluded that PBL programs were unlikely to produce substandard students on knowledge assessments.

The focus of a study by Hmelo (1998) was to determine the effect of PBL on problem-solving ability of medical students. Hmelo compared students from two medical programs, each with an optional PBL track and a traditional track. A longitudinal design was used to compare the resulting four groups. Groups were compared for equivalence on academic ability. While differences in academic ability existed across institution, there were no differences between the PBL group and traditional group at either of the two institutions.

Hmelo (1998) measured problem-solving ability according to three different perspectives: accuracy, coherence of explanation, and use of science concepts. On accuracy, PBL students showed a linear increase over time while the traditional students showed no significant improvement. While PBL students showed greater improvement in coherence over time, both groups showed improvement and the difference between groups was not statistically significant. A significant difference was detected in use of science concepts indicating the PBL students were more likely to use science concepts in their reasoning than traditional students. Hmelo concluded that PBL was an effective approach for developing problem-solving ability in medical students.

As PBL has gained recognition in medical programs and has become popular in post-secondary programs, other studies have examined student outcomes associated with PBL outside of medical education. Cockrell, Caplow, and Donaldson (2000) investigated students' perspectives of their learning in a qualitative study of a PBL structured graduate level education course. Eighteen participants were assigned to groups of three for the entire semester. A qualitative analysis of the data revealed a core theme described as ownership of knowledge. Students indicated an increase in confidence in content knowledge. They further described a feeling that they owned that knowledge. Three sub themes were embedded in the core; group dynamics, tutor feedback, and metacognitive awareness.

Participants perceived that the collaborative nature of the group processes enhanced their learning. Group comments indicated they valued the multiple perspectives offered within the group and attributed their knowledge construction to group discussions. Participant comments additionally indicated that tutor feedback was essential to guiding group process. They valued the feedback and perceived feedback in a variety of different forms.

With regard to metacognitive awareness, participants indicated a greater awareness of their self-directed learning activities. Students developed exam questions at the end of each problem case. These questions indicated growth in analytic and critical thinking skills. Questions written became increasingly complex, beginning with recall and comprehension questions after the first case and progressing towards higher cognitive levels according to Bloom's taxonomy (1956).

Ball and Knobloch (2004) investigated outcomes of PBL in a case-study of a cohort of pre-service agriculture teachers. Twenty two pre-service teachers were randomly assigned to groups to resolve problem scenarios related to program supervision. Participant perceptions of the PBL process were measured on scaled-response items and open-ended questions. Findings indicated that participants felt the PBL activity had better prepared them to solve problems related to program supervision. It was concluded that PBL engaged pre-service teachers to be creative and reflective problem-solvers. Additionally, it was concluded that pre-service teachers were prepared to solve similar problems related to supervision of student organizations.

Lieux (1996) compared lecture to PBL in a Quantity and Food Production and Service course. Lieux, the instructor, offered two sections of the course: PBL and lecture format; and compared students on academic performance and satisfaction. Data were collected on prior-knowledge, preferred learning environment, attendance, course evaluations, and final exam scores. Using final exam scores as a measure of performance, there was no difference found in academic achievement based on type of instruction. One caveat to Lieux's findings was that although no differences were found on academic achievement, students in the PBL section perceived that they had learned less than those in the lecture section.

Problem-based learning has been the focus of several studies at the secondary level in both middle school and high school programs. Gordon, Rogers, Comfort, Gavula, and McGee (2001) sought to identify the impact of PBL in urban, minority middle school students. This study compared alternate tracks for sixth, seventh, and eighth grade students at an urban Philadelphia middle school. Approximately half of each grade level was exposed to PBL activities while the other half did not participate. PBL activities represented less than two percent of the total instruction. It was found that adolescents enjoyed and valued PBL. Findings also indicated that although most were performing below grade level, they responded well to the high academic challenge of PBL. Improvements were found in both academic achievement, specifically science scores, and in behavior.

Mergendoller, Maxwell, and Bellisimo (2000) compared PBL and traditional instruction in high school economics classes. Their study compared instructional strategies on academic performance and attitude toward economics. Participants included 186 students in nine classes taught by three teachers. Teachers included PBL activities in a required high school economics course. Students were compared on knowledge acquisition as well as attitude toward economics with students taught in comparison courses lacking the PBL component. While some differences were found between PBL and traditional approaches when analyzed by individual teacher, the pooled analysis indicated no treatment effect on content knowledge or attitude toward economics between the types of instruction.

Dods (1997) conducted an action research study of secondary biochemistry students to investigate the effectiveness of PBL in promoting knowledge acquisition and retention. A total of 30 students from the Illinois Mathematics and Science Academy participated. Course content was delivered via PBL, traditional lecture, and a combination of PBL and traditional lecture. Data were gathered using a pre- and post-course self-evaluation of student understanding and a measure of depth of understanding. It was found that students acquired knowledge at about an equal rate, regardless of instructional strategy used. Content coverage was promoted by lecture, but PBL was more effective than both traditional lecture and a combination of lecture and PBL in promoting comprehensive understanding of biochemical content; and students taught using PBL had greater retention of knowledge.

In an action research study of 18 freshmen in an introductory agricultural education course, Herman and Knobloch (2004) compared constructivist and behaviorist teaching approaches, specifically PBL and illustrated lectures. Participants were exposed to instruction representing constructivist approaches, specifically problem-based learning and cooperative learning, and the behavioral approach of illustrated lecture. Instruction occurred over three instructional units encompassing more than 60 class periods. Data were collected on knowledge acquisition, retention, and student motivation. Students scored on average 6.6% higher on the PBL unit and 5.27% higher on the cooperative learning unit than on the illustrated lecture unit. They concluded that, while findings were mixed on knowledge retention, PBL improved student achievement, understanding, and motivation.

Summary

Educators have long recognized the need for students to be able to think clearly. Even so, concerns have arisen over educational approaches that emphasizes the stockpiling of information with little focus on problem solving and critical thinking (Brooks & Brooks, 2001; Black and Deci, 2000; Norris, 1985; National Commission of Excellence in Education, 1983). Recent legislation is representative of these growing concerns that have refocused education toward the development of critical thinking skills (DESE, 1996). Researchers have suggested that instructional strategy can impact the development of critical thinking skills (Whittington, Stup, Bish, & Allen, 1997; Burback, Matkin, & Fritz, 2004; Elliot, Oty, McArthur, & Clark, 2001)

Dunkin and Biddle (1974) suggested a model for the investigation of the teaching and learning process. The model classified variables into four categories. Presage variables represent teacher characteristics that have an effect on the teaching process. Context variables represent conditions to which the teacher must adjust including the population of students and the characteristics of the students, classroom, school, and community. Process variables are the actual activities of classroom teaching, including the instructional activities carried out in the classroom. Product variables represent student outcomes such as subject-matter learning and attitude toward the subject. Other product variables of interest include knowledge acquisition and critical-thinking ability.

This model provides a framework for investigating the effects of instructional strategy on content knowledge and critical thinking ability.

While the literature reveals no consensus definition of critical thinking, there are some similarities found in the conceptualization of critical thinking. Critical thinking is generally regarded as a composite of attitudes, knowledge, and skills (Watson & Glaser, 1994; Bailin, et al., 1999; Burden & Byrd, 1994; Facione, 1990; Siegel, 1988; Beyer, 1987; Ennis, 1985;). Critical thinking has been regarded as a component of, or closely associated with higher-order thinking, decision making, and problem-solving (Burden & Byrd, 1994; Facione, 1990; Ennis, 1985).

Traditionally, the problem-solving approach has been the most recommended approach for teaching agriculture (Ball, Knoblock, & Settle, 2003; Brown, 1998; Flowers & Osborne, 1987). The problem-solving approach mirrors Dewey's steps of reflective thinking (Newcomb, et al., 1993). Newcomb, et al. suggested various group and individual teaching techniques for instruction within this approach. Missouri agriculture curricula have historically been written using the supervised study strategy for problem-solving as outlined by Newcomb, et al.

Problem-based learning is an instructional strategy that favors a more constructivist approach. Learning occurs when students construct their own knowledge by solving authentic problems and reflecting on their own experiences. PBL differs from problem-solving strategies in several key areas. In PBL, students encounter problems prior to any instruction. Problem-solving techniques use problems that are applicable to clearly defined, pre-established objectives. PBL problems are messy and ill-structured (Jonassen, 1997). Problems used in the problem solving approach are clearly defined

(Newcomb, et al., 1993). Finally, in PBL, students work in groups to create unique solutions to a problem that has no right or wrong answer. Problem-solving techniques focus on discovering a single correct answer.

Studies have explored the outcomes related to PBL at virtually all levels of education. There is agreement on the contribution of PBL to factors such as knowledge retention, student satisfaction, motivation, and critical thinking. There is much less agreement on the role of PBL in knowledge acquisition.

Vernon and Blake (1993) concluded that PBL students are at a disadvantage when compared to traditional students on content knowledge. Albanese and Mitchell (1993) were much less confident, asserting that PBL students are at a disadvantage sometimes, but not always. They also content that much of the disparity could depend upon the variation of PBL used. Others (Alleyne, et al, 2002; Leiux, 1996; Mergendoller, 2000; and Dods, 1997) found no difference in the content knowledge of students exposed to PBL compared to traditional instructional strategies.

Evidence does exist to suggest that PBL can help promote critical thinking skills. Studies investigating problem-solving, a component of critical thinking have found that students exposed to PBL consistently display growth in problem-solving skills (Ball & Knobloch, 2004; Hmelo, 1998). Additionally, students in PBL programs showed an increase in transfer and application of knowledge (Norman & Schmidt, 1992) and in clinical trials requiring analysis and application (Albanese & Mitchell, 1993), each considered essential to problem-solving. PBL has been found to be effective in promoting higher-order thinking (Albanese & Mitchell; Vernon & Blake, 1993; Cockrell, et al., 2000; Dods, 1997).

The literature additionally suggests a general consensus regarding a positive impact of PBL on student dispositions. PBL has been found to improve student motivation and interest (Norman & Schmidt, 1992; Gordon, et al., 2001; Herman & Knobloch, 2004). In addition to motivation, students indicate more satisfaction with PBL than with traditional methods of instruction (Albanese & Mitchell, 1993; Vernon & Blake, 1993; Cockrell, et al., 2000; Ball & Knobloch, 2004; Gordon, et al. 2001).

CHAPTER III

METHODOLOGY

Purpose of the Study

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship between critical thinking ability and content knowledge among selected secondary agriculture students in Missouri. The following research objectives and hypothesis were generated to focus and guide the direction of the study.

Research Objectives and Hypotheses

1. Describe subjects on gender, grade classification, and academic aptitude (7^{th} grade science MAP index).

2. Describe the critical thinking ability of students before and after instruction in a quail management unit.

3. Describe the content knowledge of students before and after instruction in a quail management unit.

4. Compare the effect of instructional strategy (problem-based learning versus supervised study) with regard to secondary agriculture students' critical thinking ability and content knowledge.

   H_1: Students taught using the problem-based learning instructional strategy will demonstrate a greater improvement in critical thinking than students taught using the supervised study instructional strategy.

   H_2: A significant difference exists in content knowledge for students taught using the problem-based learning instructional strategy and students taught using the supervised study strategy.

5. Describe the relationships between critical thinking ability and content knowledge.

Research Design

This study employed a quasi-experimental, non-equivalent comparison group design. According to Campbell and Stanley (1969), this design is appropriate for groups that are naturally assembled, such as intact classrooms. The design includes both pre-test and post-test data gathered on the same unit making it a dependent samples design. Campbell and Stanley (1969) advocated the use of both pre-test and post-test when the groups are similar, but not so similar that a pre-test is unnecessary. Using both a pre-test and a control group, it is easier to examine threats to internal validity (Shadish, Cook, & Campbell, 2002). In this study, the effect of instructional strategy on critical thinking ability and knowledge acquisition was investigated. Table 3 provides a graphic representation of the design.

Table 3

Quasi-Experimental Research Design

Group	Assignment	Treatment	Pretest	Posttest
A	Nonrandom	Problem-based Learning	1. Quail Management Unit Test 2. WTGCA	1. Quail Management Unit Test 2. WTGCA
B	Nonrandom	Supervised Study	1. Quail Management Unit Test 2. WTGCA	1. Quail Management Unit Test 2. WTGCA

Variables

The independent variable in this study was the type of instructional strategy used to teach a quail management unit. For this study, instructional strategy was considered to be the method of instruction assigned to the teacher to teach the desired information. Students received instruction in the unit through one of two assigned instructional strategies; supervised study or problem-based learning. Students were part of intact classroom groups. Each group was randomly assigned to either the supervised study strategy or the PBL strategy.

There were two dependent variables in the study. The first dependent variable was the critical thinking ability of secondary agriculture students as measured by the Watson-Glaser Critical Thinking Appraisal® (WGCTA®). For the purpose of this study, critical thinking was operationalized according to the definition provided by Watson and Glaser (1994).

> Critical thinking is a composite of attitudes, knowledge, and skills which includes: (1) attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true; (2) knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined; and (3) skills in applying the above attitudes and knowledge (p 1).

The second dependent variable was content knowledge. A quail management unit test was used to determine content knowledge of subjects at the conclusion of the unit. The pre- and post-test design controlled for differences in students on existing knowledge of quail management.

Control Factors

Campbell and Stanley (1969) suggested eight classes of extraneous variables that possibly threaten internal validity. Classes of extraneous variables include history, maturation, testing, instrumentation, statistical regression, selection, experimental mortality, selection interaction. Threats to internal validity as a result of history, maturation, testing, instrumentation, selection, and mortality are controlled by the non-equivalent control group design. Differences resulting from these threats would be found in both the experimental and control group.

The non-equivalent control group design does present concern with two types of threats to internal validity: regression and selection interaction. The random assignment of each classroom to the control or treatment group will control for regression threats to internal validity. According to Shadish, Cook, and Campbell (2002), regression poses a threat when selection of participants is based on extreme scores. For this study, participants were selected on the basis of the instructor, not on student characteristics. Intact classroom groups for this study were randomly assigned to either the control group or treatment group.

Given that participants for this study were selected as part of pre-existing intact groups, not a result of random selection, there is a possibility of an internal validity threat due to selection differences. The very name of the design, non-equivalent control group, implies that some degree of selection bias is present (Shadish, Cook, & Campbell, 2002). To control for differences between intact classroom groups, each group was compared on academic aptitude. The score on the seventh grade administration of the science portion of the Missouri Assessment Program (MAP) test was used as a covariate to control for pre-existing differences in academic aptitude among subjects.

Variations in how treatments are administered can pose an implementer threat to internal validity (Fraenkel & Wallen, 1990). To control for implementer threat, teachers were purposefully selected based on characteristics of their formal preparation for teaching. All selected teachers were graduates of the Department of Agricultural Education at the University of Missouri between 1998 and 2004. All selected teachers had been exposed to a consistent departmental philosophy of education, completed similar requirements for teacher certification, and received similar instruction in teaching methodology. Teachers were included in the study based on their ability to include a quail management unit in their Ag Science II or Natural Resource/Conservation class. A total of twelve teachers were selected for the study.

In addition to selection characteristics of teachers, an orientation session was conducted to help control for implementer threat to internal validity. Each teacher was required to attend an orientation session to prepare them to teach the quail management unit using one of the two designated instructional strategies. Teachers were provided with the requisite materials necessary to teach the quail management unit using their assigned instructional strategy.

Treatment and Procedures

The unit of instruction selected for this study was a quail management curriculum unit developed by the Missouri Department of Conservation. These materials were developed for secondary students in Missouri agriculture classes and were intended to be a stand alone unit of instruction, requiring no prerequisite instruction. While agriculture teachers in Missouri have the flexibility to develop course calendars as they see fit, the quail management unit most logically fit into the recommended course calendars for Agriculture Science II or Conservation and Natural Resources. In addition to the curriculum, a student resource book was developed to supplement the unit. A copy of this resource; *On the Edge: A Guide to Managing Land for Bobwhite Quail* (Daily & Hutton, 2003), was provided for each student in the study.

Each group of randomly assigned teachers was required to attend an orientation session. The following objectives were written to organize and guide the orientation sessions:

1. Describe the purpose and design of the study
2. Provide instruction on how to implement the selected treatment
3. Distribute materials needed during the course of the study

Directions for teaching the unit were written specifically for the two treatment groups. Other materials were common to both groups. Table 4 displays the materials provided to teachers of both groups. Those items included data collection instruments and report forms as well as directions for administering the data collection instruments.

Table 4

Teaching Materials Provided for Quail Management Unit

Material	Quantity	Appendix
Administrator Consent Form	1 per school	A
Quail Management Test	2 per student (pre and post administration)	B
Directions for Administering the Quail Management Pre-test	1 per school	C
Directions for Administering the Quail Management Post-test	1 per school	D
Directions for Administering the WTGCA®	1 per school	E
Quail Management Test Key	1 per school	F
Student Identification Form	1 per school	G
Score Report Form	1 per school	H
WTGCA® Answer Document	2 per student (pre and post administration)	®
Return Envelopes	2 per school	
WTGCA® Test Booklets	1 per student	®

Note. WTGCA® materials are copyright protected.

An administrator consent form (Appendix A) was provided to the teacher and was signed by a campus administrator and returned in a self-addressed stamped envelope, also provided in the packet. Copies of the data collection instruments, WGCTA® and quail management test (Appendix B), were provided for both pre-test and post-test administration. Directions for the administration of the data collection instruments were also provided (Appendices C, D, & E). The teachers were directed to score both administrations of the quail management test and a quail management test key

(Appendix F) was provided for that purpose. Teachers returned the completed WGCTA® pre-test answer documents in a self-addressed, stamped envelope provided with their materials.

Two forms were developed by the researcher to assist the teachers in reporting data. The Student ID Form (Appendix G) was used to assign an identification number to each student in the respective class. This form was used only at the local level to correspond student identification numbers to respective scores on data collection instruments. This form was not returned to the researcher and as a result, the identification of subjects remained anonymous to the researcher. The Score Report Form (Appendix H) was used to report student identification numbers and corresponding scores as well as demographic information to the researcher. No names of student were recorded on this form. The Score Report Form, WGCTA® post-test answer documents, and WGCTA® test booklets were collected by the researcher at the conclusion of the treatment.

Supervised Study Treatment

Historically, curriculum for Missouri secondary agriculture courses has been written and produced by the Instructional Materials Laboratory (IML) at the University of Missouri. IML, working under the direction and funding of the Career and Technical Education Division of the Department of Elementary and Secondary Education, has produced this curriculum in a consistent format. This format provides content information and teaching instructions in a lesson plan design. The instructional strategy called for in these lesson plans is best described as the supervised study method.

Newcomb, McCracken, and Warmbrod (1993) described supervised study as a method of teaching in which students use basic reference materials to find information on their own. Newcomb, et al. suggested a four part sequence to successfully implement this method of instruction: planning the supervised study, conducting the supervised study, terminating the supervised study, and developing conclusions based on the supervised study.

The planning phase consists of both developing an interest approach designed to create student interest in the topic and develop study questions. In conducting the supervised study, the teacher is responsible for directing the students, keeping students productively involved, and observing and monitoring student progress. Teachers are responsible for terminating the supervised study when they feel that most students have had an opportunity to answer most of the study questions. Newcomb, McCracken, and Warmbrod (1993) acknowledged this determination as often a judgment call based on the teacher's experience. The final phase, developing conclusions, provides an opportunity for the teacher clear up misconceptions, elaborate on crucial concepts, and synthesize class findings (Newcomb, McCracken, & Warmbrod, 1993).

Curriculum designed by IML has followed the format outlined by Newcomb, McCracken, and Warmbrod as supervised study. The quail management unit of instruction used for this study, though written and developed by the Missouri Department of Conservation and not IML, was designed in the same format as all other Missouri curriculum for agriculture courses. The unit consisted of four separate lessons. Each lesson included an interest approach and identified study questions related to that lesson. The instructor's guide provided an outline of content related to each of the study questions. The teaching directions called for supervised study, directing students to find answers to the study questions on the page numbers specified. After students had an opportunity to answer questions independently, a concluding discussion followed.

In addition to selection criteria used to identify teachers for the study, measures were taken to ensure consistency in the administration of the treatments. Teachers were oriented to the study in an orientation session designed to prepare them for the supervised study unit. All teachers assigned to the supervised study treatment group attended the orientation session, approximately two hours in length. At that meeting, teachers were instructed in the teaching strategies to be used and procedures to follow for the study. They were also provided materials and resources to teach the unit.

Table 5 provides descriptive information for each of the classes randomly assigned to the supervised study treatment group. Steps were taken to control for differences among these classes. Each teacher randomly assigned to the supervised study treatment group was provided with a teaching outline (Appendix I) describing the steps of supervised study instruction. This outline provided a structure to ensure that each teacher followed the same steps of instruction and allocated similar amounts of time to each of the steps in the lessons. According to this outline, a lesson cycle required approximately 85 minutes of class time.

Table 5

Summary Description of Classrooms Assigned to Supervised Study

Teacher	Length of Period (Min)	Type of Course	Grade Level Range	Number of Students	Type of School
1	75	Conservation	11-12	13	Comprehensive
2	50	Ag Science II	10	7	Comprehensive
3	75	Ag Science II	10-11	12	Comprehensive
4	90	Conservation	10-12	11	Comprehensive
5	50	Ag Science II	10	14	Technical
6	50	Conservation	10-12	6	Technical
Total				63	

In addition to an instructional outline, teachers were provided with a time allocation table (Appendix J). This table described the number of class periods needed to teach the four lesson unit based upon the length of class period. This table was constructed using the 85 minute model detailed in the instructional outline. Finally, the instructor's guide for the quail management unit was provided to the teachers.

Problem-Based Learning (PBL) Treatment

An alternate version of the quail management curriculum was developed by the researcher and designed according to the Ryan and Millspaugh Model for Problem-Based Learning (PBL). Table 6 displays the steps of the model.

Table 6

Ryan and Millspaugh Model for Problem-Based Learning

Step	Task to Accomplish
1	Explain why Problem-Based Learning is used.
2	Establish teams and assign team member roles
3	Present “case” to students
4	Identify problem and stakeholders. Identify information to be learned.
5	Provide additional or background information related to the case.
6	Identify formal learning objectives
7	Assign individual responsibilities
8	Provide instructional activities to assist in interpreting and understanding information
9	Report on learning objectives within teams
10	Relate learning objectives to case solution
11	Exchange ideas among teams
12	Prepare/Present case resolutions
13	Debrief the case
14	“Generalize” from case experience through discussion

The formal objectives utilized for the PBL unit were taken from the original version of the curriculum. Materials were prepared to teach those objectives using the PBL strategy. Teachers were provided all materials necessary to teach the unit using the PBL strategy. Teachers randomly assigned to the PBL treatment group participated in an orientation session designed to prepare the teachers for the PBL unit. The session highlighted the teaching strategies to be used and procedures to be followed. Materials and resources for teaching the unit were distributed during the orientation session.

Table 7 provides descriptive information for each of the classes randomly assigned to the experimental group. A Unit Overview (Appendix K) was provided to each teacher identifying the tasks to accomplish during instruction and allocation of time for those tasks. The unit overview provided a structure to ensure that the treatment was implemented consistently by all teachers.

Table 7

Summary Description of Classrooms Assigned to Problem-Based Learning

Teacher	Length of Period (Min)	Type of Course	Grade Level Range	Number of Students	Type of School
1	50	Ag Science II	10	12	Technical
2	75	Conservation	10	12	Comprehensive
3	50	Ag Science II	10	8	Comprehensive
4	50	Conservation	10-12	11	Comprehensive
5	50	Conservation	10-12	20	Comprehensive
6	50	Ag Science II	10	14	Comprehensive
Total				77	

The Problem Case was developed by the researcher to provide a context for learning in the PBL unit. This case (Appendix L) was adapted from an actual newspaper article describing realistic events. Some details were modified to fit the learning objectives of the case. To support the case, an additional resource sheet providing information on the area of land under investigation was also developed by the researcher

(Appendix M). Two additional handouts, Formal Learning Objectives (Appendix N) and Individual Organizer for Investigation (Appendix O) were developed to facilitate the PBL instruction.

Teachers were provided with specific daily directions (Appendix P) for teaching according to the PBL strategy. While the teacher's role in PBL is to guide and facilitate, a content outline for the unit was provided to prepare teachers to answer questions and better direct investigation.

Procedures

Teachers were identified based on criteria related to their program of preparation. Selection of teachers for the study was dependent upon their ability to include a quail management unit into an Ag Science II or Natural Resource/Conservation class. Once twelve teachers had been selected, they were randomly assigned to a treatment group. Each group of teachers attended an orientation session identifying the purpose of the study and describing the proper implementation of the assigned strategy. All teachers assigned to the PBL treatment group attended the orientation session. The session lasted approximately two hours. Materials were disseminated at this orientation session as well.

While the approach to instruction varied dependent upon the strategy assigned to the teacher, each teacher was asked to follow a schedule to ensure that equal time was spent on learning the content in each of the two groups. Table 8 displays a comparison of the time spent between the two strategies. This comparison is based on a 50 minute class period. Teachers with different class lengths received a modified schedule. A consent letter was signed by an administrator at each sight prior to the beginning of treatment and returned to the researcher in a self-addressed, stamped envelope.

Table 8

Comparison of Daily Schedule by Group

Day	Supervised Study	PBL
1	Pre-test on Quail Management Content	Pre-test on Quail Management Content
2	Pretest on Critical Thinking Ability	Pretest on Critical Thinking Ability
3-8	Instruction on Quail Management Unit organized by lessons 1 through 4 and consisting of individual supervised study.	Instruction on Quail Management Unit organized around a real-world problem and consisting of group investigation of information.
9	Post-test on Quail Management Content	Post-test on Quail Management Content
10	Post-test on Critical Thinking Abilities	Post-test on Critical Thinking Abilities
32	Post post-test on Quail Management Content	Post post-test on Quail Management Content

Note. Days based on 50 minutes periods of instruction.

Population

The target population for this study was secondary agriculture students in Missouri. Students were included in the study based on the selection of their instructor. Secondary agriculture teachers in Missouri were purposefully selected to participate as part of the study based on characteristics of their formal preparation for teaching. All selected teachers were graduates of the Department of Agricultural Education at the University of Missouri between 1998 and 2004. All selected teachers had been exposed to a consistent departmental philosophy of education, completed similar requirements for teacher certification, and received similar instruction in teaching methodology. Teachers were included in the study based on their ability to include the quail management unit into their Ag Science II or Natural Resource/Conservation class. A total of twelve teachers were included in the study.

The result of purposefully selecting teachers was twelve naturally occurring clusters of students. The number of students in each of those classes was previously reported in Table 6 and Table 8. The sample for this study consisted of students (n = 140) in classes of those selected teachers. While the selection of students was based on the qualifications of the teacher and lacked a random component for selection, there was no systematic process to the selection of students and students became participants in the study as a result of chance. It was determined that the sample approximated the target population.

Instrumentation

Three data collection instruments were used to collect data for this study. Critical thinking ability was operationalized as a score on the Watson-Glaser Critical Thinking Appraisal® (WGCTA®)(Form S). Content knowledge was determined by a score on the quail management test at different points of administration. Finally, descriptive information (gender, grade level, 7th grade science MAP index) on subjects was reported by the teacher on the score report form.

Watson-Glaser Critical Thinking Appraisal®

The Watson-Glaser Critical Thinking Appraisal® is a standardized, copyrighted assessment tool for assessing the success of programs and courses in developing critical thinking skills (Watson & Glaser, 1994). The WGCTA® was used to measure the critical thinking skills of participants in the study. The instrument was used with the permission of the Psychological Corporation. The WGCTA® is designed to measure critical thinking as a composite of attitudes, knowledge, and skills. The WTGCA is available in parallel forms A and B and is also available in an abbreviated version (Form S). Form S was used for this study as it is approved for secondary students and can be completed in approximately 45 minutes. This form of the instrument consisted of 40 items.

"The Critical Thinking Appraisal seeks to provide an estimate of an individual's standing in the composite of abilities by means of five subtests, each designed to tap a somewhat differing aspect of the composite" (Watson & Glaser, 1994, p 1). The five subtests of the instrument are as follows:

Test 1 *Inference*. Discriminating among degrees of truth or falsity of inferences drawn from the given data.

Test 2 *Recognition of Assumptions*. Recognizing unstated assumptions or presuppositions in given statements or assertions.

Test 3 *Deduction*. Determining whether certain conclusions necessarily follow from information in given statements or premises.

Test 4 *Interpretation*. Weighing evidence and deciding if generalizations or conclusions based on the given data are warranted.

Test 5 *Evaluation of Arguments*. Distinguishing between arguments that are strong and relevant and those that are weak or irrelevant to a particular question at issue.

The WGCTA® included exercises which are purported to be examples of problems, statements, arguments and interpretations of data which are regularly encountered at work as well as at school and in other activities.

Reliability. The Watson-Glaser is a standardized instrument and the reliability of this instrument has been previously established. Reliability estimates for Form S of the WGCTA® were determined from a developmental sample (N = 1,608). Cronbach's alpha coefficient was .81 (r_{alpha} = .81) (Watson & Glaser, 1994).

Validity. Validity refers to the effectiveness with which a test measures what it is intended to measure. According to Watson and Glaser (1994), "the content validity of the WGCTA® in classroom and instructional settings may be examined by noting the extent to which the WGCTA® measures a sample of the specified objectives of such learning programs. The Missouri Show-Me Goals, which represent the statewide objectives of public education, clearly identify importance of critical thinking skills as evident by the references to analysis, problem solving, and decision making.

Quail Management Test

Knowledge acquisition was determined by a score for participants on the post test administration of the quail management test (See Appendix B). This test was developed in conjunction with the original instructional unit. The test consisted of 50 selected response, multiple choice items related to four unit objectives.

Reliability. The post-test administration of the quail management test was analyzed for reliability. The reliability of the instrument was determined post-hoc by assessing the inter-item consistency according to Kuder-Richardson formula 20. According to Ary, Jacobs, and Razavieh (2002), Kuder-Richarson 20 is applicable to tests whose items are scored dichotomously as either right or wrong. The coefficient of internal consistency was determined post hoc to be .85. An item analysis for each of the 50 items can be found in Appendix Q.

Validity. Each of the 50 content items utilized on the quail management test were selected and written by the authors of the original unit and included with original unit of instruction. Some items were adapted to selected response format. Each item corresponded to one of the four instructional objectives of the quail management unit and the answer to each item could be located by page number in the student resources used during the unit of instruction (Appendix R).

Student Characteristics

Descriptive data for students in each of the classes were collected on the score report form. Teachers were asked to record these data (gender, classification, and 7th grade science MAP index) in the appropriate field of the Score Report Form (see Appendix H). That form was returned to the researcher at the conclusion of the unit.

Data Collection

The pre-test version of both the WGCTA® and the quail management test were administered prior to the instruction on the quail management unit. The pre-test answer documents for the WTGCA were returned in a self-addressed, stamped envelope. Scores for the quail management test were calculated by the classroom teacher using the test key. At the conclusions of the unit, the post-test versions of both the WGCTA® and the quail management test were administered.

Teachers were provided with a reporting form to report scores on the content knowledge assessment to the researcher. To protect the confidentiality of the students, no names were reported by the teacher on any of the forms. Individual students within the class were identified by an identification number assigned to the student by the classroom teacher. Only those identification numbers, along with corresponding scores, were provided to the researcher. Both administrations of the quail management test were scored by the instructor and recorded on the Score Report Form. The answer forms for the WGCTA®, which were returned to the researcher for scoring, were distinguishable only by the student identification number placed on the answer form.

Teachers were asked to provide descriptive information for each of their students. Additional descriptive information (gender, classification, and 7th grade science MAP score) was reported on the Score Report Form. No student names, only assigned identification numbers, were reported on the Score Report Forms. The score report form, the post-test WGCTA® answer documents, and the WGCTA® test booklets were collected on site by the researcher at the conclusion of the unit.

Both the WGTCA and the content knowledge assessment test were administered by the classroom teachers. All teachers were provided with verbal and written instructions during the orientation session regarding the administration of the instruments. All of the instructors had completed college coursework in testing and measurement and were familiar with standardized testing procedures. The WGTCA was administered according to the testing procedures. A copy of the administration procedures is available in Appendix E.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 12.0 computer program for windows. The alpha level was established *a priori* at .05. The magnitudes of relationships reported were interpreted using Davis' (1971) descriptors.

Coefficient	Description of Relationship
.70 to Greater	Very Strong
.50 to .69	Substantial
.30 to .49	Moderate
.10 to .29	Low
.01 to .09	Negligible

Research Objective One

Describe subjects on gender, grade classification, and academic aptitude (7^{th} grade science MAP index).

To complete research objective one, descriptive statistics were reported of both measures of central tendency and measures of variability. Frequency counts and percentages were used to describe categorical data. Mean scores, standard deviations and ranges were generated to describe continuous data. Characteristics analyzed included gender, grade classification, and academic aptitude of students. Academic aptitude was determined by the index score on the 7^{th} grade administration of the science portion of the MAP test.

Research Objective Two

Describe the critical thinking ability of students before and after instruction in a quail management unit.

To complete research objective two, mean scores, standard deviations and ranges were generated for critical thinking ability. Critical thinking ability was measured by the WTGCA. Scores on the five sub-tests of the WGCTA® were summated to provide a critical thinking index score. Descriptive statistics for critical thinking ability were reported by individual classroom as well as by treatment group.

Research Objective Three

Describe the content knowledge of students before and after instruction in a quail management unit.

To complete research objective three, mean scores, standard deviations and ranges were generated for content knowledge. Content knowledge was measured by a quail management test. This instrument consisted of 50 selected response items. Individual scores were determined by the cumulative number of correct responses. Descriptive statistics for content knowledge were reported by individual classroom as well as by treatment group.

Research Objective Four

Compare the effect of instructional strategy (problem-based learning versus supervised study) with regard to secondary agriculture students' critical thinking ability and content knowledge.

The fourth research objective contained two research hypotheses. An Analysis of Covariance (ANCOVA) was conducted to test the hypotheses of objective four. Certain assumptions concerning the distribution of scores must be met for this procedure (Keppel, 1991). The assumption of homogeneity of variance was tested with Levene's test for equality of error variance (see Appendix R). The assumption of normality of data distribution was tested using descriptive statistics (see Appendix S).

Research Hypothesis One

Students taught using the problem-based learning instructional strategy will demonstrate a greater improvement in critical thinking than students taught using the supervised study instructional strategy.

The null hypothesis was: $H_0: \mu_{PBL} = \mu_{Supervised\ Study}$

The research hypothesis was: $H_1: \mu_{PBL} > \mu_{Supervised\ Study}$

To test the first null hypothesis, the post-test critical thinking score was entered as the dependent variable and treatment group was entered as the facto variable. Pre-test critical thinking score and science MAP score were entered as covariates to control for differences among students before the treatment. The alpha level was established *a priori* at .05.

Research Hypothesis Two

A significant difference exists in content knowledge for students taught using the problem-based learning instructional strategy and students taught using the supervised study strategy.

The null hypothesis was: $H_0: \mu_{PBL} = \mu_{Supervised\ Study}$

The research hypothesis was: $H_1: \mu_{PBL} \neq \mu_{Supervised\ Study}$

To test the second null hypothesis, the post-test content knowledge score was entered as the dependent variable and treatment group was entered as the factor variable. Pre-test content knowledge score and science MAP score were entered as covariates to control for differences among students before the treatment. The alpha level was established *a priori* at .05.

Research Objective Five

Describe the relationship between critical thinking ability and content knowledge.

To complete research objective five, Pearson product-moment correlations were calculated between critical thinking ability and content knowledge. Correlation coefficients were reported between critical thinking and content knowledge for each treatment group as well as the complete sample.

Summary

The study employed a quasi-experimental, non-equivalent control group design. Purposive cluster sampling techniques were used. Twelve secondary agriculture teachers in Missouri were purposefully selected to participate as part of the study. Subjects of the study were students in the Ag Science II or Conservation class of those teachers (n=140). Teachers were randomly assigned to a group based on the instructional strategy to be used to teach a wildlife management unit. Six teachers were assigned to the supervised study treatment group using supervised study as the instructional strategy (n = 63) and six teachers were assigned to the problem-based learning group using problem-based learning as the instructional strategy (n = 77). An orientation session was conducted for each group on separate days to prepare the teachers according to the strategy assigned.

Descriptive statistics were generated to describe critical thinking ability and content knowledge. ANCOVA procedures were performed to compare the means of those taught using the PBL method and those taught using the supervised study method. Pearson product-moment correlations were calculated to determine the relationship between critical thinking ability and content knowledge.

CHAPTER IV

FINDINGS

Purpose of the Study

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship between critical thinking ability and content knowledge among selected secondary agriculture students in Missouri.

Population and Sample

The target population for this study was identified as secondary agriculture students in Missouri. Subjects were part of a purposive sample. Selection was determined by criteria of the instructors. Twelve teachers were selected based on characteristics of their teacher preparation program. Each teacher was randomly assigned to the supervised study treatment group or problem-based learning treatment group. Subjects were part of the intact classroom groups of the selected teachers. The resulting sample (n = 140) consisted of 77 students in the PBL treatment group and 63 students in the supervised study treatment group.

Objective One

Describe subjects on gender, grade classification, and academic aptitude (7^{th} grade science MAP index).

A total of 140 students participated in the study. Categorical demographic data of students were reported by level of treatment in frequencies and percents (Table 9). Group one consisted of students in the Problem-based Learning (PBL) treatment group. In group one (n = 77), 44 students (58%) were male and 32 students (42%) were female. The second group consisted of students in the supervised study treatment group. The supervised study treatment group (n = 63) was composed of 47 males (73%) and 17 females (26%). For the sample (n = 140), 91 students (65%) were male and 49 students (35%) were female.

Table 9

Summary of Descriptive Characteristics of Students by Level of Treatment

	Problem-based Learning (n = 77)		Supervised Study (n = 63)		Total (n = 140)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Gender						
Male	44	57.9	47	73.4	91	65.0
Female	32	42.1	17	26.6	49	35.0
Class						
Freshmen	10	13.0	11	17.5	21	15.0
Sophomore	47	61.0	32	50.8	79	56.4
Junior	6	7.8	11	17.5	17	12.1
Senior	14	18.2	9	14.3	23	16.4

A summary of the grade classification of the student can also be seen in Table 9. In the study (n = 140), a majority (79, 56.4%) of the students were classified as sophomores. Twenty three of the students (16.4%) were classified as seniors. The remainder of the sample was made up of freshmen (21, 15%) and juniors (17, 12.14%). When distinguished by group, sophomores made up 61.0% (47) of the PBL group and 50.8% (32) of the supervised study group. The PBL group was additionally comprised of 14 seniors (18.2%), 10 freshmen (13.0%), and 6 juniors (7.8%). The supervised study group was represented by 11 freshmen (17.5%), 11 juniors (17.5%), and 9 seniors (14.3%).

Academic aptitude was operationally defined as the scale score on the science portion of the MAP (Missouri Assessment Program). The most recent administration completed by all students in this study was the 7th grade administration. MAP scores were reported by means, standard deviations, and ranges (Table 10). The mean MAP score for the PBL group (n = 59) was 683.3 (SD = 23.1). MAP scores from this group ranged from 625 to 733 (range = 108). For students in the supervised study group (n = 46), the mean MAP score was 691.7 (SD = 28.6). Scores in this group ranged from 610 to 752 (range = 142). The mean MAP score for the sample (n = 105) was 686.5 (SD = 25.5).

Table 10

Seventh Grade Science MAP Scores by Level of Treatment

MAP Score	Problem-based Learning (n = 59)	Supervised Study (n = 46)	Total (n = 105)
Mean	683.29	691.67	686.46
Standard Deviation	23.09	28.64	25.52
Range (Min-Max)	625 - 733	610 - 752	610 – 752

The Missouri Department of Elementary and Secondary Education (DESE) reports MAP scores by achievement level (DESE, 2004). Scale scores were divided into five categories of achievement (Table 11). Almost half (44%, n = 46) of the students in the sample were in the *progressing* category. Thirty two percent (n = 34) of the sample was categorized as nearing proficiency. The remainder of the sample consisted of *step 1* (n = 13, 12%), *proficient* (n = 11, 11%), and *advanced* (n = 1, 1%).

Table 11

Achievement Categories of Science MAP Scores by Treatment Group

	Problem-Based (n= 59)		Supervised Study (n=46)		Total (n=105)	
Achievement Category	Frequency	Percent	Frequency	Percent	Frequency	Percent
Step 1 (520-656)	7	11.9	6	13.0	13	12.4
Progressing (657-693)	32	54.2	14	30.4	46	43.8
Nearing Proficiency (694-717)	16	27.1	18	39.1	34	32.3
Proficient (718-744)	4	6.8	7	15.2	11	10.5
Advanced (745-925)	0	0.0	1	2.2	1	.9
Total	59	100.0	46	100.0	105	100.0

Students categorized as *progressing* (n = 32, 54%) accounted for the largest percentage of the PBL treatment group followed by *nearing proficiency* (n = 16, 27%), *step 1* (n = 7, 12%), and *proficient* (n = 4, 7%). For the supervised study treatment group, the largest percentage was represented by students categorized as *nearing proficiency* (n = 18, 39%) followed by *progressing* (n = 14, 30%), *proficient* (n = 7, 15%), *step 1* (n = 6, 13%), and *advanced* (n = 1, 2%).

Objective Two

Describe the critical thinking ability of students before and after instruction in a quail management unit.

The Watson-Glaser Critical Thinking Appraisal® (WGCTA®) was used to measure the critical thinking ability of students and was administered before (pre-test) and after (post-test) instruction of the quail management unit. Pre-test and post-test critical thinking scores were summarized for the 12 intact classrooms that participated in the study (Table 12). The mean scores on the WGCTA® pre-test for classrooms in the PBL treatment group ranged from 20.0 to 21.2. Means score on the WGCTA® pre-test were similar for the classrooms in the supervised study treatment group and ranged from 18.8 to 22.7. Scores for schools in each of the treatment groups were similar on the post-test administration of the WGCTA®. Post-test means for schools in the PBL treatment group ranged from 19.1 to 23.8. In the supervised study treatment group, the post-test means ranged from 19.3 to 24.9.

Table 12

Comparison of Pre-test and Post-test Critical Thinking Scores by Classroom

			Pre-Test			Post-Test		
Treatment	School	*n*	*M*	*SD*	Min-Max	*M*	*SD*	Min-Max
Problem-Based Learning (*n*=77)	1	12	20.33	3.77	15-27	20.83	4.57	14-30
	2	12	21.17	2.92	16-25	23.75	4.00	17-33
	3	8	20.75	3.54	17-26	19.62	3.74	13-25
	4	11	20.82	3.34	17-27	19.09	4.46	10-27
	5	20	22.65	5.11	15-37	21.10	5.05	15-33
	6	14	20.00	5.42	11-33	22.25	4.94	16-33
Supervised Study (*n*=63)	1	13	22.69	5.76	13-34	24.85	3.80	19-32
	2	7	20.86	5.61	13-30	20.57	1.51	18-23
	3	12	21.92	4.36	17-31	23.00	3.88	17-28
	4	11	20.36	3.14	13-24	19.27	2.65	14-22
	5	14	22.00	4.74	14-34	20.43	4.60	13-28
	6	6	18.83	5.27	11-24	19.83	3.49	16-25

Note. Maximum possible score = 40.

WGCTA® summary statistics were calculated for each treatment group on the pre-test administration of the WGCTA® (Table 13). The average WGCTA® score for the PBL group (n = 77) was 21.1 (SD = 4.3). The minimum score for this group was 11 and the maximum score was 37 (range = 26). Students in the supervised study treatment group (n = 63) achieved an average WGCTA® score of 21.4 (*SD* = 4.7) with scores ranging from 11 to 34 (range = 23).

Table 13

A Comparison of WGCTA® Pre-Test Scores by Level of Treatment

Treatment	*n*	*M*	*SD*	Range
Problem-Based Learning	77	21.12	4.30	11-37
Supervised Study	63	21.42	4.73	11-34
Total	140	21.26	4.49	11-37

Post-test WGCTA® scores were reported by means, standard deviations, and ranges for the two treatment groups (Table 14). Students in the PBL treatment group (*n* = 77) achieved an average WGCTA® score of 21.2 (*SD* = 4.7) with scores ranging from 10 to 33 (range = 23). The average WGCTA® score for the supervised study treatment group (*n* = 63) was 21.6 (SD = 4.1). The minimum score for this group was 13 and the maximum score was 32 (range = 19).

Table 14

A Comparison of WGCTA® Post-Test Scores by Level of Treatment

Treatment	*n*	*M*	*SD*	Range
Problem-Based Learning	77	21.16	4.68	10-33
Supervised Study	63	21.64	4.06	13-32
Total	140	21.38	4.39	10-33

Objective Three

Describe the content knowledge of students before and after instruction in a quail management unit.

Content knowledge was determined by the score on a quail management test (Appendix B). The quail management test was administered before and after instruction in the quail management unit. The test was comprised of 50 selected response items and the score was determined by summating the number of correct items resulting in a possible score of 0 to 50. Pre-test and post-test content knowledge scores were summarized for the 12 intact classes (Table 15). Pre-test content knowledge mean scores for classrooms in the PBL treatment group ranged from 18.2 to 23.1. Classes in the supervised study treatment group had similar means scores ranging from 17.6 to 22.0. Differences were observed in the post-test scores of the two treatment groups. A broader range of scores was detected in the PBL treatment group as mean post-test scores ranged from 20.2 to 29.8. A similar pattern was detected in the supervised study treatment group as mean post-test scores by school ranged from 21.9 to 36.6.

Table 15

Comparison of Pre-test and Post-test Content Knowledge Scores by Classroom

			Pre-Test			Post-Test		
Treatment	School	*n*	*M*	*SD*	Min-Max	*M*	*SD*	Min-Max
Problem-Based Learning (*n*=77)	1	12	18.17	2.79	14-23	24.08	2.78	20-30
	2	12	23.08	3.34	18-28	29.75	5.66	22-36
	3	8	19.13	7.16	12-35	26.25	5.06	20-33
	4	11	20.91	2.26	18-25	26.27	4.27	20-34
	5	20	19.20	3.94	13-26	22.20	5.15	11-30
	6	14	20.50	4.62	14-31	20.21	7.92	8-34
Supervised Study (*n*=63)	1	13	21.08	4.65	10-27	34.92	4.39	26-42
	2	7	19.71	2.06	16-23	36.57	2.64	33-40
	3	12	22.00	4.77	14-30	28.17	5.18	17-35
	4	11	17.64	4.61	12-27	21.91	5.70	13-32
	5	14	22.00	3.37	16-28	27.54	4.93	22-36
	6	6	21.50	1.38	19-23	25.00	6.26	17-33

Note. Maximum possible score = 50

Table 16 displays a comparison of the treatment groups on the pre-test administration scores for content knowledge. Students in the PBL group (n = 77) correctly identified an average of 20.1 items (SD = 4.3) on the quail management test. Scores from this group had a range of 23 (min = 12, max = 35). The average score for students in the supervised study treatment group was 20.8 (SD = 4.1) with a range of 20 (min = 10, max = 30).

Table 16

A Comparison of Content Knowledge Pre-Test Scores by Level of Treatment

Treatment	*n*	Mean	Standard Deviation	Range
Problem-Based Learning	77	20.05	4.25	12-35
Supervised Study	63	20.81	4.14	10-30
Total	140	20.40	4.20	10-35

A summary of the data collected on the post-test administration of the quail management test is displayed in Table 17. Students in the PBL group (*n* = 77) scored an average of 24.2 (*SD* = 6.1) on the quail management post-test. The minimum score was 8 and the maximum score was 36 (range = 28). The average quail management test score for students in the supervised study treatment group (*n* = 63) was 29.0 (*SD* = 6.9). Scores ranged from 13 to 42 (range = 29).

Table 17

A Comparison of Content Knowledge Post-Test Scores by Level of Treatment

Treatment	*n*	Mean	Standard Deviation	Range
Problem-Based Learning	77	24.22	6.14	8-36
Supervised Study	63	29.02	6.87	13-42
Total	140	26.40	6.89	8-42

Objective Four

Compare the effect of instructional strategy (problem-based learning versus supervised study) with regard to secondary agriculture students' critical thinking ability and content knowledge.

Analysis of Covariance (ANCOVA) was used to test the null hypotheses of objective four. There are some key assumptions for using ANCOVA to test hypotheses. The most fundamental assumption is homogeneity of variance. Levene's test of equality of variance was used to determine that this assumption had been met. The null hypothesis stating that no difference existed in the error variance between treatment groups was tested for critical thinking ($F_{2, 105} = .21$, $p = .65$) and for content knowledge ($F_{2, 105} = 1.13$, $p = .29$). The differences of error variances were not significant for either variable; therefore, the null hypothesis was accepted meeting the assumption of homogeneity of variance.

Research Hypothesis One

Students taught using the problem-based learning instructional strategy will demonstrate a greater improvement in critical thinking than students taught using the supervised study instructional strategy.

The null hypothesis was: $H_0: \mu_{PBL} = \mu_{Supervised\ Study}$

The research hypothesis was: $H_1: \mu_{PBL} > \mu_{Supervised\ Study}$

The null hypothesis was tested using ANCOVA to control for critical thinking ability prior to instruction (pre-test WGCTA®) and for academic aptitude (MAP score) (Table 18). The *F*-value ($F_{2,105} = 10.96$) was significant ($p = .01$) at the alpha level of

.05, establish *a priori,* indicating that there was a difference in critical thinking between the level of treatment when controlling for critical thinking pre-test scores and MAP scores. The null hypothesis stating that no difference existed between groups on critical thinking scores was rejected. However, descriptive statistics (see Table 14) indicated that students in the supervised study group scored higher than students in the PBL group. Therefore, the findings did not support the research hypothesis and favored an alternative explanation.

Table 18

Analysis of Covariance (ANCOVA) in Critical Thinking by Instructional Strategy

Source	Sum of Squares	*df*	Mean Square	*F*	*p* - value
Instructional Strategy	505.05	3	168.35	10.96	.01*
MAP	139.24	1	139.24	9.06	.01*
Pre-test	134.98	1	134.98	8.79	.01*
Error	1351.94	105			

Note. Adjusted R Squared = .25
*$p < .05$

According to Keppel (1991), effect size provides a measure of the treatment magnitude. An effect size of .27 was determined for the effect of instructional strategy on critical thinking ability. According to Cohen (1977), an effect size greater than .15 is considered "large". Power indicates the sensitivity of an experiment. Keppel (1991) describes power as the probability of replicating an experiment with the same findings and is largely affected by sample size. The power for this comparison was .99.

Research Hypothesis Two

A significant difference exists in content knowledge for students taught using the problem-based learning instructional strategy and students taught using the supervised study strategy.

The null hypothesis was: $H_0: \mu_{PBL} = \mu_{\text{Supervised Study}}$

The research hypothesis was: $H_1: \mu_{PBL} \neq \mu_{\text{Supervised Study}}$

ANCOVA was used to test the null hypothesis that there was no significant difference in content knowledge between groups when controlling for pre-existing knowledge (quail management pre-test) and academic aptitude (MAP score) (Table 19). The ANCOVA resulted in an *F*-value ($F_{2,105} = 14.74$) for content knowledge that was significant ($p = .01$) at the alpha .05 level. The null hypothesis was rejected in favor of the research hypothesis that, there was a difference between groups on content knowledge scores when controlling for pre-test content knowledge scores and MAP scores. Students taught using supervised study scored higher on content knowledge than students taught using PBL. The effect size (.43) was large (Cohen, 1977), with a power of 1.0.

Table 19

Analysis of Covariance (ANCOVA) in Content knowledge by Instructional Strategy

Source	Sum of Squares	*df*	Mean Square	*F*	*p* - value
Instructional Strategy	1315.99	3	438.66	14.74	.01*
MAP	429.37	1	429.37	14.42	.01*
Pre-test	90.11	1	90.11	3.03	.01*
Error	2678.45	105			

Note. Adjusted R Squared = .31
*p<.05

Objective Five

Describe the relationship between critical thinking ability and content knowledge.

A Pearson product-moment correlation was calculated to determine the relationship between content knowledge and critical thinking ability (Table 20). Content knowledge was determined by the score on the post-test administration of the quail management test and critical thinking ability was determined by the score on the post-test administration of the WGCTA®. The correlation coefficients between content knowledge and critical thinking ability for both groups (r_{PBL}=.23, r_{SS}=.29) was found to be positive and low (Davis, 1971). Additionally, the overall correlation coefficient (r_{sample}=.26) was also found to be positive and low (Davis, 1971).

Table 20

Pearson Product-Moment Correlations Between Content Knowledge and Critical Thinking Ability

Variable	Content Knowledge	*p* - value
Critical Thinking Ability		
PBL Group (*n*=77)	.23	.05
Supervised Study Group (*n*=63)	.29	.02*
Total (*n*=140)	.26	.01*

*p<.05

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Purpose of the Study

The purpose of this study was to determine the effect of problem-based learning (PBL) on critical thinking ability and content knowledge. Furthermore, this study examined the relationship between critical thinking ability and content knowledge among selected secondary agriculture students in Missouri. The following research objectives and hypotheses were generated to focus and guide the direction of the study.

Research Objectives and Hypotheses

1. Describe subjects on gender, grade classification, and academic aptitude (7th grade science MAP index).

2. Describe the critical thinking ability of students before and after instruction in a quail management unit.

3. Describe the content knowledge of students before and after instruction in a quail management unit.

4. Compare the effect of instructional strategy (problem-based learning versus supervised study) with regard to secondary agriculture students' critical thinking ability and content knowledge.

   H_1: Students taught using the problem-based learning instructional strategy will demonstrate a greater improvement in critical thinking than students taught using the supervised study instructional strategy.

   H_2: A significant difference exists in content knowledge for students taught using the problem-based learning instructional strategy and students taught using the supervised study strategy.

5. Describe the relationships between critical thinking ability and content knowledge.

Limitations of the Study

Participants in the study were selected by the qualifying characteristics of the instructor and remained in intact classroom groups. While groups were randomly assigned to a level of the treatment, the design of the study lacked random selection. The sample in the study approximates the target population; however, caution should be used when generalizing beyond participants of the study. The sample was limited to students of selected agriculture teachers. Cost and time prohibited the study of a larger sample.

Design of the Study

The study employed a quasi-experimental, non-equivalent comparison group design. Internal threats to validity were more easily examined in this design because of the pre-test and a comparison group. The pre-test served as a mechanism to evaluate the possibility of selection bias resulting from the naturally occurring, intact classroom groups. Random assignment determined the level of treatment for the groups.

Population and Sample

The target population for this study was identified as secondary agriculture students in Missouri. Subjects in the study were part of a purposive sample. Selection was determined by criteria of the instructors. Twelve teachers were selected based on characteristics of their teacher preparation program. Each teacher was randomly assigned to a level of the treatment (problem-based learning or supervised study). Subjects were part of the intact classroom groups of each of the selected teachers. The resulting sample (n = 140) consisted of 77 students in the PBL treatment group and 63 students in the supervised study treatment group.

Instrumentation

Three data collection instruments were used for this study. Critical thinking ability was operationalized as a score on the Watson-Glaser Critical Thinking Appraisal® (WGCTA®)(Form S). Content knowledge was determined by scores on a quail management test at different points of administration. Finally, descriptive information (gender, grade level, 7th grade science MAP index) on subjects was reported by the teacher on the score report form.

The Watson-Glaser Critical Thinking Appraisal® (WGCTA®) was designed to measure critical thinking as a composite of attitudes, knowledge, and skills. Form S was used for this study as it is approved for secondary students and can be completed in approximately 45 minutes. The WGCTA® provided an estimate of an individual's standing in the composite of ability sub-tests: inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. The WGCTA® included exercises which are purported to be examples of problems, statements, arguments and interpretations of data which are regularly encountered at work as well as at school and in other activities. A raw score is determined from a composite of the five sub-tests and possible scores range from 0 to 40.

Content knowledge was determined by a score for participants on the post-test administration of the quail management test. This test was developed in conjunction with the original instructional unit. The test consisted of 50 selected response items related to four unit objectives. The score was determined by the number of correct responses on the test. Possible scores ranged from 0 to 50.

Descriptive data for students in each of the classes were collected on the score report form. Teachers were asked to record these data (gender, classification, and 7th grade science MAP index) in the appropriate field of a researcher generated report form. The report form was returned to the researcher at the conclusion of the unit.

Data Collection

The pre-test version of both the WGCTA® and the quail management test were administered prior to the instruction on the quail management unit. The pre-test answer documents for the WGCTA® were returned in a self-addressed, stamped envelope. At the conclusions of the unit, the post-test versions of both the WGCTA® and the quail management test were administered. Teachers were provided with a reporting form to report scores on the content knowledge assessment to the researcher. Both administrations of the quail management test were scored by the instructor and recorded on the Score Report Form. The answer forms for the WGCTA® were returned to the instructor for scoring. Teachers provided descriptive information for each of their students. Additional descriptive information (gender, classification, and 7th grade science MAP score) was reported on the Score Report Form. The score report form, the post-test WGCTA® answer documents, and the WGCTA® test booklets were picked up on site by the researcher at the conclusion of the unit.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 12.0 computer program for windows. Objectives one, two and three were completed using descriptive statistics. Measures of central tendency and measures of variability were reported. Frequency counts and percents were used to describe categorical data. Mean scores, standard deviations and ranges were generated to describe continuous data.

The fourth research objective contained two research hypotheses. An Analysis of Covariance (ANCOVA) was conducted to test the null hypotheses. ANCOVA techniques were employed to determine differences in critical thinking scores and content knowledge scores between the levels of the treatment when controlling for pre-test scores and academic aptitude (MAP score).

To complete research objective five, Pearson product-moment correlations were calculated between critical thinking ability and content knowledge. Correlation coefficients were reported between critical thinking and content knowledge for each level of the treatment as well as the complete sample.

Summary of Findings

Objective One

Seventy-seven students completed the problem-based learning (PBL) treatment. A majority (44, 58%) were male and 32 (42%) were female. In the supervised study treatment group (n = 63), 47 students (73%) were male and 17 (27%) were female. In total (n = 140), 91 students (65%) were male and 49 students (35%) were female.

In the study (n = 140), a majority of the students (79, 56%) were classified as sophomores and 23 (16%) were seniors. The remainder of the sample consisted of 21 freshmen (15%) and 17 juniors (12%). Sophomores made up 61% (47) of the PBL treatment group and 51% (32) of the supervised study treatment group. The PBL group was additionally comprised of 14 seniors (18 %), 10 freshmen (13%), and 6 juniors (8%). The supervised study treatment group was represented by 11 freshmen (18%), 11 juniors (18%), and 9 seniors (14%).

The mean MAP score for the PBL treatment group (n = 59) was 683.3 (SD = 23.1). MAP scores from this group range from 625-733 (range = 108). For students in the supervised study treatment group (n = 45), the mean MAP score was 691.7 (SD = 28.6). Scores in this group ranged from 610 to 752 (range = 142). The mean MAP score for the sample (n = 105) was 686.5 (SD = 25.5).

The Missouri Department of Elementary and Secondary Education (DESE) reports MAP scores by achievement level. Scale scores were divided into five categories of achievement. Almost half (44%, n = 46) of the students in the sample were in the *progressing* category. Thirty two percent (n = 34) of the sample was categorized as nearing proficiency. The remainder of the sample consisted of *step 1* (n = 13, 12%), *proficient* (n = 11, 11%), and *advanced* (n = 1, 1%).

Objective Two

The average WGCTA® score on the pre-test administration for the PBL treatment group (n = 77) was 21.1 (SD = 4.3). The minimum score for this group was 11 and the maximum score was 37 (range = 26). Students in the supervised study treatment group

(n = 63) achieved an average pre-test WGCTA® score of 21.4 (SD = 4.7) with scores ranging from 11 to 34 (range = 23).

Results from the post-test administration of the WGCTA® indicated that students in the PBL treatment group (n = 77) achieved an average WGCTA® score of 21.2 (SD = 4.68) with scores ranging from 10 to 33 (range = 23). The average WGCTA® score on the post-test administration for the supervised study treatment group (n = 63) was 21.6 (SD = 4.1). The minimum score for this group was 13 and the maximum score was 32 (range = 19).

Objective Three

Students in the PBL treatment group (n = 77) correctly identified an average of 20.1 items (SD = 4.25) on the pre-test administration of the content knowledge assessment with a range of 23 (min = 12, max = 35). The average pre-test content knowledge score for students in the supervised study treatment group was 20.81 (SD = 4.1). The minimum score was 10 and the maximum score was 30 (range = 20).

Students in the PBL group (n = 77) scored an average of 24.2 (SD = 6.1) on the quail management post-test. The minimum score was 8 and the maximum score was 36 (range = 28). The average quail management post-test score for students in the supervised study treatment group (n = 63) was 29.0 (SD = 6.9). Scores ranged from 13 to 42 (range = 29).

Objective Four

Levene's test of equality of variance indicated that there was no significant difference in the variance of critical thinking score and content knowledge score between the two treatment groups. Analysis of covariance (ANCOVA) indicated there was a significant difference in critical thinking scores ($F_{2,105} = 10.96$, $p_{.05} = .01$) between treatment groups when controlling for critical thinking ability prior to instruction (pre-test WGCTA®) and for academic aptitude (MAP score). A large (Cohen, 1977) effect size (.27) was determined. The null hypothesis stating that no difference existed between groups on critical thinking scores was rejected. However, descriptive statistics indicated that students in the supervised study treatment group scored higher than students in the PBL treatment group. Therefore, the findings did not support the research hypothesis and favored an alternative explanation.

ANCOVA procedures detected a significant difference in content knowledge score ($F_{2,105} = 14.74$, $p_{.05} = .01$) between treatment groups when controlling for pre-existing knowledge (quail management pre-test) and academic aptitude (MAP score). The effect size (.43) was large (Cohen, 1977). The null hypothesis was rejected in favor of the research hypothesis that there is a difference between groups on content knowledge scores when controlling for pre-test content knowledge scores and MAP scores. Students taught using supervised study scored higher on content knowledge than students taught using PBL.

Objective Five

The correlation coefficients between content knowledge and critical thinking ability for both groups ($r_{\text{PBL}} = .22$, $r_{\text{SS}} = .29$) was found to be low (Davis, 1971) and positive. Additionally, for the sample, the correlation coefficient ($r_{\text{sample}} = .26$) was also found to be low (Davis, 1971) and positive.

Conclusions and Implications

Conclusions: Objective One

Participants in this study were typically male, classified as sophomores, and were at the *proficient* level of achievement based on state-wide standardized assessment scores. Thirty five percent of participants were female and 65% were male. Data from the Missouri Department of Elementary and Secondary Education (DESE, 2005) indicate approximately 30% of students enrolled in secondary agriculture classes for 2003-04 were female and 70% were male. Therefore, it can be concluded that the sample is representative of the gender distribution of secondary agriculture students in Missouri.

Approximately 44% of the sample was categorized as *nearing proficiency* or higher according to state MAP achievement level classifications in science. The remaining 56% fell into a lower category. This is similar to state-wide figures reported by DESE (2005) (see Appendix T). In the 2004 school, approximately 40% of 7^{th} grade students in Missouri were classified as *nearing proficiency* or higher. Reports for 2002 reported 41% of students state-wide were classified as *nearing proficiency* or higher. It was concluded that students in this study performed at a similar level of achievement as students across the state of Missouri with regard to the science portion of the Missouri Assessment Program (MAP).

Implications: Objective One

Our current educational climate reflects the value placed on standardized testing. Elective programs, such as agricultural education, must justify their contribution to student performance on core subjects. It is reassuring to know secondary agriculture students in Missouri appear to be performing at the level of students state-wide on the science portion of the MAP. This information may be valuable to agriculture programs at the secondary level as they struggle with issues of accountability.

Conclusions: Objective Two

While there were no normative data available for secondary students, the WGCTA® Manual (1994) provides normative data for 17 various occupations spanning upper-level management positions to railroad dispatchers. Members of the clergy had the highest group mean (34.6) and railroad dispatchers had the lowest (25.2). Critical thinking mean scores on the WGCTA® for both levels of the treatment (problem-based learning and supervised study) were low. The mean for the sample on both pre-test and post-test were below 22. Participants did not score as high as other normative groups on the WGCTA®. Additionally, there was little difference in the pre-test and post-test scores on critical thinking ability. Therefore, it was concluded that critical thinking ability did not change as a result of instruction in the quail management unit.

Implications: Objective Two

The WGCTA® instrument was originally developed to predict occupational performance in adults and has since been recommended for use on subjects as young as 9^{th} grade and has been used in a variety of educational settings (Watson & Glaser, 1994). Helmstadter (1985) noted a logical progression of mean scores for successive age groups on the WTGCA®. The low critical thinking scores of secondary students found in this study support the argument that there may be a developmental component to critical thinking. The lack of change between pre-test and post-test administrations may be attributed to a combination of functions. It is likely that the relatively short duration of the treatment was not sufficient to detect any differences that can be attributed to the levels of the treatment. It is possible that extending the length of treatment may yield different results.

Conclusions: Objective Three

Pre-test scores on content knowledge were similar between groups. It can be concluded from these findings that the two groups were similar in pre-existing content knowledge. Although intuitive, the gain in content knowledge score observed in both levels of treatment indicates that content knowledge increased as a result of instruction.

Implications: Objective Three

Findings on content knowledge suggest that supervised study is a more efficient strategy for increasing content knowledge. However, some discrimination should be used in interpreting these findings. The content knowledge assessment used for data collection consisted of knowledge and comprehension level items (Bloom, et al., 1956). Supervised study may not be the most efficient method for accomplishing educational objectives written and assessed at higher levels of cognition, such as analysis, synthesis, and evaluation.

Conclusions: Objective Four

Statistical procedures indicated a difference between levels of the treatment on critical thinking ability when controlling for pre-test critical thinking scores and academic aptitude. However, post-test means between the treatment groups differed only by .2. Therefore, it was concluded that there is no practical difference between treatments on critical thinking ability. These findings contrast previous studies (Albanese and Mitchell, 1993; Hmelo, 1998) that concluded students in PBL courses outperformed traditional students in problem-solving ability, a component of critical thinking.

Furthermore, from a practical standpoint, students scored the same on the WGCTA® after instruction as they did before instruction indicating that neither treatment had an effect on critical thinking ability. This contradicts Lundy, et al. (2002), who concluded critical thinking skills could be acquired by utilizing critical thinking instructional techniques. An even more direct contrast exists between findings from this study and Burbach, Matkin, & Fritz (2004). They concluded that instructional strategy resulted in improved critical thinking skills as defined by the Watson-Glaser Critical Thinking Appraisal®.

From the findings related to content knowledge, it can be concluded that students in the supervised study treatment tended to score higher on content knowledge assessments than students in the PBL treatment. Students receiving the supervised study treatment scored an average of almost 9 points greater than their pretest scores on content knowledge and an average of almost 5 points greater than students in the PBL treatment. Students in the PBL treatment exhibited an improvement of slightly more than 4 points on pre-test scores. These findings are consistent with other studies that found PBL students did not perform as well on knowledge exams (Albanese & Mitchell, 1993; Vernon & Blake, 1993).

Implications: Objective Four

The static critical thinking scores observed in this study present some concern for how critical thinking is operationalized and measured. There is general agreement in the literature that critical thinking cannot be narrowly defined. Many regard the concept of critical thinking as a combination of processes and skills (Bailin, et al., 1999; Burden & Byrd, 1994; Pascarella & Terenzini, 1991; Watson & Glaser, 1994). However, it is possible that the WGCTA® (Form S) is only capturing a portion of the concept of critical thinking as suggested by Berger (1985). Measures of problem-solving ability may be more appropriate for detecting the impact of instructional strategies.

This study focused on a single unit of instruction implemented over a two-week time period. Most likely, discrepancies between the current study and prior studies that found instructional strategy to effectively increase critical thinking ability (Lundy et al., 2002; Mabie & Baker, 1996; Burbach, Matkin, & Fritz, 2004; Elliot, Oty, McArthur, & Clark, 2001) can be explained by the relative short treatment length of this study. Treatment lengths in those studies ranged from 10 to 16 weeks. It is likely that the relatively short duration of the treatment was not sufficient to detect any differences caused by that treatment. It is conceivable that extending the length of treatment may yield different results.

Differences found in content knowledge have implications as well. Alternative types of assessment may be necessary to evaluate learning from more student-centered approaches to learning. Dods (1997) concluded that more traditional approaches to instruction promoted content coverage. While PBL students may have a deeper understanding of the material, that understanding is not represented at a content knowledge level.

Treatment lengths were equal between groups for this study, yet a significant difference in content knowledge was found. Gains recorded for the supervised study treatment level were almost twice as much as gains in the PBL treatment level. A portion of this difference can possibly be attributed to the lack of familiarity students had for the PBL strategy of instruction. The history of problem-solving in agricultural education is well established, but the use of Problem-based Learning is a relatively new approach in this discipline. Students in the PBL classes may have experienced some discomfort in adjusting to a new strategy for instruction. Ryan and Millspaugh (2004), in their model of PBL, described step 1 of instruction as a description of why PBL is used. It can be argued that some time on task was lost due to learning an unfamiliar process. Extended exposure to the treatment may offset this learning process and better detect effects on student outcomes.

Conclusions: Objective Five

The findings in this study indicated a low, positive relationship between critical thinking and content knowledge. This low relationship is consistent with the static nature of critical thinking scores among the treatment groups in this study. It can be concluded from these findings that students can demonstrate a gain in content knowledge without indicating an increase in critical thinking ability. In fact, assessment at the elementary and secondary levels is most often developed at lower levels of thinking (Ball, 2002).

Implications: Objective Five

Common goals of education are to improve content knowledge and increase critical thinking ability of students. The low correlation between the two suggests that planning instruction with one goal in mind does not automatically address the other. Strategies efficient at achieving one goal may not lend themselves to the other.

Recommendations

Recommendation One:

When categorizing science MAP scores into achievement levels, findings from this study were similar to data reported for all Missouri students. The relatively low number of students performing at the *proficient level* or above is alarming. Further investigation is necessary to determine effective methods for teaching to meet state standards. Additionally, the contribution of agricultural programs related to standardized testing should be investigated.

Recommendation Two:

Findings from this study indicated that instructional strategy had an effect on content knowledge. Do these strategies have similar effects on other student outcome variables? Research is warranted to determine the effects of instructional strategy on performance and knowledge retention.

Recommendation Three:

Teachers must continue to recognize the importance of critical thinking. However, teachers need to take stronger actions with their classes to develop critical thinking. This includes incorporating innovative practices that promote deeper understanding of content in an authentic context. Teacher education programs need to continue their efforts in preparing teachers to be proficient in their use of these innovative teaching techniques.

Recommendation Four:

This study was limited by the amount of time provided for each treatment. This study should be replicated with an increased treatment period. Further investigation may provide insight into the effects that instructional strategies can have on student outcomes over a longer duration. The development of additional teaching materials to be used as part of the PBL strategy that can be used in conjunction with the quail management unit will help lengthen the amount of the treatment period.

Recommendation Five:

There is much confusion over what exactly constitutes critical thinking. Researchers have used a common term to refer to a variety of phenomena. More investigation is needed to determine the differences between problem solving, higher-order thinking, and critical thinking. Additionally, instrumentation designed to distinguish these concepts should be developed and identified.

APPENDIX A

ADMINSTRATOR CONSENT FORM

Dear <<Administrator>>:

Your agriculture teacher, <<Teacher's Name>>, has been selected to participate in an important study of the effectiveness of teaching strategies. <<Teacher's Name>>has agreed to teach an instructional unit using one of two randomly assigned teaching methods.

The unit of instruction will be the quail management unit developed by the Missouri Department of Conservation and approved by DESE for secondary agriculture classes. The only manipulation is the strategies used to teach the content.

Data will be collected on your students in three forms; a unit test on quail management, the Watson-Glaser Critical Thinking Appraisal (WGCTA), a standardized instrument used to measure students' ability to think critically and solve problems, and the MAP score for 7th grade science. In all cases, the information will be collected by <<Teacher's Name>>and student identification will be kept anonymous. I will never have access to the identity of the students participating. In addition, data collected from your school will be kept confidential and individual school data will not be reported. In addition to your school, there are 11 other schools participating in this study. The findings from this study will be submitted for publication in research type journals. Only aggregate information will be reported in that manuscript.

<<Teacher's Name>>will be provided with all necessary instructional materials needed to teach the quail management unit. The entire process should take approximately two weeks. Your program will benefit by receiving current curriculum related to the conservation of wildlife. Additionally, <<Teacher's Name>>will have an opportunity to develop additional strategies for classroom instruction. The results from this study will help teacher educators plan a more effective program of study for perspective teachers.

Participation in this study is completely voluntary. Consent or refusal to participate in this study will in no way affect your school's relationship with the University of Missouri. For more information concerning the rights of research participants, please contact the MU Campus Institutional Review Board by phone at 573/882-9585 or by mail at 483 McReynolds, University of Missouri, Columbia, MO 65211.

Respectfully,

Scott Burris
Ph.D. Candidate, Research Assistant

Bryan L. Garton
Associate Professor and Chair

Please sign below to indicate your consent for the participation of your school and agriculture program in this study. Return this form in the enclosed self-addressed, stamped envelope.

____
(signature)

APPENDIX B

QUAIL MANAGEMENT TEST

Unit Exam

Unit: Managing Land for Bobwhite Quail

Directions: For each of the following questions, **circle** the best answer.

1. Which of the following would be beneficial to the future of quail habitat?

    a. Intensive use of land for crop and livestock production.
    b. Loss of land to a growing population.
    c. Increasing weedy vegetation.
    d. Loss of brushy cover due to natural succession.

2. Each year, as much as ________________ percent of the quail population dies from predators, weather, disease, maturity, or harvest.

    a. 10
    b. 40
    c. 70
    d. 90

3. Quail are highly productive and can easily increase in population because:

    a. Hens lay small clutches of eggs.
    b. Hens quickly start a second or third nest if initial nests are destroyed.
    c. Hens stay with their chosen mate for the entire breeding season.
    d. Hens stay with their broods until they are mature and ready to breed.

4. Early settlers increased quail habitat through which practices?

    a. Planting small fields.
    b. Using more pesticides.
    c. Eliminating hedgerows.
    d. Taking down fences.

5. A single nesting cycle requires about ____________days.

    a. 15
    b. 30
    c. 45
    d. 60

6. In a typical year, over half of the quail deaths are a result of ______________.

    a. hunting
    b. predators
    c. maturity
    d. disease

7. Which of the following wildlife can have a positive impact on quail?

    a. Skunks
    b. Deer
    c. Cotton Rats
    d. Red-tailed hawks

8. An adult quail covering its young chicks with its body or wings is _________.

a. nesting
b. brooding
c. roosting
d. dusting

9. A covey of quail that gathers together from dusk to dawn is _____________.

a. nesting
b. brooding
c. roosting
d. dusting

10. Quail throw finely ground soil across their backs with their beaks and feet during an activity called ____________________.

a. nesting
b. calling
c. roosting
d. dusting

11. The lifecycle period when quail incubate their eggs is ______________.

a. Nesting
b. Brooding
c. Roosting
d. Dusting

12. Which of the following would make the best escape cover for quail?

a. A fescue pasture.
b. Native warm season grasses.
c. Recently disked field with annual weeds.
d. Forest edge containing a variety of brushy plants.

13. Tall-fescue pastures can be managed for quail by __________________.

a. eliminating and controlling the growth of shrubs.
b. mowing frequently to remove excess growth.
c. preventing heavy grazing.
d. disking to allow native plants to grow.

14. Crop fields can be improved for quail habitat by:

a. Applying less herbicide.
b. Eliminating buffer strips.
c. Double-cropping soybeans after winter wheat is harvested.
d. Planting rows up and down the slope.

15. Quail-friendly improvements to CRP land could include:

a. Plant a fescue monoculture; disk; burn; use herbicides.
b. Promote a diversity of plants; disk; burn; use no herbicides.

c. Promote a diversity of plants; burn; don't disk or use herbicides.
d. Promote a diversity of plants; disk; burn; use herbicides.

16. Which steps are best for improving grasslands for quail habitat?

 a. Reduce fescue, leave strips of unmowed grass, graze and over-seed.
 b. Reduce fescue, remove shrubs and woody plants, and disk lightly.
 c. Reduce fescue, over-seeding with diverse plants, and remove fences.
 d. All will improve quail habitat.

17. Why is predator control not considered a cost effective way to increase quail numbers?

 a. Predator control in many cases is illegal.
 b. There are too few trappers.
 c. There are too many predators.
 d. We don't know enough about animals that prey on quail.

18. In what month should whistle counts be conducted for pre-season evaluation?

 a. January
 b. June
 c. October
 d. December

19. Which of the following is not essential for quail to reproduce at a high rate?

 a. Abundant nesting habitat
 b. Low predator numbers
 c. Mild spring and summer weather
 d. Abundant brood-rearing habitat

20. In what month should whistle counts be conducted for evaluation the population of breeding birds?

 a. January
 b. June
 c. October
 d. December

21. In the winter, quail need high __________________ feed.

 a. protein
 b. energy
 c. fat
 d. calcium

22. In the spring, quail need high__________________ feed.

 a. protein
 b. energy
 c. fat
 d. calcium

23. Which if the following best describe when Quail eat?

a. Daylight
b. Daylight and noon
c. Daylight and mid-afternoon
d. Daylight and Dusk

24. What factor has the greatest impact on quail population numbers?

a. Habitat
b. Weather
c. Hunting
d. Urbanization

25. Disking pastures and other ground helps quail by:

a. Improving plant diversity.
b. Thinning grass stands.
c. Allowing more native annual weeds to grow.
d. All the above.

26. A control burn can improve quail habitat by ____________________.

a. decreasing seed production of grasses
b. increasing seed production of legumes and wildflowers
c. decreasing the amount of bare ground
d. eliminating Predators

27. Pen raised quail do not survive in the wild because they ________________________.

a. have different habitat needs than live quail
b. are less susceptible to predators
c. lack survival skills
d. cannot fly

28. The best method for increasing quail population is ________________________.

a. managing habitat
b. reducing bag limits
c. stocking and relocating
d. artificial feeding

29. Which of the following statements most accurately reflect quail population trends?

a. Quail populations have steadily declined since Missouri was first settled.
b. After Missouri was settled, quail populations dramatically increased before declining in more recent years.
c. Quail populations have steadily increased since Missouri was first settled.
d. After Missouri was settled, quail populations decreased and are now rebounding as a result of current agricultural practices.

30. Common habitat management practices include all of the following except ________________________.

a. using herbicide
b. protection from burning
c. disking
d. planting diverse plants.

31. Incubation of quail eggs takes __________ days.

a. 12
b. 23
c. 34
d. 45

32. _________________ is the last resort for quail as a way to escape danger.

a. Freezing
b. Running
c. Flying
d. Walking

33. What inventories of current conditions should be conducted when evaluating your land's potential for quail?

a. Nature and distribution of vegetation.
b. Quality of habitat on neighboring lands.
c. Number of birds to be taken for harvest.
d. Number of location of existing coveys.

34. Which of the following inventory methods is actually a measure of hunting ability?

a. Whistle counts
b. Observation
c. Harvesting
d. Encounter rates

35. Quail nest ________________ for warmth and protection.

a. in a linear pattern
b. in a disk shape
c. in pairs
d. individually

36. Most of the food that quail eat is ____________________.

a. buried in the soil
b. protected by dead vegetation
c. near the surface of the ground
d. at least 24" from the ground

37. In the spring, insects make up _______ % of an adult quail's diet.

a. 2
b. 15

c. 50
d. 95

38. A typical clutch size for quail is __________ eggs.

a. 2 to 8
b. 5 to 10
c. 10 to 20
d. 15 to 40

39. Quail feed _________time(s) a day.

a. one
b. two
c. three
d. four

40. Typically, ________________ of the quail eggs laid will not hatch.

a. almost none
b. less than one fourth
c. about half
d. almost all

41. The ability of quail populations to withstand harvest pressure depends upon the______.

a. extent of the harvest pressure
b. quality of the habitat
c. severity of weather conditions
d. all of the above

42. Having additional body fat will allow quail to ___________________.

a. live a few days without food
b. die more quickly of hypothermia
c. run faster from predators
d. fly for longer distances

43. Dusting ____________.

a. keeps quail warm in cold temperatures
b. camouflages quail from predators
c. reduces insect parasites
d. attracts partners for mating

44. Each of the following provide good nesting cover except ____________.

a. a monolithic stand of thick grass
b. a mix of grasses forbs and shrubs
c. no-till row crops
d. moderately grazed native pastures

45. Which of the following make the best nesting cover for quail?

a. A fescue pasture.
b. Mix of erect grass, forbs, and scattered shrubs.
c. Recently disked field with annual weeds.
d. Forest edge containing a variety of brushy plants.

46. The nesting season for quail is from ________________________.

a. April to September
b. October to April
c. January to June
d. July to December

47. The major seasonal activity of quail in the winter (October – April) is ____________.

a. pair-bonds
b. nesting
c. brooding
d. escape and protection

48. ___________ is not good quail habitat because of its dense growth.

a. Lespedeza
b. Corn
c. Fescue
d. Blackberry

49. Small clear-cuts in ______________ can positively affect quail populations.

a. crop fields
b. grasslands
c. fencerows
d. forests

50. Which of the following is not a significant predator of quail?

a. Striped skunk
b. Wild turkey
c. Cooper's hawks
d. Black rat snake

APPENDIX C

DIRECTIONS FOR ADMINISTERING QUAIL MANAGEMENT PRE-TEST

DIRECTIONS FOR ADMINISTERING QUAIL MANAGEMENT PRE-TEST

Preparation

Each student will need:

- 1 test
- Pen or pencil

Answering Questions

Specific questions about the test should be answered by telling the students to:

- Reread the directions
- Do their best

Directions (read the shaded areas)

When all students have been seated, give each examinee two pencils.

Say **We are about to begin a unit related to wildlife conservation. The test you are about to take is designed to see how much you already know about the subject. Some of the questions may seem difficult. It is OK to guess but do not feel bad if you do not know an answer. This WILL NOT be part of your grade but it is important that you do your best. Are there any questions?**

Answer any questions.

Say **After you receive the test, you will have 45 minutes to work on it. Do not begin until I tell you to.**

Distribute the tests.

Say **Ready? … Begin.**

Immediately start your timing procedure. If any of the students finish before the end of the test period, either tell them to sit quietly until everyone has finished or collect their materials and dismiss them quietly. At the end of 45 minutes,

Say **Stop! Put your pencils down. This is the end of the test.**

Concluding Administration

Collect all tests. Use the test key to determine the number of correct answers. Record the number of correct answers on the data report form. DO NOT RETURN THE PRETEST TO THE STUDENTS.

APPENDIX D

DIRECTIONS FOR ADMINISTERING QUAIL MANAGEMENT POST-TEST

DIRECTIONS FOR ADMINISTERING
QUAIL MANAGEMENT POST-TEST

Preparation

Each student will need:

- 1 test
- Pen or pencil

Answering Questions

Specific questions about the test should be answered by telling the students to:

- Reread the directions
- Do their best

Directions (read the shaded areas)

When all students have been seated,

Say **Now that we have completed our unit on quail management, it is time to see what you know. The test you are about to take is designed to see how much you learned about the subject. You may remember some off the questions from the pre-test. You should be able to answer more questions now. It is important that you do your best. Are there any questions?**

Answer any questions.

Say **After you receive a test, you will have 45 minutes to work on it. Do not begin until I tell you to.**

Distribute the tests.

Say **Ready? … Begin.**

Immediately start your timing procedure. If any of the students finish before the end of the test period, either tell them to sit quietly until everyone has finished or collect their materials and dismiss them quietly. At the end of 45 minutes,

Say **Stop! Put your pencils down. This is the end of the test.**

Concluding Administration

Collect all tests. Use the test key to determine the number of correct answers. Record the number of correct answers on the data report form.

APPENDIX E

DIRECTIONS FOR ADMINISTERING WATSON-GLASER CRITICAL THINKING APPRAISAL

DIRECTIONS FOR ADMINISTERING
WATSON-GLASER CRITICAL THINKING APPRAISAL

Preparation

Each student will need:

- 1 test booklet
- 1 answer sheet
- 2 No. 2 pencils with erasers

Answering Questions

Specific questions about the sub-test should be answered by telling the students to:

- Reread the directions for the sub-test
- Do their best

Directions (read the shaded areas)

When all examinees have been seated, give each examinee two pencils. Then distribute the answer sheets.

Say **Please make sure that you do not fold, tear, or otherwise damage the answer sheets in any way. Notice that your answer sheet has an example of how to properly blacken the circle.**

Point to the *"Correct Mark"* and *"Incorrect Marks"* samples on the answer sheet.

Say **Make sure that the circle is completely filled in as shown.**

Say **You will only fill in information in the boxes labeled B, E, F, G, H, and I. DO NOT fill in your name in box A.**

Say **In the box labeled B, fill in the identification number I have assigned to you. Blacken the appropriate circle under each digit.**

Say **Are there any questions?**

Answer any questions.

Say **After you receive a test booklet, please keep it closed. You will do all your writing on the answer sheet only. DO NOT MARK ON THE TEST BOOKLET. DO NOT make additional marks on the answer sheet until I tell you to do so.**

Distribute the test booklets.

Say **In this test, all the questions are in the test booklet. There are five separate tests in the booklet, and each one is preceded by its own directions. For each question, decide what you think is the best answer. Since your score will be the number of items you answered correctly, try to answer each question even if you are not sure that your answer is correct.**

Say **Record your choice by making a black mark in the appropriate space on the answer sheet. Always be sure that the answer space has the same number as the question in the booklet and that your marks stay within the circles. Do not make any other marks on the answer sheet. If you change your mind about an answer, be sure to erase the first mark completely.**

Say **Do not spend too much time on any one question. When you finish a page, go right on to the next one. If you finish all the tests before time is up, you may go back and check your answers.**

Say **You will have 45 minutes to work on this test. Now read the directions on the cover of your test booklet**

After allowing time for students to read the directions,

Say **Are there any questions about what you are to do?**

Answer any questions, preferable by rereading the appropriate section of the directions, then

Say **Ready? … Begin.**

Immediately start your timing procedure. If any of the students finish before the end of the test period, either tell them to sit quietly until everyone has finished or collect their materials and dismiss them quietly. At the end of 45 minutes,

Say **Stop! Put your pencils down. This is the end of the test.**

Concluding Administration

Collect all test booklets, answer sheets and pencils. Place the completed answer sheet in the pre-addressed stamped envelope and mail to:

Scott Burris
Dept. of Ag Education
110 Gentry Hall
Columbia, MO 65211-7040

APPENDIX F

QUAIL MANAGEMENT TEST KEY

Unit Exam (KEY)

Unit: Managing Land for Bobwhite Quail

Directions: For each of the following questions, **circle** the best answer.

1. Which of the following would be beneficial to the future of quail habitat?

    a. Intensive use of land for crop and livestock production.
    b. Loss of land to a growing population.
    c. Increasing weedy vegetation.
    d. Loss of brushy cover due to natural succession.

2. Each year, as much as ________________ percent of the quail population dies from predators, weather, disease, maturity, or harvest.

    a. 10
    b. 40
    c. 70
    d. 90

3. Quail are highly productive and can easily increase in population because:

    a. Hens lay small clutches of eggs.
    b. Hens quickly start a second or third nest if initial nests are destroyed.
    c. Hens stay with their chosen mate for the entire breeding season.
    d. Hens stay with their broods until they are mature and ready to breed.

4. Early settlers increased quail habitat through which practices?

    a. Planting small fields.
    b. Using more pesticides.
    c. Eliminating hedgerows.
    d. Taking down fences.

5. A single nesting cycle requires about ____________days.

    a. 15
    b. 30
    c. 45
    d. 60

6. In a typical year, over half of the quail deaths are a result of ______________.

    a. hunting
    b. predators
    c. maturity
    d. disease

7. Which of the following wildlife can have a positive impact on quail?

    a. Skunks
    b. Deer
    c. Cotton Rats
    d. Red-tailed hawks

8. An adult quail covering its young chicks with its body or wings is _________.

a. nesting
b. brooding
c. roosting
d. dusting

9. A covey of quail that gathers together from dusk to dawn is _____________.

a. nesting
b. brooding
c. roosting
d. dusting

10. Quail throw finely ground soil across their backs with their beaks and feet during an activity called ____________________.

a. nesting
b. calling
c. roosting
d. dusting

11. The lifecycle period when quail incubate their eggs is ______________.

a. nesting
b. brooding
c. roosting
d. dusting

12. Which of the following would make the best escape cover for quail?

a. A fescue pasture.
b. Native warm season grasses.
c. Recently disked field with annual weeds.
d. Forest edge containing a variety of brushy plants.

13. Tall-fescue pastures can be managed for quail by __________________.

a. eliminating and controlling the growth of shrubs.
b. mowing frequently to remove excess growth.
c. preventing heavy grazing.
d. disking to allow native plants to grow.

14. Crop fields can be improved for quail habitat by:

a. Applying less herbicide.
b. Eliminating buffer strips.
c. Double-cropping soybeans after winter wheat is harvested.
d. Planting rows up and down the slope.

15. Quail-friendly improvements to CRP land could include:

a. Plant a fescue monoculture; disk; burn; use herbicides.
b. Promote a diversity of plants; disk; burn; use no herbicides.

c. Promote a diversity of plants; burn; don't disk or use herbicides.
d. Promote a diversity of plants; disk; burn; use herbicides.

16. Which steps are best for improving grasslands for quail habitat?

    a. Reduce fescue, leave strips of unmowed grass, graze and over-seed.
    b. Reduce fescue, remove shrubs and woody plants, and disk lightly.
    c. Reduce fescue, over-seeding with diverse plants, and remove fences.
    d. All will improve quail habitat.

17. Why is predator control not considered a cost effective way to increase quail numbers?

    a. Predator control in many cases is illegal.
    b. There are too few trappers.
    c. There are too many predators.
    d. We don't know enough about animals that prey on quail.

18. In what month should whistle counts be conducted for pre-season evaluation?

    a. January
    b. June
    c. October
    d. December

19. Which of the following is not essential for quail to reproduce at a high rate?

    a. Abundant nesting habitat
    b. Low predator numbers
    c. Mild spring and summer weather
    d. Abundant brood-rearing habitat

20. In what month should whistle counts be conducted for evaluation the population of breeding birds?

    a. January
    b. June
    c. October
    d. December

21. In the winter, quail need high __________________ feed.

    a. protein
    b. energy
    c. fat
    d. calcium

22. In the spring, quail need high__________________ feed.

    a. protein
    b. energy
    c. fat
    d. calcium

23. Which if the following best describe when Quail eat?

a. Daylight
b. Daylight and noon
c. Daylight and mid-afternoon
d. Daylight and Dusk

24. What factor has the greatest impact on quail population numbers?

a. Habitat
b. Weather
c. Hunting
d. Urbanization

25. Disking pastures and other ground helps quail by:

a. Improving plant diversity.
b. Thinning grass stands.
c. Allowing more native annual weeds to grow.
d. All the above.
e.

26. A control burn can improve quail habitat by ___________________.

a. decreasing seed production of grasses
b. increasing seed production of legumes and wildflowers
c. decreasing the amount of bare ground
d. eliminating Predators

27. Pen raised quail do not survive in the wild because they _______________________.

a. have different habitat needs than live quail
b. are less susceptible to predators
c. lack survival skills
d. cannot fly

28. The best method for increasing quail population is _______________________.

a. managing habitat
b. reducing bag limits
c. stocking and relocating
d. artificial feeding

29. Which of the following statements most accurately reflect quail population trends?

a. Quail populations have steadily declined since Missouri was first settled.
b. After settlement, quail populations dramatically increased before declining in more recent years.
c. Quail populations have steadily increased since Missouri was first settled.

d. After settlement, quail populations decreased and are now rebounding as a result of current agricultural practices.

30. Common habitat management practices include all of the following except ________________________.

a. using herbicide
b. protection from burning
c. disking
d. planting diverse plants.

31. Incubation of quail eggs takes __________ days.

a. 12
b. 23
c. 34
d. 45

32. _________________ is the last resort for quail as a way to escape danger.

a. Freezing
b. Running
c. Flying
d. Walking

33. What inventories of current conditions should be conducted when evaluating your land's potential for quail?

a. Nature and distribution of vegetation.
b. Quality of habitat on neighboring lands.
c. Number of birds to be taken for harvest.
d. Number of location of existing coveys.

34. Which of the following inventory methods is actually a measure of hunting ability?

a. Whistle counts
b. Observation
c. Harvesting
d. Encounter rates

35. Quail nest ________________ for warmth and protection.

a. in a linear pattern
b. in a disk shape
c. in pairs
d. individually

36. Most of the food that quail eat is ____________________.

a. buried in the soil
b. protected by dead vegetation
c. near the surface of the ground
d. at least 24" from the ground

37. In the spring, insects make up _______ % of an adult quail's diet.

a. 2
b. 15
c. 50
d. 95

38. A typical clutch size for quail is __________ eggs.

a. 2 to 8
b. 5 to 10
c. 10 to 20
d. 15 to 40

39. Quail feed _________time(s) a day.

a. one
b. two
c. three
d. four

40. Typically, ________________ the quail eggs laid will not hatch.

a. Almost none of
b. Less than one fourth of
c. About half of
d. Almost all of

41. The ability of quail populations to withstand harvest pressure depends upon the ______.

a. extent of the harvest pressure
b. quality of the habitat
c. severity of weather conditions
d. All of the above

42. Having additional body fat will allow quail to ___________________.

a. live a few days without food
b. die more quickly of hypothermia
c. run faster from predators
d. fly for longer distances

43. Dusting ____________.

a. keeps quail warm in cold temperatures
b. camouflages quail from predators
c. reduces insect parasites
d. attracts partners for mating

44. Each of the following provide good nesting cover except ____________.

a. a monolithic stand of thick grass
b. a mix of grasses forbs and shrubs
c. no-till row crops
d. moderately grazed native pastures

45. Which of the following make the best nesting cover for quail?

a. A fescue pasture.
b. Mix of erect grass, forbs, and scattered shrubs.
c. Recently disked field with annual weeds.
d. Forest edge containing a variety of brushy plants.

46. The nesting season for quail is from ________________________.

a. April to September
b. October to April
c. January to June
d. July to December

47. The major seasonal activity of quail in the winter (October – April) is ____________.

a. pair-bonds
b. nesting
c. brooding
d. escape and protection

48. ___________ is not good quail habitat because of its dense growth.

a. Lespedeza
b. Corn
c. Fescue
d. Blackberry

49. Small clear-cuts in ______________ can positively affect quail populations.

a. crop fields
b. grasslands
c. fencerows
d. forests

50. Which of the following is not a significant predator of quail?

a. Striped skunk
b. Wild turkey
c. Cooper's hawks
d. Black rat snake

Unit Exam Key
Answers only

1. c
2. d
3. b
4. a
5. c
6. b
7. d
8. b
9. c
10. d
11. a
12. d
13. d
14. c
15. d
16. a
17. c
18. c
19. b
20. b
21. b
22. a
23. c
24. a
25. c
26. b
27. c
28. a
29. b
30. b
31. b
32. c
33. c
34. c
35. b
36. c
37. b
38. c
39. b
40. c
41. d
42. a
43. c
44. a
45. b
46. a
47. d
48. c
49. d
50. b

APPENDIX G

STUDENT IDENTIFICATION FORM

FOR LOCAL USE ONLY **DO NOT** RETURN THIS FORM

Student Identification Form

List students alphabetically. Use this ID # for all correspondence.

Student Name ***(Fill in Alphabetically)***	***ID #***	***Team #*** ***Assignment***	***Learning Objective #*** ***Assignment***
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		

APPENDIX H

SCORE REPORT FORM

RETURN THIS FORM TO
MU DEPT.OF AG ED

DO NOT INCLUDE STUDENT
NAMES ON THIS FORM

Score Report Form

Student ID #	***MAP Score 7th Grade Science*** (index score)	***Pre-Test Quail Score*** (number correct)	***Post-Test Quail Score*** (number correct)	***Gender*** (Circle)	***Classification*** (Circle)
1				M F	FR SOPH JR SR
2				M F	FR SOPH JR SR
3				M F	FR SOPH JR SR
4				M F	FR SOPH JR SR
5				M F	FR SOPH JR SR
6				M F	FR SOPH JR SR
7				M F	FR SOPH JR SR
8				M F	FR SOPH JR SR
9				M F	FR SOPH JR SR
10				M F	FR SOPH JR SR
11				M F	FR SOPH JR SR
12				M F	FR SOPH JR SR
13				M F	FR SOPH JR SR
14				M F	FR SOPH JR SR
15				M F	FR SOPH JR SR
16				M F	FR SOPH JR SR
17				M F	FR SOPH JR SR
18				M F	FR SOPH JR SR

19				M F	FR SOPH JR SR
20				M F	FR SOPH JR SR

APPENDIX I

SUPERVISED STUDY TEACHING OUTLINE

Teaching Outline

A. Interest Approach (10 min)

   a. Each lesson has an activity to motivate and create interest in the lesson.
   b. Sufficient time should be given to the activity and discussion to create a felt need to learn the objective.

B. Communicate Objective(s) - The lesson objective(s) should clearly identify student expectations (i.e. what students should know and/or be able to do at the conclusion of the lesson).

C. Assign Study Questions (5 min)

   a. Each lesson contains questions to be investigated by the student. Ideally, those questions follow the discussion created by the interest approach.
   b. Study questions may be assigned by posting on chalk/white board, power point, overhead transparency, or handout. For each lesson, handouts have been prepared that identify the objectives and study questions.

D. Independent Study (20 – 30 min)

   a. Students should inquire into information related to the study questions. Sufficient time should be provided for students to read the resource materials provided (*On the Edge: A Guide to Managing Land for Bobwhite Quail*) and record information needed to answer the study questions.

E. Discussion (20 – 30 min)

   a. Following independent study, students should share their findings with the class in an open discussion of the study questions.
   b. The instructor should take this opportunity to clarify content and/or add to the content provided by students.
   c. A content outline is provided for the instructor with each lesson.

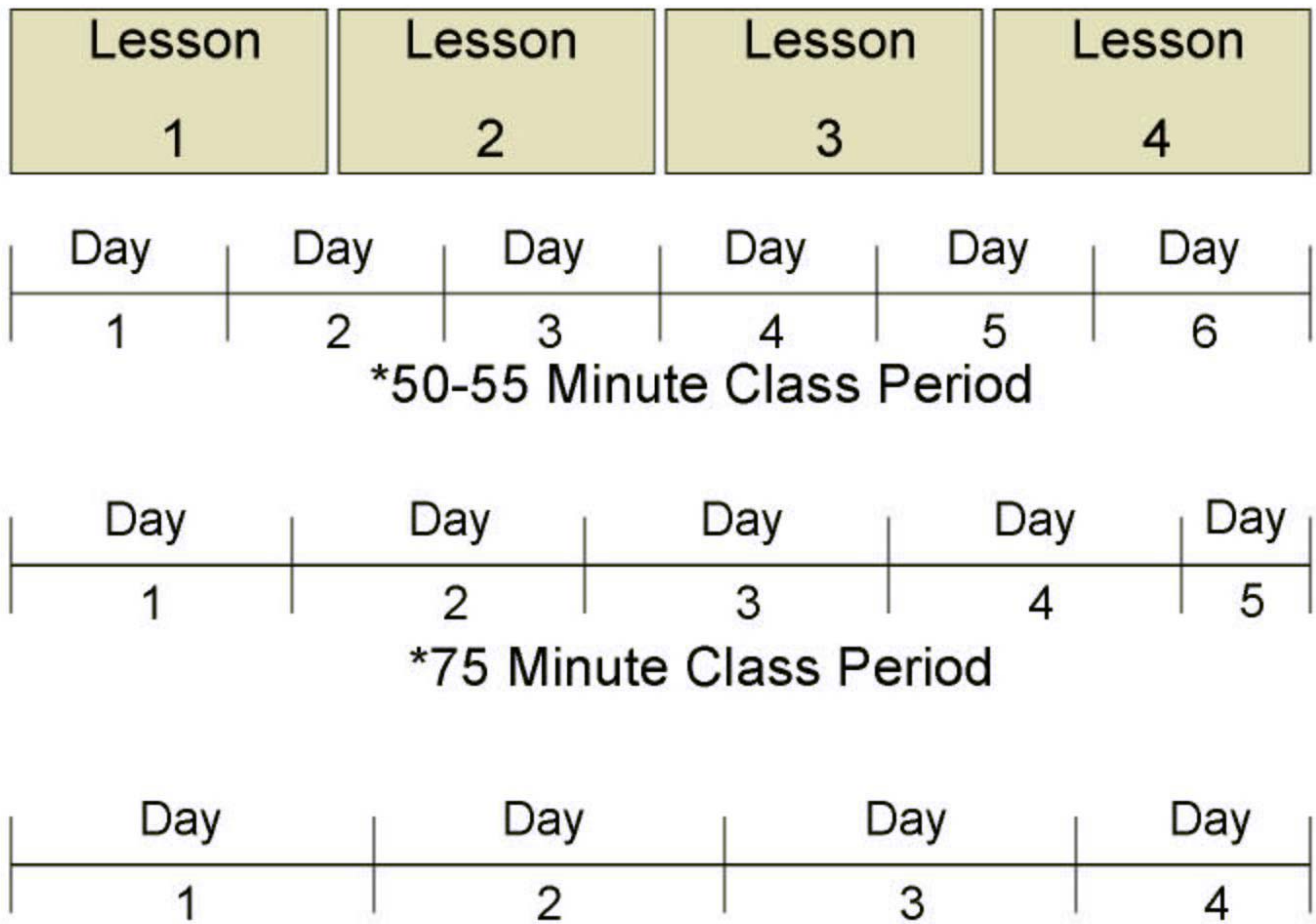
F. Conclusion/Summary (10 min)
   a. After discussion of the study questions, closure should be provided.
   b. The concluding discussion should draw out the key concepts discovered as a result of the study questions.

<u>Note</u>: Times are suggested.

APPENDIX J

SUPERVISED STUDY TIME ALLOCATION TABLE

Suggested Distribution of Time



APPENDIX K

UNIT OVERVIEW: PROBLEM-BASED LEARNING

Unit Overview
50 minute periods

Phase	Day	Tasks to accomplish
Pre-test	1	Pretest administration of Quail Management Test Discuss Natural Resource Conservation
	2	Pretest administration of Watson-Glaser (WGCTA) Discuss problem-solving vs. problem-resolving
Unit of Instruction	3	Explain purpose of PBL Establish teams and identify member roles Orient groups to the problem case and facilitate group processing of case information
	4	Present handout of formal learning objectives Provide resources for learning objectives Facilitate individual investigation of information
	5	Facilitate individual investigation of information Prepare learning objective reports
	6	Learning objective presentations Relate learning objectives to case resolution
	7	Relate learning objectives to case resolution Develop Resolution to problem case
	8	Present case resolutions Debrief the process of resolving the case
Post-test	9	Post-test administration of Quail Management Test
	10	Post-test administration of WGCTA

APPENDIX L

PROBLEM CASE

COLUMBIA DAILY
TRIBUNE

In Search of Elusive Quail

Bird season was challenging in 2004.

Adapted from an article
By
SPENCER E. TURNER
Special to the Tribune

Published Monday, January 24, 2005

"Let's quail hunt this weekend. It looks like the weather will cooperate with us."

My hunting partner's call came when I was looking for a hunt somewhere to end my season.

The 2004 Missouri quail season had been, to say the least, poor for me. Usually, by the end of December, I'd hunted quail 10 or 11 times, following an English setter or two. This time, it had been almost a bust. I'd only hunted quail five times since the November opening. All in all, it had been a poor bird season.

The day was cold, temperatures holding in the mid-20s, as I headed north to Edina. Snow and ice blanketed fields, woods and fences, and a cold wind blew from the northeast. I met Dave in Edina, where Tim, Dave's son-in-law, joined us.

Tim stuffed Heidi, Dave's shorthair, into one side of his dog crate, and we headed for Wittyville, one of Dave's farms. He'd flushed a large covey during deer and turkey seasons along an old bulldozed roadbed overgrown with trees, rose thickets and brush piles.

"I'll take the roadbed," Dave explained, directing traffic. "Spence, you take one side and Tim, you cover the other."

The flush came unexpectedly as it always seems to. Dave shot, wounding a bird, which landed in a tree in front of me. Tim shot three times but no cigar. I shot once on the covey flush, then again, finishing the bird in the tree.

We followed the birds, but it became quickly apparent once spooked, the birds were very shy. We didn't have any more bird contacts as we circled the field.

The morning hunt passed rapidly, and, although we didn't contact any new coveys, the walk showed how a working farm could include wildlife. Dave's farm held turkey and deer and still was profitable. It contained a mixture of fence rows and draws, corn and bean fields where crops had been harvested and idle areas of land intended to provide food for wildlife of all kinds through the north Missouri winter.

But few quail.

Missouri's quail population has been on a steady decline since the late 1970s. Now, a good day means two to four coveys, where it used to be eight to 10. As we talked over lunch, Dave, thinking out loud, suggested many young quail hunters considered two or three coveys a day good hunting.

The afternoon hunt proved to be a repeat of the morning. After a long walk, covering several fields and fence rows, we moved turkeys like I've never seen before and even jumped a few deer, but no quail.

The day ended as it began … a long walk back to the trucks looking forward to the next year's season. Dave expressed his concerns, wishing there was something he could do that would make Wittyville a better hunt.

As I returned south, pleasantly tired, I remembered past hunts and wondered what the future for Missouri quail hunting would be. I don't think biologists have a clue why the quail population has been in a steady decline.

Develop a management plan that will promote the growth of the quail population and still allow "Wittyville" to remain a productive farm. Your plan will be published in the newspaper. It should address the allegations from the original article and explain, in layman's terms, how your suggested management strategies can improve quail populations.

APPENDIX M

DESCRIPTION OF WITTYVILLE

“Wittyville” Description

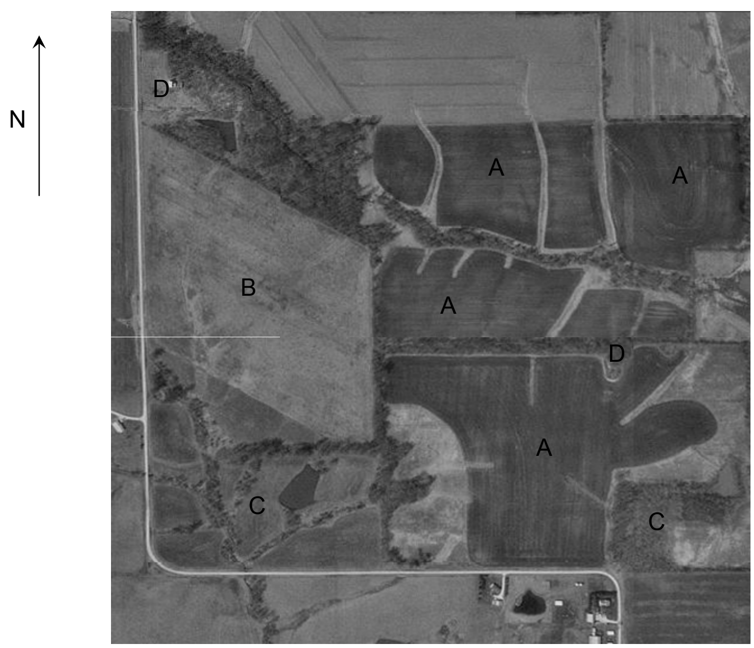
“Wittyville” is located in Knox County in Northeast Missouri. This farm was named affectionately after Dave’s great-grandfather and has been in Dave’s family for six generations. It is a working production farm. Its primary function is the production of field crops; specifically corn and soybeans. As evident in the aerial photograph, approximately half of the nearly 800 acres is in field crop production (A on map). Dave’s family has always taken great pride in the appearance of their farm.

Approximately 100 acres on the West edge was placed in CRP in the mid 1990s (B on map). Once farmed for bean and corn production, this area was more susceptible to erosion. It was sewn with a mix timothy and orchard grass when it was entered into the program and has gone virtually untouched since. The CRP contract will expire in the coming year and Dave is undecided as to whether he should reenroll in the program or put this land back into production.

The extreme southwest and southeast corners of “Wittyville” have a much more uneven topography (C on map). The native warm-season grasses are broken up by occasional wooded drainages. Both areas are used as a weaning pasture for Dave’s cow/calf operation when needed. This light stress hardly impacts the abundant Indian grass and bluestem.

A large drainage cuts diagonally from the northwest corner through the crop fields. For the last twenty years, this area has been left idly by Dave’s family in an effort to provide some cover for wildlife (D on map). The dense brush and trees serves as a home to both turkey and deer. Although quail were once abundant in this area, there have been very few covey sightings in the recent years. On old roadbed in the center sits idle and is overgrown with trees and shrubs.

The area adjacent to this farm is much less diverse. Except for the occasional wooded drainage area, most of the land is used intensively for field crop production.



APPENDIX N

FORMAL LEARNING OBJECTIVES

Learning Objectives – Managing Quail Habitat

1. How has the quail population in Missouri changed over time? What role did people play in this change? What are some misconceptions about quail populations?

2. What role do quail play in their ecosystem? How are they affected by predators, weather, hunting?

3. What are biological and reproductive characteristics of quail? What habitat characteristics are needed by quail?

4. What management techniques are available to improve quail habitat? How do techniques differ between cropland, pasture, CRP, and idle land?

Resources for Managing Quail Habitat

On the Edge: A Guide to Managing Land for Bobwhite Quail. (T. Hutton & J. McKee, Eds.). Jefferson City, MO: Conservation Commission of the State of Missouri.

The Conservation Resource. Winter 2005, Volume 1, Number 2. Missouri Department of Conservation. Jefferson City, MO.

Rich Grasslands for Missouri Landowners (Missouri Department of Conservation, 2001). Conservation Commission of the State of Missouri.

Native Plants for Your Farm. (Missouri Department of Conservation, 2004). Conservation Commission of the State of Missouri.

Wood is Good Even for Quail. Missouri Conservationist Online
http://www.mdc.missouri.gov/conmag/2005/02/30.htm

Quail Management: MDC Online (with various links)
http://www.conservation.state.mo.us/landown/wild/quail/

Farming and Wildlife – Bobwhite Quail
http://www.conservation.state.mo.us/landown/wild/quail/farming/

Managing CRP Grasslands for Bobwhite Quail
http://www.conservation.state.mo.us/landown/wild/quail/crp/

Missouri Quail: At the Crossroads of the Future
http://www.conservation.state.mo.us/landown/wild/quail/future/

Quail Management
http://www.conservation.state.mo.us/landown/wild/quail/management/

APPENDIX O

SAMPLE: INDIVIDUAL ORGANIZER FOR INVESTIGATION

ORGANIZER FOR INVESTIGATION

Learning Objective #1: How has the quail population in Missouri changed over time? What role did people play in this change? What are some misconceptions about quail populations?

With the arrival of Europeans in North America, what contributed to the up and down pattern of quail populations in Missouri?

What are the main threats to the future of quail habitat and populations in Missouri?

What approaches are necessary today to increase quail habitat and their populations?

What popular misconceptions have made their way into quail management?

APPENDIX P

TEACHER DIRECTIONS: PROBLEM-BASED LEARNING

Teaching Directions: Day 1		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar :	Day One		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Pre-test administration of Quail Management Test			
Equipment, Supplies, References, and Other Resources:			
Quail Management Test – one copy per student (Buff pre-test)			

Content Outline and/or Procedures
Administer Quail Management Test 1. Explain to students that this is a pre-test. It is not for a grade and will be used to determine what they already know about an upcoming topic. 2. Instruct students to answer questions to the best of their ability 3. Allow students up to 45 minutes to complete the assessment. Completing the assessment will take between 15 and 45 minutes. The following are suggested ideas to use remaining class time to facilitate the transition to a new unit on wildlife management:
IF you have class time remaining: Conduct group activity/discussion to introduce natural resource conservation. In pairs or small groups, have students brainstorm a list of natural resources they have used today (or during the past week). If needed, guide them toward some resources with questions. Example: How did you get to school? What materials were used in the construction of that? How is power created for that? Allow 3 to 5 minutes. Have students share items on their list with classmates. Discuss the following: There are 2 types of natural resources: a. Renewable: natural resources that have the ability to sustain themselves; sunlight, soil, water, forests, fish and wildlife. b. Non-renewable: resources that exist on earth in fixed quantities which cannot be increased; coal, metals, natural gas, petroleum, phosphate and potassium are examples. Conservation: is the "wise use" of natural resources Preservation: is not using resources. Is this realistic in our lives today?

Teaching Directions: Day 2		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar :	Day Two		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Administer pre-test for Watson Glaser Critical Thinking Appraisal (WGCTA)			
Equipment, Supplies, References, and Other Resources:			
WGCTA Test Directions WGCTA Test Booklets (one for each student) WGCTA Answer Sheets (one for each student)			

Content Outline and/or Procedures

Administer Watson Glaser Critical Thinking Appraisal (WGCTA)

1. Follow the guidelines on the test administration sheet.
2. This test is timed. Students should have 45 minutes to complete the test.

IF you have class time remaining:

Discuss Problem solving vs. Problem resolving

What problems do you encounter in your daily lives? What challenges does our school face? Our community? (Possible answers might include finding time to do schoolwork, finding a place to park, maintaining roads and parks, etc.)

Unlike math problems, most problems in the real world do not have right or wrong answers. Math problems can be solved. That means there is only one answer or solution. Problems we encounter, such as how to spend our money or time, have many possible answers. Some are more practical than others but all are possible answers. These are called resolutions.

Does anyone remember Rubik's cube? The game where the task was to rotate the puzzle until all of the same color appears on the same side. The problem was getting the pieces on the correct side of the puzzle. Did this have a solution or resolution? Answer: There may have been a different order for accomplishing the goal, but the answer, or SOLUTION was to get all colors to match. There was only one solution.

Unlike the Rubik's cube, there are any numbers of ways we can choose to deal with them, all of them being correct – just different. The key is that they are viable options.

Teaching Directions: Day 3		Instructor:	
Unit:	Wildlife Conservation: Quail management		
Daily Calendar :	Day Three		
Estimated Time:	50 minutes		

Tasks to accomplish:

Explain purpose of PBL
Establish teams and identify member roles
Orient groups to the problem case/ facilitate group processing of case information.

Equipment, Supplies, References, and Other Resources:

Team Assignments (on student ID form)
Problem Case: In Search of Illusive Quail Handout
Wittyville Description Handout
Dry Erase Board/Chalkboard

Content Outline and/or Procedures

Explain problem-based learning (2-5 minutes)

Describe the process

1. This problem will take approximately 7 class periods to develop a resolution
2. Each person will be in charge of investigating part of the information and reporting to the rest of their team
3. Each team will create a resolution that will be presented next week.
4. This problem is an actual situation that is occurring all over Missouri. The article you will read was actually printed just a couple of weeks ago.

Establish teams and member roles (5 minutes)

Assemble teams

1. Create 4-person teams (you may have some teams with 3. Avoid teams of 5).
2. Each team will work together to resolve the case.
3. Purposefully group teams together with the goal of creating as many highly productive teams as possible.
4. Have teams sit together (this may require you to modify classroom arrangement slightly).

Assign roles to each group member (according to roster)

1. Discussion leader – this person will be in charge of leading discussions when appropriate. Their primary responsibilities are to get the discussion started and to make sure that all team members have an opportunity to contribute to the discussion.
2. Recorder – this person will write down and record the accomplishments of the team. This is especially important when the team is assigned a group task to report on.
3. Project Manager – This person is in charge of resource materials as well as monitoring

Content Outline and/or Procedures
progress and making sure that everyone is prepared on time. 4. Devil's advocate – this person will challenge the good ideas. This person will explore the negative consequences of proposed ideas which will help the team to see issues from all perspectives.
<u>Present the case to students</u> ~Give each group 20 to 30 minutes to read individually and formulate individual ideas. Identify key aspects of case: ~allow 15 to 20 minutes to discuss the following ***within their group***: 1. What is the problem and who are the stakeholders? 2. What do we already know in that will help us resolve this problem? 3. What else do we need to know before we can resolve this problem? 4. What terms have we read that need to be learned? 5. What concepts, principles, and facts can be utilized in resolving the problem? 6. What might be some possible resolutions? (consider stakeholder perspectives) 7. Generate list of learning objectives. **Write these items on whiteboard or overhead to give groups some structure to their discussion. *Early in the discussion, students should identify a need to know more about the specific area of land mentioned in the article. As a team reaches this conclusion and asks for additional information, give them the Wittyville Description handout. This will help stimulate the discussion more. ***As a whole class***(10 to 20 minutes) discuss those same issues. The goal of the whole class discussion is for students to take an active role in seeking out information. They should produce their own answers to the above questions. However, be prepared to use questions to guide them to appropriate answers. As you work through each question, list student responses on board. Have each team explain why they came up with that answer. **1. What is the problem?** *(Possible ideas, they may generate more)* Quail population is too low. Quail hunting is declining. Habitat for quail is poor. Current practices are reducing quail numbers Ultimately: How can we increase the quail population on Wittyville? **1. Who are the Stakeholders?** *(Possible ideas, they may generate more)* Dave (producer/landowner) Tim (Hunter) General public (who enjoy viewing wildlife)

Content Outline and/or Procedures
Sporting goods businesses (who sell sporting equipment) People opposed to hunting as a form of recreation Other species of wildlife that rely on quail **2. What do we know?** *(Possible ideas, they may generate more)* Encounter rate of quail is low (only 1 covey per day) Wittyville will support other wildlife (turkey and deer) Wittyville consists of a variety of types of land (crp, crop, pasture, etc.) Quail population has been on decline since 1970. Possibly other issues. **3. What do we need to know?** (Discussion of this question will set the tone for the rest of the unit) 1. Ideally, the students will identify the same information identified in the formal learning objectives. 2. It is crucial that students think through this process on their own. (You may need to ask how and why questions) 3. Record their answers on board (discussion may reveal that they don't really need to know that to resolve the problem. Only record valid ideas.) 4. Some will match the formal learning objectives. 5. Others will be legitimate concerns but outside of the scope of this unit. By listing these ideas on the board, you are (as a group) creating a list of learning objectives. Note: Questions 4, 5, and 6 are intended to facilitate the team discussions. They do not need to be addressed specifically in the group discussion but may come up during the discussion of other questions.
<u>Closure</u> Allow students to recap key points that were identified. ***What is the problem we are addressing?*** ***Who will be affected in the resolution (stakeholders)?*** ***What do we need to find out to resolve this problem?***

Teaching Directions: Day 4		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Activities :	Day Four		
Estimated Time:	50 minutes		

Tasks to accomplish:
Present Handout of Formal Learning Objectives Provide Resources for learning objectives Facilitate individual investigation of information
Equipment, Supplies, References, and Other Resources:
Handout: Formal Learning Objectives/Resources Group packet of resources On the Edge (1 per student) Individual Organizers for Investigations Dry Erase Board/Chalkboard

Content Outline and/or Procedures
<u>Review Progress from Previous Class</u> In individual teams, allow students to recap the previous day culminating with the learning objectives they identified that were important to the case resolution. (5 mins) ***What is the problem we are addressing?*** ***Who will be affected by the resolutions (stakeholder)?*** ***What do we need to know to resolve this issue?*** As a whole class, review learning objectives identified in each group (5 mins) 1. Record these on board. They should be very similar to the things they identified in the previous class period.
<u>Present Handout of Formal Learning Objectives</u> Handout formal learning objectives 1. In teams, compare the formal objectives to the ones generated by the teams. (3-5 mins) ***What things did we identify that are represented in these formal objectives.*** ***What things did we identify that are not represented in these formal objectives.*** Discuss the answers in a whole class discussion. You may need to take a couple of minutes to explain that some of their objectives were valid but we do not have access to or have time to incorporate them into our investigations.

Content Outline and/or Procedures
2. Each person on your team will be responsible for investigating one of the formal objectives. Take a couple of minutes and decide what objective each team member will be investigating. 3. Distribute individual organizers for investigation. You are responsible for investigating the information related to your objective. This handout will help to ensure that you don't overlook something important.
<u>Distribute Resources for learning objectives</u> 1. Each person should get an "On the Edge" book. 2. Other materials should be distributed one per team. 3. Web resources are best investigated on the computer.(If you do not have computer access for your class, paper copies of web resources should be included with other resources) 4. Encourage students to explore other sources of information
<u>Facilitate individual investigation of information</u> At this point, students become responsible for uncovering information relevant to the case resolution. For those that struggle, try to guide them to appropriate investigations using questions and allowing them to figure out what they should look for, where they should look, and how to look for it. The individual organizers for investigation will help with this process as well Explain learning objective reports 1. You have this class and the next class to prepare for the learning objective report. 2. In two days, you will present what they found about their objective to their team 3. Each student should prepare an outline of the key points 4. You will use your outline to "teach" their team members 5. Each person will have 10 to 12 minutes to teach their material
<u>Closure</u> The individual investigation of learning objectives will stretch into the next class period. • End this class by stopping with about 5 minutes remaining in class. • Facilitate a brief whole class discussion on the process of investigation. • Identify any problems encountered to this point

Teaching Directions: Day 5		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Activities :	Day Five (Continuation of day 4)		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Facilitate individual investigation of information			
Equipment, Supplies, References, and Other Resources:			
White board/chalk board			

Content Outline and/or Procedures
Review the details of the learning objective reports 6. You have this class to finish your investigation and prepare for the learning objective report. 7. Tomorrow, you will present what you found about your objective to your team 8. Each student should prepare an outline of the key points 9. You will use your outline to "teach" their team members 10. Each person will have 10 to 12 minutes to teach their material
Continue individual investigation • Begin with a short discussion reviewing the problems they encountered in the previous class period and what were some effective methods of investigation • Allow approximately 30 minutes to conclude investigations and transition to learning objective report. • Students should have a written plan (outline) for what they will report. In addition to the outline, they should provide verbal explanations (teach) of their content to the other members of their group.
Closure End with a brief (5 min) discussion on the process of investigation. What was effective? What was ineffective? Where else might we search for information related to our topic? Additionally, use this time to clear up misunderstanding or confusion. If many of the groups are making the same mistake, take time to clarify the problem and get them on track.

Teaching Directions: Day 6		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar	Day Six (Learning Objective Reports)		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Learning Objectives Presentations Relate learning objectives to problem case.			
Equipment, Supplies, References, and Other Resources:			
Dry Erase Board/Chalk board			

Content Outline and/or Procedures
Learning Objectives Presentations (25 to 45 Mins) In individual teams, students will present to their team members over the content related to the learning objective they were in charge of investigating. One by one, team members will take turns reporting within their group. Each presentation should be between 5 and 10 minutes. The goal is for the presenter to be the teacher and educate their fellow group members.
Relate learning objectives to the problem case Inevitably, no groups will finish the presentation at the same time. As they began to finish, on a group by group basis, have them discuss "how" the learning objective information fits in to the problem and how it will help them with a resolution.
Closure End with a brief (5 min) whole class discussion on the learning objective reports. What have you learned? What information was most surprising? How will this help us in resolving our problem case?

Teaching Directions: Day 7		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar	Day Eight		
Estimated Time:	50 minutes		

Tasks to accomplish:
Relate learning objectives to problem case. Develop resolution to problem case.

Equipment, Supplies, References, and Other Resources:
Computer/word processing program

Content Outline and/or Procedures

Continue to develop resolution to problem case.

From the perspective of a wildlife conservationist, write a reply to the newspaper. Include a plan for Dave the will allow Wittyville to remain a productive farm and still provide quality quail habitat .(Original problem as stated on problem case)

The resolution consists of two main parts.

1. First, an explanation of quail conditions and a response (or explanation) to allegations in the letter. This part will present information learned from learning objectives 1 through 3.
2. The second part is a suggested management plan for Dave's farm, Wittyville. This will be an application of objective four. It should address all of the types of land found on Dave's farm and provide suggestions to make it more friendly for quail.

The resolution should appear as an article/letter submitted to the Columbia Daily Tribune.

Prepare teams for presentation

The presentation of team resolutions will be a time to compare the resolutions that each group developed. Some resolutions may be similar while others may have approached the management plan from a completely different perspective.

1. Each team will draw for the order of presentation.
2. Each team will have an opportunity to read their newspaper article to the rest of the class.
3. This should be followed by an explanation by the team of why they chose the methods in their plan.

Closure

In a whole class discussion, discuss similarities and differences in the plan. Allow students to identify unique aspects of their team's plan.

Teaching Directions: Day 8		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar	Day Nine		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Present Case Resolutions Debrief the process of resolving the case			
Equipment, Supplies, References, and Other Resources:			

Content Outline and/or Procedures
<u>Present Case Resolutions</u> Draw numbers for random order 1. Have each group present in front of the class. 2. Each group should read their letter to the paper. 3. Discuss unique aspects of their plan and why they decided to implement those ideas. This should be a time to celebrate and showcase accomplishments.
<u>Debrief</u> If time allows, debrief the resolution process. This is an important step in the process and should be given approximately 30 minutes of class time for discussion. This can be completed following the resolutions and may carry over into the next class periods designated for testing if there is not adequate time at the conclusion of the presentation. In a whole class discussion, debrief the problem solving process. Possible discussion questions are as follows: ***1. What process did you use to reach a conclusion?*** ***2. What parts did you find challenging?*** ***3. What parts did you overlook or not pay enough attention to?*** ***4. What techniques did you try that worked well and not so well?*** ***5. Can this same or a similar process be used to solve different problems? How?*** ***6. How would you modify the process for a different problem*** 7. ***How can information learned about quail be applicable to other species of wildlife or domesticated animals?***

Teaching Directions: Day 9		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar	Day Ten		
Estimated Time:	50 minutes/each		
Tasks to accomplish:			
Post-test Quail content assessment			
Equipment, Supplies, References, and Other Resources:			
Quail Management Assessment			

Content Outline and/or Procedures
Administer Quail Management Assessment 4. Students should be instructed to answer questions to the best of their ability 5. Allow students up to 45 minutes to complete the assessment. This will take between 15 and 45 minutes.
Finish Debriefing In a whole class discussion, debrief the problem solving process. Possible discussion questions are as follows: ***8. What process did you use to reach a conclusion?*** ***9. What parts did you find challenging?*** ***10. What parts did you overlook or not pay enough attention to?*** ***11. What techniques did you try that worked well and not so well?*** ***12. Can this same or a similar process be used to solve different problems? How?*** ***13. How would you modify the process for a different problem*** ***14. How can information learned about quail be applicable to other species of wildlife or domesticated animals?***

Teaching Directions: Day 10		Instructor:	
Unit:	Wildlife Conservation: Quail Management		
Daily Calendar	Day Eleven		
Estimated Time:	50 minutes		
Tasks to accomplish:			
Post-test WGCTA			
Equipment, Supplies, References, and Other Resources:			
WGCTA Test Booklets WGCTA Answer Sheets WGCTA Test Directions			

Content Outline and/or Procedures
Administer Watson Glaser Critical Thinking Appraisal (WGCTA) 3. Follow the guidelines on the test administration sheet. 4. This test is timed. Students should have 45 minutes to complete the test.

APPENDIX Q

QUAIL MANAGEMENT TEST: ITEM ANALYSIS

Table Q

Item Analysis of Quail Management Test

Test Item	Pg #	Percent Correct	Frequency of Responses			
			A	B	C	D
Objective 1 (6)						
4	7	76.7	**102**	2	15	13
17	15	62.4	23	8	**83**	18
27	55	76.7	17	9	**102**	5
28	16	75.2	**100**	8	16	7
29	8	48.9	31	**65**	14	23
50	54	57.1	32	**76**	6	18
Objective 2 (14)						
2	13	22.6	11	45	47	**30**
3	13	69.9	18	**93**	9	13
5	21	58.6	23	27	**78**	5
6	14	64.7	32	**86**	7	8
7	15	34.6	9	36	41	**46**
19	13	28.6	12	**38**	43	39
24	13	53.4	**71**	16	21	24
31	14	48.9	13	**65**	24	29
34	19	28.6	49	22	**38**	23
38	14	69.9	15	21	**93**	3
40	13	54.1	9	43	**72**	9

Test Item	Pg #	Percent Correct	Frequency of Responses A	B	C	D
41	18	81.2	6	8	11	**108**
46	23	49.6	**66**	24	37	5
47	23	30.8	19	31	40	**41**
Objective 3 (17)						
8	22	63.9	30	**85**	15	3
9	22	69.2	11	21	**92**	7
10	25	87.2	7	5	4	**116**
11	21	75.2	**100**	17	11	4
12	27	66.2	10	20	14	**88**
21	22	37.6	44	**50**	34	3
22	22	43.6	**58**	58	5	11
23	22	51.1	3	13	**68**	49
32	25	78.9	12	7	**105**	7
35	16	61.7	7	**82**	39	5
36	22	78.2	12	8	**104**	9
37	23	18.8	5	**25**	55	45
39	22	82.7	3	**110**	14	6
42	23	88.0	**117**	5	4	7
43	25	60.2	10	30	**80**	11
44	27	30.1	**40**	13	52	7
45	27	48.9	17	**65**	8	43

Test Item	Pg #	Percent Correct	Frequency of Responses A	B	C	D
Objective 4 (13)						
1	33	78.9	15	4	**105**	7
13	38	48.1	14	14	41	**64**
14	35	30.1	66	10	**40**	15
15	44	16.5	7	77	26	**22**
16	38	37.6	**50**	9	18	56
18	57	53.4	25	33	**71**	3
20	57	47.4	23	**63**	35	12
25	39	18.0	9	6	**24**	94
26	40	60.9	21	**81**	10	20
30	36	28.6	79	**38**	8	8
33	33	18.8	33	48	**25**	26
48	38	51.1	21	17	**68**	27
49	51	28.6	27	36	30	**38**

APPENDIX R

LEVENE'S TEST FOR HOMOGENEITY OF VARIANCE

Table R

Levene's Test of Equality of Error Variances

Variable	*F*	*p* - value
Critical Thinking	.21	.65
Content Knowledge	1.13	.29

APPENDIX S

SKEWENESS AND KURTOSIS OF CONTINOUS VARIABLES

Table S

Skewness and Kurtosis of Continous Variables

Variable	Skewness	Kurtosis
Critical Thinking	.49	.26
Content Knowledge	-.09	-.42

APPENDIX T

COMPARISON OF SCIENCE MAP ACHEIVEMENT LEVELS

Table T

Comparison of Science MAP Achievement Levels

	Sample	2002 State-Wide Report	2004 State-Wide Report
Achievement Category	Percent	Percent	Percent
Step 1 (520-656)	12.4	18	22
Progressing (657-693)	43.8	41	38
Nearing Proficiency (694-717)	32.3	27	24
Proficient (718-744)	10.5	12	13
Advanced (745-925)	.9	2	3

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