INQUIRY-BASED INSTRUCTION FOR STUDENTS WITH SPECIAL NEEDS IN SCHOOL BASED AGRICULTURAL EDUCATION

By

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To Allison, for giving me the push I needed to do what I was capable of

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Inquiry-based instruction, based on constructivist principles has been shown to be an effective method of instruction. Inquiry-based instruction also shows promise for educating students with special needs. A quasi-experimental design was used to determine if inquiry-based instruction impacts content knowledge achievement for students with special needs. This study analyzed ten intact classes taught by ten instructors, teaching 204 students. A total of 170 students posttest scores for content-knowledge achievement were analyzed using an analysis of covariates [ANCOVA] using pretest scores as a covariate. No differences were found between students with IEPs and students without IEPs using ANCOVA analysis. Comparisons were also made on other demographic factors. No differences existed for gender or free and reduced lunch status, but a difference did exist for ethnicity on three of the seven posttests. Based on the findings the conclusion was made that inquiry-based instruction does not adversely affect content knowledge achievement for students with special needs and inquiry based instruction leads to knowledge gain for all students regardless of IEP status. Based on these conclusions it is recommended that instructors use inquiry-based instruction when appropriate.

CHAPTER 1
INTRODUCTION

Inquiry-Based Instruction

Prior to 1900 direct instruction of science was commonplace in science classrooms. In these classrooms, students would be expected to memorize facts from the text provided by the instructor (National Research Council [NRC], 2000). Dewey (1938) theorized a change was necessary. He called for teachers to find the intimate and necessary relations between the process of experiences and education. This type of learning called for a more organic connection between the natural curiosity of students and the instruction they received in the classroom. Dewey (1910) also recognized science should occur as a process rather than be presented as a collection of facts.

Inquiry-based instruction is built on the tenants of constructivism. Constructivism is the belief that students "construct" their own knowledge based on the world around them. In constructivism the learner creates understanding of natural phenomena through a self regulated process of learning. This type of student centered, goal oriented learning is practical for gaining the dynamic knowledge and skills required in science (Doolittle & Camp, 1999).

Inquiry-based instruction, which is born out of constructivist ideals, is a method of instruction that forces students to use the scientific process to find the answers to questions. The National Science Education Standards (NRC, 1996) define inquiry in education as:

> A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanation. (p. 23)

Inquiry-based instruction is a teaching method that causes students to find the link between content and scientific thinking. Inquiry-based instruction is also a way for students to understand the natural world around them and allows students to think like scientists and engage in activities that promote the use of the scientific process (NRC, 1996).

The National Science Education Standards (NRC, 1996) called for a use of inquiry-based instruction which encouraged instructors to teach students the scientific process rather than a collection of unrelated facts. The standards were based on the principle that science is an active process that all students should participate in. Supovitz and Turner (2000) found that teachers recognized the need for inquiry in the classroom but also noted teachers that had more than 80 hours of training on the use of inquiry-based instruction were the most likely to use it in their classrooms. Coln (2008) found that in one district in North Carolina, teachers used inquiry at a moderate level, and that the most common teaching method used by instructors was inquiry-based, and hands on. According to Gejda (2006) most teachers integrate some type of inquiry component into their instruction.

Joyce and Weil (1972) expressed that inquiry-based instruction shifts away from the focus of the acquisition of specific skills, and towards a focus on how students process information and act upon it. Thinking is a process that can be taught, is a transaction between an individual and the data, and evolves in an orderly sequence (Taba, 1966). Inquiry-based instruction is based on these tenants. The purpose of inquiry instruction is to promote thinking and making of links to the world surrounding the students, causing them to make their own connections and think critically to make sense of the complex world around them.

Educating Students with Special Needs

The Individuals with Disabilities Education Act of 1997 (IDEA) requires that students with special needs receive individualized special instruction that meets their needs in the least restrictive environment (Kinder, Kubina, & Marchand-Martella, 2005). Nationally 13.5% of students are served under the IDEA act, of those students 59% were White, 20% were Black, and

17% were Hispanic (U.S. Department of Education, National Center for Educational Statistics, 2008a; 2008b). In School Based Agricultural Education [SBAE] the number of students with special needs tends to be higher than in core content classes. Dormody, Seevers, Andreasen, and VanLeeuwen, (2006) found 19% of students in New Mexico SBAE had IEP's compared to Pense (2008) who found 23% of SBAE students in Illinois have IEP's. Ninety seven percent of students with disabilities are in general education courses for at least 40% of the day (Smith, 2007). These students take career and technical education courses to aide in career transition based on the students' ability and interest (Harvey, 2001).

The Perkins Act (2006) refers to the Americans with Disabilities Act for a definition of an individual with a disability. The Americans with Disabilities Act (1990) defines a disability as a physical or mental impairment that substantially limits one or more life activities, and a record of the impairment exists. Students with physical disabilities are limited by their mobility, dexterity, or communication abilities. Students with cognitive and emotional disabilities can include anything from severe disabilities such as mental retardation to manageable learning disabilities such as dyslexia (Talbert, Vaughn, & Croom, 2005).

Students with special needs require special consideration in the agricultural education classroom. According to Phipps, Osborne, Dyer, and Ball (2008) students with special needs should be taught lessons that give specific directions and demonstration, provide models of key points and provide practice and application. They also call for teachers to include students with special needs in the lessons and to take a sincere interest in these students' learning. Inquiry-based instruction provides a means for instructors to make the instruction more detailed and specific, explain concepts through examples, and take an interest in their students' progress.

Placing students in the least restrictive environment causes the entire educational support system to adapt, including the instructor (Giffing, 2009). Historically direct instruction, where content is directly taught to students, is believed to be the best method for educating students with disabilities (Kinder et al., 2005). Rapp (2005) argued instructors of special needs students need to be more creative in their instruction and use inquiry teaching strategies. McCarthy (2005) found when compared to a textbook approach to teaching, thematic-based hands-on science is a more effective method of teaching for students with emotional disturbances. While she admitted thematic-based hands-on instruction takes more time and effort, positive difference in academic achievement have been found.

The National Science Education Standards (NRC, 1996) stated that science instruction should be provided to all students, regardless of their age, sex, ethnicity, or disability. While Rapp (2005) and McCarthy (2005) both agree active teaching strategies, similar to inquiry-based instruction, are successful for students with special needs, Giffing (2009) stated that a lack of confidence could limit the full integration of students with special needs, especially in the laboratory section. Research needs to be conducted to determine if inquiry-based instruction promotes content knowledge achievement for students with special needs.

Most SBAE instructors agree special needs students should be integrated into each aspect of the program. However, most are uncomfortable with including them in the classroom and laboratory setting (Giffing, Warnick, & Tarpley, 2009).

More research on inquiry instruction for students with special needs is needed. Parr and Edwards (2004) called for more empirically based research on teachers uses of inquiry-based instruction for students with special needs. Pense, Watson, and Wakefield (2009) expressed that experimental research should be done to determine how students with special needs are motivated by various curriculum manipulations. Dyer and Osborne (1996) called for more research to be conducted on students from various backgrounds to determine how they respond to different teaching methods. Frew and Klein (1982) claimed that an analysis of the interaction of learners involved with a variety of instructional methods will add to the understanding of education students with special needs. Mastropieri and Scruggs (1992) expressed that research on incorporating scientific question and reasoning skills, like those used in inquiry-based instruction, could be a useful direction of research for students with special needs in inclusion settings. Scruggs, Mastropieri, Bakken, and Bringham (1993) also expressed the need for future research to validate inquiry-based instruction methods for students with special needs.

Research Problem

The National Research Council (2000) provided a framework for inquiry instruction as it relates to the National Science Education Standards. This framework provides a structure for how inquiry instruction should take place in the classroom. However, it failed to mention how inquiry relates for students with special needs and it does not specifically discuss School Based Agricultural Education [SBAE].

This study will help instructors to better understand the difference in students with and without special-needs in regards to inquiry-based instruction. The study will provide insight on how students with special needs respond to inquiry-based instruction and validate or refute the appropriateness of the inquiry-based method of teaching. The problem under investigation is the impact of inquiry-based instruction in educating students with special needs who are mainstreamed into SBAE classes.

Purpose and Objectives

The purpose of this study is to determine if inquiry-based instruction impacts content knowledge achievement for students with special needs. The study is guided by the objectives:

- Describe the population of special needs School Based Agricultural Education students.
- Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.
- Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

Significance of the Study

The most recent national science education standards have called for the use of inquiry instruction in science classrooms (NRC, 1996). While this shift in educational philosophy is considered positive for general students (NRC, 1996), little is known about how students with special needs respond to inquiry-based instruction.

This study provides insight on whether inquiry instruction is appropriate for students with special needs in SBAE. This research holds merits for scholars researching teaching methods for special needs students, inquiry-based instruction in the science classroom, agriscience integration in secondary SBAE, and special needs students in SBAE. This research also has a practical application for practitioners in the field teaching agriscience concepts to students with special needs. Individuals involved in science instruction for students with special needs may also find this study useful.

Definition of Terms

Content Knowledge Achievement- Measurement of students knowledge of the content on the pretest and posttest.

IEP STATUS- Whether or not a student has an IEP. For this study students with IEP's were considered those students with special needs (Smith, 2000).

INDIVIDUALIZED EDUCATION PLAN (IEP)- A tailored instruction plan that identifies students' disability and guaranties an individualized education to that student (Smith, 2000).

INQUIRY-BASED INSTRUCTION- A method of instruction which students observe the natural world around them and propose explanations based on scientific reasoning and the scientific process (National Research Council, 2000).

MAINSTREAMED- Students who spend time in both regular education classrooms and in an inclusive special needs classroom (Deutsch Smith, 2000; Fuchs, Roberts, Fuchs & Bowers, 1995).

NATIONAL AGRISCIENCE TEACHER AMBASSADOR ACADEMY [NATAA]- An inservice training provided to SBAE instructors that focuses on integrating science into the SBAE curriculum. The content of the NATAA is based on inquiry principles (National FFA Organization, 2009).

SCHOOL-BASED AGRICULTURAL EDUCATION [SBAE]- "Formal agricultural education programs offered in the public schools (as opposed to non-formal agricultural education programs offered by businesses of other non-school agencies)" (Phipps, Osborne, Dyer, & Ball, 2008, p. 537).

STUDENTS WITH SPECIAL NEEDS- Students who have specific needs identified by the Individuals with Disabilities in Education Act (IDEA) of (1997) that have Individualized Education Plans that provide detailed goals and modifications for their educational success (Kinder et al., 2005).

Limitations

Since this study is utilizing intact classes, the validity of the study is compromised since the groups are not randomly assigned. Moreover since the study took place over several weeks, history and maturation of subjects and mortality factors were considered. The study is also limited in its generalizability since the instructors participating are chosen from instructors at the National Agriscience Teacher Ambassador Academy [NATAA]. Since this study utilizes a small number of specially trained SBAE instructors the results are not generalizable outside of those participating in the study (Ary, Cheser Jacobs, Razavieh, & Sorenson, 2006; Campbell & Stanley, 1963).

Assumptions

This study operates under the assumption that inquiry-based instruction is a useful teaching method and is the norm for SBAE courses. Parr and Edwards (2004) found inquiry-based instruction to be an effective teaching method that leads to development of understanding and higher academic achievement.

For this study, the IEPs were used to identify the students' disabilities. An assumption must be made that the students' IEPs are correct, relevant, and current. It is also important to assume the students without IEPs do not need them and that states use similar terminology when coding IEPs. IEPs vary from state to state, however the codes are based on the IDEA 2004 act, which provides a bases for each states terminology for the IEP codes (Smith, 2007).

It is also important to assume the instructors have access to the students' IEP so they can identify the students' disability for data collection and can modify the instruction for the student. The assumption must also be made that the instructors are modifying the lessons for their students with disabilities.

Chapter Summary

This chapter introduced inquiry-based instruction, educating students with special needs, and inquiry-based instruction for students with special needs. While NRC (1996) highlighted inquiry instruction as a meaningful method of instruction, very little research exists on the use of inquiry instruction for students with special needs. Rapp (2005) and McCarthy (2005) argued that the strategies implemented in inquiry instruction are beneficial to special needs students learning.

The chapter identified the research problem: the impact of inquiry-based instruction in educating students with special needs who are mainstreamed into SBAE classes is not known. The impact of this study is to determine if inquiry-based instruction impacts content knowledge achievement for students with special needs. The study is guided by the objectives:

- Describe the population of special needs School Based Agricultural Education students.
- Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.
- Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

This chapter highlighted the significance of this study in determining if inquiry instruction impacts content knowledge based on IEP status in SBAE. This chapter highlighted important terms and outlined basic assumptions and limitations to consider.

CHAPTER 2
LITERATURE REVIEW

Chapter 2 outlines previous research on students with special needs and inquiry-based instruction. The study began by analyzing the problem of educating students with special-needs in school-based agricultural education, then proposed several possible solutions to the problem. One possible solution is inquiry-based instruction. Some researchers (Fuller, 2001; McCarthy, 2005; Rapp, 2005; Scruggs, Mastropieri, Bakken, & Brigham, 1993) indicated that inquiry-based instruction has promise in educating students with special needs, more research should be done to determine if it is appropriate in school-based agricultural education.

Educating Students with Special Needs

Definition and History

The Individuals with Disabilities Education Act of 2004 (IDEA) requires that students with special needs receive individualized instruction that meets their needs in the least restrictive environment (Kinder, Kubina, & Marchand-Martella, 2005). For most students with special needs this includes being mainstreamed into the regular classroom. Ninety-seven percent of students with disabilities are in general education courses for at least 40% of the day (Smith, 2007).

According to Tomlinson (2001), students learn in classrooms where they are actively involved in the learning process and are appropriately challenged according to their ability level. In any classroom some students will be more cognitively advanced or more familiar with the skills or content than other students. These more advanced students tend to do well in school but often are not challenged and may fail to develop studying and coping skills. Struggling learners also have their own challenges to overcome. These challenges can stem from any number of sources including problems at home or a genetic or developmental disability (Tomlinson, 2001).

For this study the term “students with special needs” was used to describe those students who have difficulty achieving in the classroom. As mentioned by Tomlinson (2001) these students could have needs from situations ranging from a developmental disability, such as autism, that makes communication cues difficult to understand, to a genetic disorder, such as Downs Syndrome, which limits cognitive function, to a Traumatic Brain Injury, which also limits cognitive function. Students could also be labeled as academically gifted, which needs to be identified so that instructors can modify instruction.

Most students with special needs receive their education in inclusive settings for all or at least part of the day (Smith, 2007). According to Blackorby, Wagner, Cameto, Davis, Levine, and Newman (2005) special needs students who spent more time in regular classrooms performed better on achievement tests, attended class more regularly, and performed closer to their expected level. Wagner, Newman, Cameto, and Levine (2003) also found that special needs students in inclusive settings outperformed students taught in a special needs classroom. Jordan, Schwartz, and McGhie-Richmond (2009) noted that it is more effective for students with special needs to be involved in a normal classroom due to the lack of a social stigma for those students with special needs. They did however note that teaching special needs students in inclusion settings puts a strain on the instructor since the majority of teachers have little training in educating students with special needs. Inclusive classrooms can have other benefits for the school system. According to Chambers, Parrish, Lieberman, & Wolman (1998) inclusive settings can cost 25% to 60% less than serving the same students in a special education setting.

The IDEA Act of 2004 lists disabilities recognized by the Act. These disabilities are mental retardation, hearing impairment, speech or language impairment, visual impairment, emotional disturbance, orthopedic impairments, Autism, Traumatic Brain Injury, other health impairments, multiple disabilities, deaf-blindness, specific learning disabilities, and developmental delay. An Individualized Education Plan (IEP) identifies a student's disability and provides goals for the student, modifications that need to be made, as well as plans for educating that student (Smith, 2007).

Educating Students with Special Needs

An instructional model can be helpful in delivering content to students (Frew & Klein, 1982). Taba, Levine and Elzey (1964) stated "The impact of teaching lies not alone in its single acts, but in the manner in which these acts are combined into a pattern" (p. 55). These acts combined together form models of instruction. According to Lembo (1969) there are five components of an instructional model. They are (a) identification of predispositions, (b) specification of the objectives, (c) utilization of appropriate instructional procedures, (d) performance assessments, and (e) formulating and testing hypotheses. A well developed instructional model can provide the framework on which effective lessons are developed. Determining which model works best for the teacher and the learners involved is important to the educational process. This is especially true when teaching students with special needs (Frew & Klein, 1982).

Behavioral model

The behavioral model is based on the work of Skinner (1938), who theorized that teachers could use operant conditioning, to reward or punish students for their behavior. The behavioral model began as a theory for training animals through reinforced behaviors, such as rats depressing levers, or pigeons completing puzzles to get food (Vogel & Annau, 1984). Behaviorist theories were then expanded to student learning. According to Moran (2004), reinforcing student learning is not only effective, but it increases the rate of which students learn specific objectives. Reinforcing student behavior is crucial in a behavioral model so students will respond to a particular stimulus (Mercer & Snell, 1977). Frew and Klein (1982) stated, "[In the behavioral model] children with learning problems have been rewarded for good work instead of being punished for inadequate work" (p. 101).

Direct instruction

Direct instruction, or explicit instruction, is a model of instruction that attempts to identify the link between teacher actions and student learning (Brophy & Good, 1986; Eggen & Kauchak, 2006; Pearson & Dole, 1987; Rosenshine & Stevens, 1986). Borrich (2000) described the direct instruction model as a teacher-centered approach in which the instructor is the main source of information. Researchers (Adams & Engleman, 1996; Forness, Kavale, Blum, & Lloyd, 1997; Kinder et al., 2005; White, 1988) indicated direct-instruction is an effective model of instruction for students with special needs, since the instruction can be tailored for each student. Merchand-Martella, Slocum, and Martella (2004) claimed that direct instruction is an effective method of instruction for students with special needs because it overtly provides students with structure that they need to be successful. According to Borich (2000) direct instruction does not teach complex concepts, patterns, and abstractions to students as effectively as other methods. He also claimed that it can be difficult for students to apply the skills learned through direct instruction into other situations.

Inquiry-based instruction

The inquiry-based instruction model stresses the learning and thinking process rather than just the acquisition of specific skills. An advantage of using inquiry-based instruction for students with special needs is that it promotes the thinking process and teaches students how to process information in addition to skill and knowledge development. In essence, the focus of inquiry-based instruction is more on the actual process of learning than the understanding of specific concepts. The inquiry-based instruction model operates under the idea that if students are comfortable with the process of learning and can engage in the scientific process they can construct knowledge about new concepts and transfer knowledge from other concepts (Doolittle & Camp, 1999; Frew & Klein, 1982; NRC, 2000).

Summary

Educating students with special needs can be a challenge. Instructional models can be useful to direct instruction for student (Taba et al., 1964). Several models have been considered and have been extensively tested through empirical studies. Inquiry based instruction shows some promise in delivering effective instruction to students with special needs despite behaviorism and direct instruction being the historical pedagogical practice norm.

Special Needs Students in School Based Agricultural Education

History

In 1975 congress passed The Education of All Handicapped Children Act, and later revised it in 1990 to become the Individuals with Disabilities Education Act [IDEA] (Giffing, Warnick, & Tarpley, 2009). The most recent update of IDEA was in 2004 (Smith, 2007). IDEA requires that all students are required to be educated in the least restrictive environment. For most students this means mainstreamed into the normal classroom (Giffing et al., 2009). The 2004 reauthorization of the IDEA act added an increased focus on using scientific thinking and inquiry-based instructional strategies (Kinder et al., 2005).

The Carl D. Perkins Vocational Act of 1984 and reauthorizations in 1989, 1995, and 2006 mandated that appropriate vocational education be provided to students with special needs. The act extended IEPs to students enrolled in vocational courses (Retish, Hitchings, Horvarth, & Schmalle, 1991).

The No Child Left Behind [NCLB] Act of 2001 (U. S. Department of Education, 2008) increased accountability for students with special needs. The law made schools accountable for academic performance of all students, particularly students with special needs. If a subgroup of students does not meet the adequate yearly progress [AYP], then the school could face repercussions. Since NCLB was enacted increased pressure has been placed on students in these subgroups to meet AYP. This pressure for students with special needs to succeed encourages instructors to find ways to make these students successful (Anderson, Seevers, Dormody, & VanLeeuwen, 2007).

Research

Since Smith-Hughes, agricultural education was intended to prepare non-college bound students for the workforce. With courses using task-oriented curricula, students with special needs enrolled in these courses (Elbert & Baggett, 2003). A significantly higher proportion of students with disabilities were mainstreamed in agricultural education courses than core subjects (U.S. Department of Education, 1994). These students take career and technical education courses to aide in career transition based on the student's abilities and interests (Harvey, 2001). According to Falvey, Blair, Dingle, and Franklin (2000), career and technical education students are becoming more heterogeneous as students are being mainstreamed into these classes. This heterogeneity can be difficult for instructors to develop effective curricula and deliver meaningful instruction. Compounding this, Jones and Moore (2000) and Moore, Ingram, and Jones (2001) found that instructors were less comfortable teaching mentally challenged students.

Modifications for students with special needs can provide the support they need to be successful. According to Richardson (2005), agricultural teachers in North Carolina employed modifications for their students that are consistent with the current research. Agricultural education instructors need to be aware of their students' disabilities and have information on how to provide appropriate accommodations for them in their classroom. Without the modifications required, a student may not fully benefit from the instruction provided.

Students with special needs historically take agricultural courses in order to prepare them for careers. Agricultural education falls under the umbrella of Career and Technical Education because of the career training that these courses provide. According to Wonacott (2001), students with disabilities were less likely to drop out and were more likely to be employed if they were involved in career and technical education. Eisenmann (2000) found through qualitative measures that students with special needs had higher academic achievement and postsecondary engagement when involved in a career and technical education program. According to Gaona (2004) students with special needs benefited from career and technical education because the hands on activities in these courses tend to be more effective for these students.

Learning about student's needs is important so that instructors can tailor lessons to their students. Instructors should also be aware of which methods of instruction will help these students succeed in the classroom. A limited amount of research has been done in regard to special needs students in agricultural education.

Constructivist Theory

The theory of constructivism was born out of the observations of Piaget (1954). From watching his children discover the world around them at a very young age, he developed the theory that there is no absolute truth in the world, but that truth is constructed based on experiences and social mediated boundaries. These ideas mirrored the earlier philosophies of Dewey (1938). In constructivism, ideas merely predict or explain a certain occurrence. If the idea predicts or explains the occurrence with a certain degree of frequency, then it becomes accepted as something generally agreed upon (Colburn, 1998).

As an example consider Sir Isaac Newton's "discovery" of gravity. Gravity is simply his way to explain the phenomena of things falling to the earth. Gravity existed before it was discovered and studied. Newton attempted to construct knowledge to explain what was going on around him and scientists today continue to construct new knowledge about why and how gravity happens.

The behaviorist classroom involves a dyadic relationship between the teacher and student. The teacher provides the knowledge to the students and the students receive knowledge. In a constructivist classroom learners build their own knowledge through experiences, problems, questions, and reflection (Dewey, 1938; Glasserfield, 1996; Colburn, 1998).

For students to be able to construct their knowledge, an emphasis must be placed on the process of learning rather than the final result of the instruction. This causes classrooms and laboratories to be student centered learning environments that focus on how the students are interacting with and thinking about the concepts being taught. Papert (1996) pointed out that in education so much emphasis has been put on pedagogical approaches, or understanding the art of teaching, that emphasis has been taken away from the art of learning. Constructivism puts the emphasis back on the learner.

In a constructivist classroom various strategies are implemented that focus on how the learners are engaged with the content. These strategies can be, but are not limited to, cooperative learning, questioning, reflective practice (through journals or other means), demonstration teaching, active assessments, and inquiry-based instruction (Colburn, 1998). Inquiry-based instruction is a particularly useful way to bring constructivism to the classroom because it involves questioning, reflection, and investigation, and other learner centered strategies (Colburn, 1998; Doolittle & Camp, 1999).

Inquiry-Based Instruction

Definition and History

At the turn of the century direct instruction of science was the norm for teaching. Dewey (1938) called for a change in the way science was taught in the classroom. He called for a more hands on approach that called on the learners to not only be engaged in hands on learning, but to reflect on the situations and construct abstract conceptualizations based on those experiences. Dewey called for a style of learning that forced the learner to develop their own ideas to explain their experiences, which eventually lead to the theory of constructivism.

Inquiry was born out of constructivist ideals (McMahon, 1997; Thomas, 2008). According to Llewllyn (2002), knowledge is not capable of being transferred from one person to another but is instead created in the mind of the learner. Constructivists believe that learning is constructed personally, through reflection and socially through interactions with peers (Doolittle & Camp, 1999). A constructivist-based, inquiry oriented classroom is student centered rather than teacher centered (Thomas, 2008). The tenants of constructivism seem to be similar to the work of others. Piaget (1970) claimed that learners acquire knowledge through guided questions related to problems provided to the learner. Constructivism suggests that learners learn when they are involved in meaningful activities that challenge them to form new relationships with what they already know (Kafai & Resnick, 1996). Constructivism happens when a student's function or pattern is disrupted and they are forced to construct knowledge for this disruption to make sense. In constructivism students rely on their previous experiences and build on them in order to construct new ideas to make sense of a phenomenon (Llewellyn, 2002). The constructivist-based classroom is not a strictly structured on a fixed curriculum, but rather an environment where teachers pursue student questions, facilitate learning from various sources, promote collaborative learning, and allow the students to develop their own understanding (Brooks & Brooks, 1999; NRC, 1996; Thomas, 2008). Inquiry-based instruction has been derived from the ideals of constructivism (Thomas, 2008).

During the 1960s, researchers (Suchman, 1962;; Taba 1966; Taba et al., 1964) began developing the foundation for inquiry-based instruction. According to Taba et al. (1964):

> The role of questions becomes crucial, and the way of asking questions by far the most influential teaching act. A focus set by the teacher's questions circumscribes the mental operations which students can perform, determines which point they can explore, and which modes of thought they learn. (p. 53)

In the 1970s interest in inquiry-based instruction waned due to the "back to the basics" reform in education. Despite the movement, some continued to use inquiry instruction (Joyce & Wiel, 1972). Joyce and Wiel (1972) claimed that inquiry-based instruction was at the forefront of educational reform. They point to inquiry as a model where students inquire into and reflect about the natural world around them. More recently there has been an epistemological shift emphasizing inquiry-based instruction. A program of curriculum reform announced in 1990, which emphasized inquiry-oriented learning, was issued as a call to make the United States a world leader in student science achievement (Scruggs, Mastropieri, Bakken, & Brigham, 1993).

According to Flick (1995), one reason for the limited research on inquiry instruction is that there is not an agreed upon operational definition for inquiry-based instruction, therefore difficult to distinguish from traditional instruction. Perhaps inquiry instruction is more prevalent than once believed. However, since several operational definitions existed before the National Science Education Standards (NRC, 1996), inquiry-based instruction had different meanings to different individuals.

In 1996, the National Research Council, in developing the National Science Education Standards [NSES], provided a framework for inquiry instruction as well as a guide for instructors. This publication calls for a reform of science instruction (National Research Council, 1996) to meet the needs of science teachers in the United States, just as Dewey (1910) did many years earlier. One of the goals of the NSES (NRC, 1996) was to increase scientific literacy nationally. These standards focused on inquiry instruction as a teaching and learning strategy for students in an effort to promote scientific literacy (NRC, 1996).

Inquiry-based instruction is a method of instruction that forces students to use the scientific process to find the answers to questions. The NSES (NRC, 1996) defined inquiry in education as:

> A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanation. (p. 23)

Scientific inquiry in the classroom focused on science as a process rather than just the memorization of facts (NRC, 2000). Conducting scientific inquiry in the classroom requires instructors to facilitate instruction where the students identify and pose questions, design and conduct investigations, analyze data and evidence, use models and explanations, and effectively communicate their findings (Keys & Bryan, 2001).

Inquiry instruction involves students “doing” science (NRC, 2000). According to Thomas (2008), inquiry instruction can be divided into three phases, posing a question, planning a procedure and formulating results. Posing a question involves the teacher asking a question or directing student questioning into a researchable question. Planning a procedure includes hypothesizing a practical outcome, developing methods that control for variable, and develop a materials list. This step can be guided by the teacher or left open ended, depending on how comfortable the students are with the inquiry process. The final phase is formulating the results, which entails organizing data, analyzing data, formulating conclusions, and evaluating the validity of the experiment (Llewellyn, 2006; Thomas, 2008).

Research on Inquiry Based Instruction

Gibson and Chase (2002) tested whether students taught science using inquiry instruction at a weeklong camp considered science careers and if they enjoyed science activities. Students were interviewed and randomly selected to attend the camp and selected based on their ethnicity in order to reflect the ethnic and gender balance of traditional schools. The students not selected to attend the camp were used as the control group. While both groups lost interest in science as they grew older, longitudinal evidence found that the control group lost more interest in science and had a lower interest in science careers. This suggested that the treatment of inquiry instruction had a positive effect on these students interest in science. The decrease in interest in science in both groups in this study indicated that science instruction was perceived differently by students in high school than in middle school. Middle school instructors tend to provide more inquiry-based instruction in their classes than do high school instructors (Gibson & Chase, 2002).

Yerrick (2000) studied inquiry-based instruction on lower achieving science students. In his qualitative study he concluded through the results of pre and post interviews that lower achieving science students had more confident knowledge claims, could provide more scientific explanations and answer scientific questions better. Before issuing the treatment, students offered naïve answers as they searched for the "right answer." When the students could not find the "right answer" they stopped trying. After the open inquiry science lesson students argumentation skills increased and they were able to formulate testable hypotheses for answers to difficult questions with no "right answers."

According to a study by Huber, Smith and Shotsberger (2000), students who are taught using inquiry-based instruction according to the standards have higher perceptions of science and report a noteworthy improvement in science. They reported that students felt more successful in their science classes, enjoyed learning science, and found the lessons to be useful. Their study was significant because the inservice teachers administering the treatment attended training similar to the workshop planned for this study. Von Secker (2002) found empirical evidence that suggests inquiry-based instruction leads to higher achievement than courses not taught using inquiry-based instruction. Von Secker and Lissitz (1999) agreed inquiry instruction leads to higher achievement when taught in standards-based science classes.

Geier, Blumenfield, Marx, Krajcik, Fishman, Soloway et al. (2008) found in a study of 7th and 8th graders that inquiry-based instruction was effective in increasing scores on standardized high stakes testing, particularly when students were involved in inquiry-based classrooms for two years. Wolf and Fraser (2007) noted that 1-2 day inquiry-based lessons could be effectively used to increase skills such as student cohesiveness, task orientation, cooperation, equity, and attitudes. They also noted that brief inquiry-based lessons can be an effective way to teach the numerous objectives required from standardized tests. Geier et al. (2008) and Wolf and Fraser (2007) noted that inquiry-based instruction held more of a benefit for males. Geier et al. (2008) found that inquiry-based instruction helped males close the gender gap present in urban schools. Wolf and Fraser (2007) found that males in inquiry-based classrooms had more cooperation, task orientation, and had a more positive attitude towards learning about science concepts than did females.

There are some criticisms of inquiry instruction. Von Secker (2002) claimed that inquiry-based instruction can be sensitive to social and cultural differences and can widen achievement gaps among some groups of students due to the contextually specific examples and questioning involved in inquiry-based instruction. Von Secker and Lissitz (1999) noted females and minority students are more at risk for low achievement when taught using inquiry-based instruction. Inquiry-based instruction is more difficult to implement in schools that lack resources, due to the amount of resources needed to successfully implement effective inquiry-based lessons (Von Secker & Lissitz, 1999). Rodriguez (1997) claimed inquiry-based instruction, as outlined by the standards (NRC, 1996), omit ethnic, socioeconomic, and gender issues related to the use of the standards.

In a qualitative study involving K-12 teachers, Fuller (2001) found that instructors believe that inquiry instruction promotes student learning. She also noted that students seemed to enjoy the lessons more when taught using inquiry methods. The instructors noted that the lessons took longer to plan for and required more supplies. The study also found that once teachers began using inquiry instruction, most still used it six years later.

Inquiry-Based Instruction in School-Based Agricultural Education

The theories of Snedden and Prosser have been the basis of secondary vocational education in the United States from its inception. Implicit learning theory born out of behaviorist philosophies has been used by instructors for nearly a century (Doolittle & Camp, 1999). Doolittle and Camp argued that constructivist ideals align themselves with the goals of vocational education. Doolittle and Camp stated, "The student's ability to construct viable knowledge and to adapt is paramount" (p. 26). In vocational education too much emphasis is placed on the understanding of specific objectives. According to Doolittle and Camp, the focus should shift towards providing experiences to students that force them to think and construct new knowledge based on their experiences.

In agricultural education the problem-solving approach has been used for several years to deliver instruction to students. According to Crunkilton and Krebs (1982) the problem-solving approach is a method of teaching where teachers guide students through a series of questions, which provide a foundation for the lesson when answered by the students. Unlike inquiry-instruction, problem based instruction does not guide students through the complete inquiry process. Crunkilton and Krebs (1982) outlined the problem solving approach as an interest approach designed to get students engaged in direct instruction rather than a new teaching philosophy.

Brown (1998) defined the problem-solving approach to teaching as a four step process. These steps are:

1. Engagement- The issues in the classroom are related to the larger context of the student's world.

2. Inquiry- The students explore to find solutions to a problem that has no specific right answer.

3. Solution Building- Students generate solutions to the problem, through observation.

4. Reflection- Elements of the subject matter approach are defined in an assessment to structure the reflection.

Inquiry instruction and problem-based learning are very similar. Parr and Edwards (2004) noted that problem-based learning is inquiry instruction. They go on to argue that problem-based learning is based on constructivist principles. Dewey, (1916) emphasized the importance of reflection in education, claiming that learners must be involved in the experience both actively and cognitively, reflection during the experience process rather than simply absorbing information. Kolb (1984) also highlighted the importance of active reflection. This reflection should occur as a process during the inquiry. In problem-based learning the reflection of a structured assessment does not promote true reflection in the students, which is central to the learning process. Problem-based learning developed from behaviorist principles and inquiry based instruction born from constructivism are principally different. According to Lancelot (1929), the goal of problem-based learning is to teach students how to solve problems without help. Inquiry-based instruction goes much deeper than teaching students to solve problem.

Inquiry-based instruction focuses on teaching students how to think and process situations. The principle difference is that in inquiry-based instruction the students observe, think, process, reflect on, and test whatever is being examined. In problem-based learning, students focus only on solving the problem at hand. If the problem is the only focus then consideration of extenuating variables or alternative explanations/solutions, metacognition, and perhaps most importantly reflection is left out of the process (NRC, 1996).

Inquiry-Based Instruction for Students with Special Needs

History

Historically, direct instruction, where content is directly taught to students, is believed to be the best method for educating students with disabilities (Kinder, Kubina, & Marchand-Martella, 2005). In direct instruction, the lessons are largely instructor centered. The lessons in direct instruction are taught using the paradigm that the teachers provide the instruction to students and provide immediate correction if the student is incorrect. The ultimate goal of direct instruction is an assessment of some sort with set correct responses that are established by the instructor (Ganz & Flores, 2009).

Direct instruction was born out of behaviorist ideologies like those proposed by Thorndike and Skinner. Thorndike (1911) theorized that students would behave similar to the animals in his tests that learned faster when rewards where provided. Skinner (1938), adding to those tests claimed that the reward need not be provided every time. This operant conditioning provides the basis for direct instruction where students are operantly rewarded for correct answers (Llewellyn, 2002). Swanson and Sachse-Lee (2000) and Vaughn, Gersten, and Chard (2000) noted that students with learning disabilities learn better in environments where they are directly taught content, and opportunities are given for repetition, guided practice and review.

In congruence with Thorndike and Skinner, Flick (1995) claimed that inquiry teaching strategies can cause discourse with “slow learners.” However, Rapp (2000) argued that instructors of special needs students need to be more creative in their instruction and use inquiry teaching strategies. McCarthy (2005) found that when compared to a textbook approach to teaching, thematic-based, hands-on science is a more effective method of teaching students with emotional disturbances. While she admitted that thematic-based, hands-on instruction takes more time and effort, there was a difference in academic achievement.

While Rapp (2000) and McCarthy (2005) both referred to active teaching strategies that are similar to inquiry based instruction, little research exists on inquiry-based instruction for students with special needs. Research needs to be conducted to determine if these methods can be considered inquiry strategies.

Research on Inquiry-Based Instruction for Students with Special Needs

Scruggs, Mastropieri, Bakken, and Brigham (1993) studied the effects of an inquiry-oriented approach to science learning in special education classrooms when compared to a textbook-based approach. Using a quasi-experimental design they determined students’ vocabulary, factual recall, and application test questions scores with the two treatments. They found that inquiry-oriented approaches helped facilitate the acquisition of content knowledge by students. They also noted that when taught through inquiry-oriented approaches, students learned and remembered more and also enjoyed learning more.

Fuller (2001) found that students involved in special education and inclusion settings performed comparably to regular education students when comparing perceived change in teaching and learning component scores in their classrooms. The study also found that there was little difference in the effectiveness of inquiry in the classroom when comparing these same class types. No significant difference was found between classroom types in how much the students enjoyed inquiry-based instruction. These findings indicate that inquiry instruction can be relevant for learners with special needs and an effective way to teach science concepts.

Conceptual Model

This study is guided by a conceptual model adapted from Mitzel (1960), Dunkin and Biddle (1974), and Singer and Moscovici (2008). The model identifies several variables that need to be considered for this study. The concept for the model is based on the work of Mitzel (1960). The basic model identifies variables to be considered in teaching and learning. The structure for the model was developed by Dunkin and Biddle (1974). The IMSTRA framework for inquiry-based instruction was developed by Singer and Moscovici (2008) (see Figure 2-1).

Presage Variables

Presage (teacher) variables identify teacher differences. Some examples of presage variables could include, experience level, teacher training, age, preferred learning style, etc. All teachers are different, and these differences are important to consider (Duncan & Biddle, 1974; Mitzel, 1960). However, for this study efforts have been made to hold presage variables as a constant. Since the teachers have similar experience levels (more than three years), and have received similar training, these variables are somewhat similar. While variations of the other presage variables are expected, an assumption has to be made that these factors had no influence on the product variable.

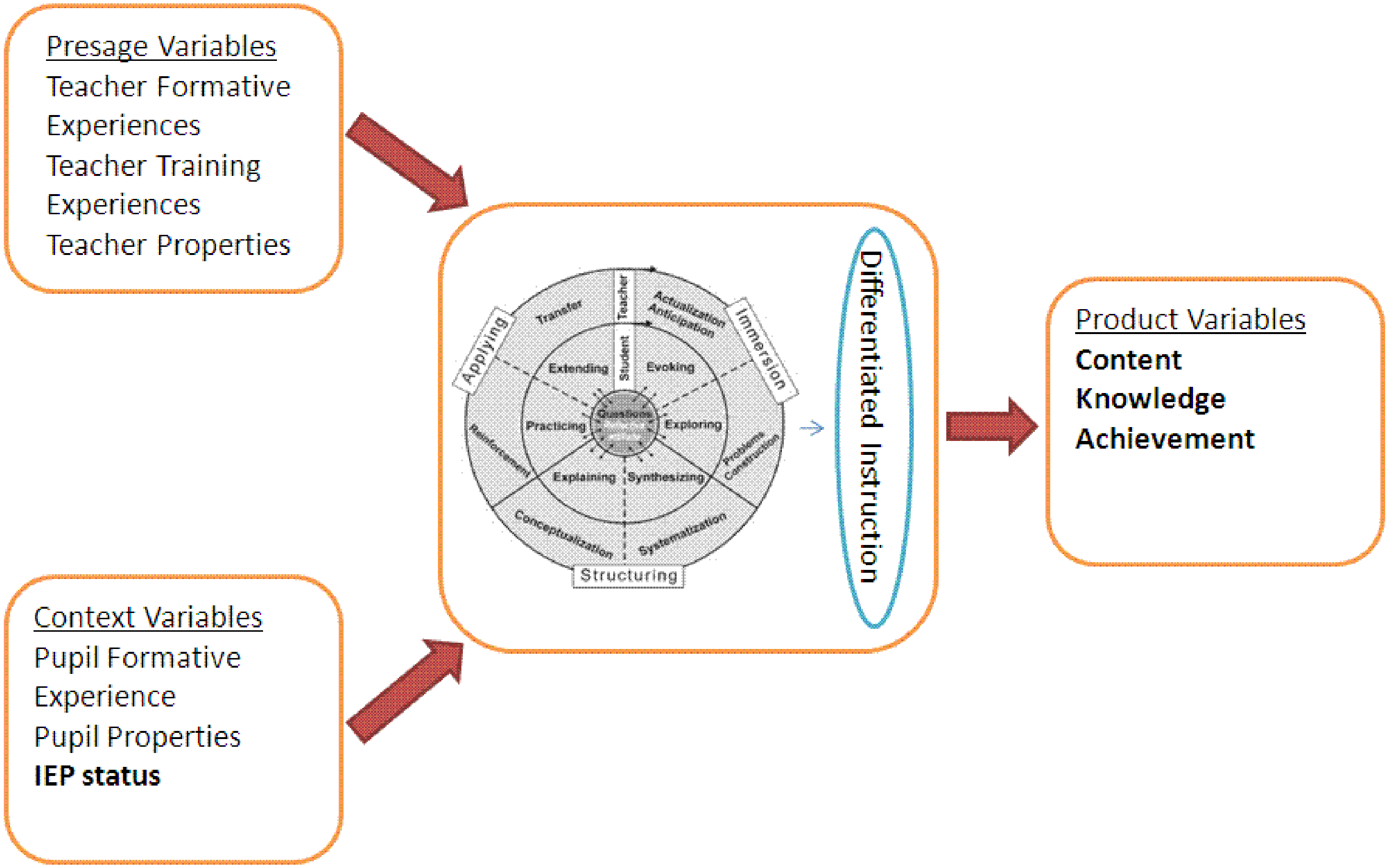

Figure 2-1. A model for the study of classroom teaching (Dunkin & Biddle, 1974) including the IMSTRA framework for teaching and learning (Singer & Moscovici, 2008) and the process of differentiated instruction (Tomlinson, 2001) as it relates to this study

Context Variables

Students in any classroom can differ drastically. Their home life, the amount of sleep they have had, their background knowledge and their learning preferences could have an influence on how the students learn in the classroom. These variables are known as context variables. For this study IEP status was the context variable of interest. Gender, ethnicity, and socio-economic status were analyzed to determine if any effect was present. Researchers (Geier et al., 2008; Wolf & Fraser, 2007; Von Secker & Lissitz, 1999; Rodriguez, 1997) have found that inquiry-based instruction is biased to these learners. All other context variables are held as constants using statistical analysis and by having a large enough sample size.

Process Variables

The process variable refers to the method of instruction used by the instructor to deliver the content. The process variable can be the teaching method used, or specific delivery for the content (Mitzel, 1960; Duncan & Biddle, 1974). For this study, inquiry-based instruction is used to deliver the content to the students. This method is held as a constant throughout the study. For instruction to be effective for all students, it must flow through the lens of differentiated instruction (Tomlinson, 2001).

IMSTRA Framework

The IMSTRA framework for the teaching and learning cycle outlines the inquiry-based instruction process in a cyclical model. The framework identifies both student and teacher variables that take place during the process of inquiry-based instruction. The framework is based on constructivist principles and built on the idea that the learner is an autonomous thinker that constructs their own knowledge. The model uses three key stages to explain the inquiry-based instruction process; Immersion, Structuring, and Applying. In the Immersion phase, students begin to address a problem or issue. Here they are probed to seek more information about the phenomena. As the name, Immersion, implies students may face a problem without an obvious answer. In the second phase, Structuring, students begin to try to explain the problem presented during the Immersion phase. Here students may test hypothesis, relate the problem to other problems, or seek abstract conceptualization to make sense of the problem. During the final stage, Applying, students apply the abstract pattern that they learned during the Structuring phase to apply it to other situations. During the Applying phase, teachers are interested in assessing what students learned and determining their ability to apply it to various situations.

The IMSTRA framework for the teaching and learning cycle can help teachers and students understand the inquiry process. As the circular nature of the model implies, each cycle of the model should lead into the next cycle. Inquiry-based instruction should build on itself so larger concepts can be linked together.

Differentiated Instruction

For instruction to be effective for all students, it must flow through the lens of differentiated instruction. Differentiated instruction is the process of making instruction a custom fit for all students in a mixed ability classroom. According to Tomlinson (2001), differentiated instruction is a proactive, qualitative, student-centered approach that is rooted in assessment, utilizes multiple approaches, and is a blend of different types of instruction. Differentiated instruction involves differentiating (a) content, (b) process, and (c) product (Tomlinson, 2001). Lessons can be differentiated by content by altering what students actually learn, or the objectives of the lesson. Process is differentiated by allowing students to explore the content through different means. Product differentiation refers to having different ways students can demonstrate what they have learned. According to Sternberg and Zhang (2005), differentiated instruction helps students explore their stylistic preferences and allows them to engage in instruction that is unique to them and specific to their preferred learning style. George

(2005) argued differentiation increases equality in mixed ability classrooms, since students are given more flexibility and variety in their instruction. Differentiated instruction can also be useful for students with disabilities because it provides teachers with an arsenal of teaching strategies to help reach these students (George, 2005).

Product Variable

The product variable is the measureable outcome performed by the student. The product variable measures knowledge or skills gained by the student. Quantifying knowledge gain can be a difficult process. Standardized tests based on precise curriculum are typically used by school systems to measure learning. This method of measurement typically makes it easier for school systems, states, and more recently federal government to make comparisons among students and school (Geier et al., 2008). Assessments based on precise curriculum were used for this study to measure content knowledge achievement. Evidence has been provided in this chapter that promotes the use of inquiry-based instruction to promote content knowledge achievement.

Chapter Summary

This chapter discussed agricultural teachers' challenges in educating students with special needs and analyzed various teaching methods for delivering instruction to them. The theoretical framework for the study, Constructivism, questioned the behaviorist and direct instruction norms that are currently used to educate students with special needs. A case for inquiry-based instruction was made, pointing to studies that outline the possible benefit of inquiry-based instruction for students with special needs. Studies of inquiry-based instruction in agricultural education were also analyzed. A limited amount of research exists on inquiry-based instruction for students with special needs in agricultural education. The little research that does exist on the subject was analyzed. The conceptual model for the study was analyzed. The presage variables were controlled in this study, and the context variable of interest was student with special needs and students without special needs. The process variable was inquiry-based instruction based on the IMSRA framework (Singer & Moscovici, 2008). The produce variable measured was content knowledge achievement.

CHAPTER 3
METHODS

Introduction

This study was designed to demine how inquiry-based instruction impacts content knowledge achievement for students with special needs. In order to achieve the purpose of this study the following objectives were investigated:

- Describe the population of special needs School Based Agricultural Education students.
- Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.
- Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

This chapter describes the pre-experimental, quasi-experimental design used to complete this research. The population is defined by the researcher (Campbell & Stanley, 1963).

Research Design

This study utilized the one-group pretest-posttest design, a quasi-experimental design (see Figure 3-1) (Campbell & Stanley, 1963). This design was selected because random assignment of subjects was not practical. Moreover, a true control group that receives no treatment as defined by Campbell and Stanley (1963) would not have been ethical since the students in the study were expected to learn the content of their courses. Only one group was needed because IEP status served as the variable of interest for the study within one type of instruction. For this design one intact group received a pretest, followed by the treatment of inquiry based instruction, and then a posttest to measure content knowledge achievement. For this study, pretests and posttests measured the dependent variable (content knowledge achievement). The treatment was inquiry-based instruction delivered by an experienced agricultural teacher that has attended the National Agriscience Ambassador Academy [NATAA]. The study utilized a series of seven treatment periods with a pretest and posttest used to measure content knowledge before and after each lesson respectively. The pretest (O_{ckpre1}) was administered prior to the first lesson. After the treatment (X_1) was delivered the posttest ($O_{ckpost1}$) was administered. The treatment typically lasted 1-2 weeks. Through the course of the study students were referred to solely by their subject ID number on the pretest, posttest, and demographic sheet to maintain student confidentiality.

One-Group Pretest-Posttest Design

O_1	X	O_2

Figure 3-1. One-group pretest-posttest design

- O_{ckpre1} X_1 $O_{ckpost1}$ O_{ckpre2} X_2 $O_{ckpost2}$ O_{ckpre3} X_3 $O_{ckpost3}$ O_{ckpre4} X_4 $O_{ckpost4}$ O_{ckpre5} X_5 $O_{ckpost5}$ O_{ckpre6} X_6 $O_{ckpost6}$ O_{ckpre7} X_7 $O_{ckpost7}$

The study took place as part of a larger quasi experimental design study that compared inquiry-based instruction to the subject matter approach.

Population

The theoretical population of this study is agricultural education students in the United States. The sample of the study was limited to 204 students instructed by a graduate of NATAA program selected for this study. The NATAA is professional development program that allows experienced agriculture teachers to develop their ability to teach inquiry-based instruction. Ten experienced agricultural teachers who have previously completed the NATAA program were selected to participate in the study. The instructors have employed inquiry strategies in their classrooms have conducted inservice workshops on inquiry instruction since completing the program. Each instructor taught inquiry-based lessons to one class of approximately 20 students. To help ensure the consistency of treatment, these instructors have all received the same training on inquiry-based instructions and were given special instructions and training regarding participation in the research project.

Sample Size

Individual students served as the sampling unit for the study but they were selected as members of an intact classroom. A large enough sample size was important to ensure reliability and to measure the variables of the study properly. Myers (2004) suggested using a formula to determine an appropriate sample size for the study. The sample size was selected in order to minimize the possibility of a Type I error to .05, achieve the desired power of .90 and detect variances grater than .10 in the dependent variable due to the independent variables. The following formula was used to establish an appropriate sample size

$$n = 2[Z_{(1-\alpha/2)} - Z_{\beta}]^2 + \Delta^2$$

In the formula $Z_{(1-\alpha/2)}$ is the *z* score for the desired alpha level (.05), Z_{β} is the *z* score for the .90 power, and Δ is the standard deviation of the effect. Δ is established by the formula

$$\Delta = 2\sqrt{(w^2)} \,/\, \sqrt{(1 - w^2)}$$

In which w^2 represents the variance of the dependent variable accounted for by the independent variable. This study used the calculations

$$\Delta = 2\sqrt{[.10 \,/\, (1 - .10)]} = .66$$

$$n = 2[1.96 - (-1.64)]^2 + .66^2 = 59.5$$

The formula determined that a minimum of 60 participants were required to have an appropriate sample size. A 50% mortality can be expected so this number should be double to 120 (Boone, 1988; Dyer, 1995; Flowers, 1986; Myers, 2004). In order to obtain 120 students 10 in tact courses were used. Students missing more than 25% of the instructional time during the semester were removed from the study.

Limitations of the Study

All possible rival hypotheses were considered. Campbell and Stanley (1963) identify several threats to internal validity, including history, maturation, testing, instrumentation, regression, subject selection, and mortality. Since this study utilized intact classes, the randomization of groups limited the validity of the study. Since the study took place over several weeks, history and maturation of subjects and mortality were possible factors. Instructors were asked to note any significant events that caused a history effect so they can be noted in the results. The maturation effect was limited due to the time frame of the study. The pretest and posttests were given before and after each lesson to limit the maturation effect. Respondents had 1-2 weeks between the pretest and posttest for most objectives. There was also a possibility of a testing effect influencing the results of the posttest, however there was a week of instruction between the pretest and posttest, and alternate forms were used, therefore the effects should be limited. Mortality was anticipated and controlled for by having a large sample of students. There was a possible instrumentation effect (instrumentation decay), but since the multiple choice tests were administered the same way and were different forms of the same exam, the testing effects were minimal. A regression effect was also considered and controlled for using statistical analysis measures. A possible threat to validity was the differences of groups. In order to eliminate the threat to validity several groups were selected and statistical measures were taken. The study was also limited in its generalizability since the instructors participating are chosen purposefully from instructors who have attended the National Agriscience Teacher Ambassador Academy (Ary, Cheser Jacobs, Razavieh, & Sorenson, 2006; Campbell & Stanley, 1963).

Procedures

The study utilized a one-group pretest-posttest design (Campbell & Stanley, 1963). Instructors administered a pretest to gauge base knowledge, then taught an 10-12 week inquiry-based unit about properties of soils to their agricultural education students. The 10-12 week inquiry-based instruction treatment was split into seven lessons guided by specific student learning objectives. The lesson plans were developed by the researcher and were created as inquiry-based instruction methods. The lessons were adopted from Center for Agricultural and Environmental Research and Training [CAERT] curriculum for inquiry-based instruction. The lessons focused on soil science content consisting of seven units. The units included the following topics: nature of soil, soil formation, soil color, soil texture and structure, soil profile, moisture holding capacity, soil erosion and management, soil chemistry, fertilizer formation, applying fertilizers, nutrient deficiencies, seed germination process and requirements, plant life cycles, photosynthesis, and respiration. Students that missed more than 25% of the instructional time were dismissed from the study since the control was not properly administered during that time. Content and face validity were validated by a panel of experts compromised of faculty from the Agricultural Education and Communication Department and the School of Teaching and Learning at the University of Florida. Upon the conclusion of each inquiry lesson the instructors administered a posttest to gauge the students' content knowledge achievement. The pretest and posttest were different forms of the same test. The pretest and posttest were developed by the researcher and piloted to a group of undergraduate students. The seven assessments have a coefficient alpha determined by a Kuder-Richardson 20 (KR 20) for dichotomous data of .94, .93, .91, .86, .87, .89, and .91 respectively (Gall, Borg, & Joyce, 1996).

Demographic information was collected on the students including their year in school, gender, IEP status, and any disabilities the students have. The instructors were encouraged to complete a differentiation checklist and reflection tool prior to and after each lesson to ensure the lessons were differentiated for the students' disabilities. This tool allows the instructors to explain how they differentiated the lesson for the special needs students in the class and to analyze how well the lesson was differentiated. Samples of digital audio recordings were used to ensure the treatment was delivered. This study received IRB approval before the study began.

Instrumentation

This study used a Content Knowledge Achievement Assessment developed by the researcher administered as a pretest and posttest before and after each unit respectively.

Content Knowledge Achievement Assessment. An assessment created by the researcher was used to gauge student content knowledge achievement of the objectives used in this study. The content knowledge achievement assessment was created based on the information given to the instructors to be taught to students. There were seven separate assessments based on the inquiry-based units, with 25 questions on each assessment. The assessments were guided by a matrix that listed the percentage of the lesson spent on each concept, then a representative amount of questions were asked so the amount of questions from each objective matched the time spent in class for each objective (see Appendix D). The seven assessments have a coefficient alpha of .94, .93, .91, .86, .87, .89, and .91 respectively.

Data Collection

Data was collected using various measures. Demographic data, including IEP data was collected using a Microsoft® Excel® form created by the researcher (see Appendix I). The demographic form was then saved to a USB flash drive and mailed to the researcher. The content knowledge achievement assessments were completed by the students, then the results were saved on a flash drive and mailed back to the researcher. The digital audio recordings of the lessons were taken using a digital audio recording device given to the instructors prior to the study. The digital audio files were then saved on a USB flash drive and shipped to the researcher upon the conclusion of the study.

Analysis of Data

Data were analyzed using SPSS® version 16.0 for Windows® software package. The posttest scores served as the dependent variables, and the results were analyzed using an analysis of covariance [ANCOVA] where the pretest served at the covariate. The independent variable was the students' IEP status.

Chapter Summary

This chapter described the methods used to conduct this study. The research design, population, sample size, limitations, procedures, content knowledge achievement assessments, data collection, and data analysis processes were discussed during this chapter.

The study used a one group pretest-posttest design which is a quasi-experimental research design. The design includes seven pretest, inquiry-based treatment, and posttest cycles. For this study graduates of the NATAA delivered the treatment to their students. A sample size of 204 was used in order to properly measure the variables of the study while preventing Type I errors. This chapter identified and addressed several threats to validity including history, maturation, testing, instrumentation, regression, subject selection, and mortality. These threats were recognized and controlled for when possible. During the study 8-10 week inquiry-based lessons were taught. The lessons were broken into 7 separate units. Demographic data was collected as well as pretest and posttest scores on a content knowledge achievement instrument. The results were analyzed using SPSS® and analysis of covariates [ANCOVA] were used to determine content knowledge achievement.

CHAPTER 4
RESULTS

Introduction

The purpose of this study is to determine if inquiry-based instruction impacts content knowledge achievement for students with special needs. In order to analyze students with special needs, comparisons were made between those students with IEPs and students without IEPs in School-Based Agricultural Education. In order to achieve the purpose of the study the research was guided by the following objectives:

- Describe the population of special needs School Based Agricultural Education students.
- Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.
- Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

In order to achieve the research objectives a purposive sample of School Based Agricultural Education programs was conducted from 10 schools around the country. A total of 204 students were enrolled in the selected classes used in this study. No data was received from three of the schools participating in the study. In one case repeated contacts were made to the instructor. After the study was completed the instructor contacted the researcher and explained their inability to participate due to personal health reasons. A second instructor incurred family medical issues and asked to withdraw from the study. A third instructor withdrew from the study during the first week because of being assigned a new teaching role that did not meet the guidelines of the study. A total of 27 students were removed from the study due to non-participation. A further 7 students were removed from the study due to missing more than 25% of the instructional time during the semester, as was determined *a priori* as outlined in chapter 3. A final *n* of 170 students were used in the study.

This chapter presents the findings distilled from unit pre and post tests taken by students taught using inquiry instruction and makes comparisons based on IEP status.

Reliability of Assessments

As outlined in chapter 3 a coefficient alpha for the dichotomous data of content knowledge achievement [CKA] exams was calculated by assessing pilot test results in order to determine the reliability of the assessments. The post-test questions were asked in a randomly selected order to reduce the overall testing effect (Campbell & Stanley, 1963). The seven CKA pretest and posttests had a mean summated score of 48.2, 50.0, 47.8, 48.2, 56.9, 45.3, and 57.5 respectively. A Kuder-Richardson [KR20] for dichotomous data was used to determine the coefficient alpha (Gall, Borg, & Joyce, 1996). The instruments were determined to have a coefficient alpha of: .94, .93, .91, .86, .87, .89, and .91 respectively (see Table 4-1).

Table 4-1. Pilot test mean content knowledge assessment scores and instrument reliability

CKA instrument	Mean score	KR-20 alpha
1	49.4	.94
2	50.0	.93
3	47.8	.91
4	48.2	.86
5	56.9	.87
6	45.3	.89
7	57.5	.91

Note: CKA = Content Knowledge Achievement; CKA max score 100

Audio recordings were analyzed to ensure teachers were correctly implementing inquiry-based instruction. The Science Teaching Inquiry Rubric (STIR) was used as an assessment tool to analyze the level of inquiry-based instruction for each class. All seven teachers in the study effectively derived inquiry-based instruction (see Appendix A).

Objective 1 Describe the population of special needs School Based Agricultural Education. Students.

One-hundred and seventy students in 7 different schools across the nation participated in this study. In the study 57.6% (*n* = 98) of students were male and 42.4% (*n* = 72) were female.

Instructors were asked to report the ethnicity of students, for this study 81.8% (*n* = 139) were Caucasian, 9.4% (n = 16) were Hispanic, 4.7% (*n* = 8) were black, and 4.1% (*n* = 7) were listed as other (see Table 4-2).

Table 4-2. Summary of ethnicities

Ethnicity	*n*	%
White, non-Hispanic	139	81.8
Hispanic	16	9.4
Black	8	4.7
Other	7	4.1

Students were also analyzed based on their free and reduced lunch status as a measure of socio-economic status. Seventy-one point eight percent (*n* = 122) did not qualify for free or reduced lunch, 15.3% (*n* = 26) qualified for reduced lunch, and 12.9% (*n* = 22) qualified for free lunch.

Instructors were also asked to indicate whether or not the students were assigned an IEP. In this study 79.4% (*n* = 135) did not have an IEP assigned to them, 20.6% (*n* = 35) did have an IEP assigned to them. There were various reasons for the assignment of the IEPs, 13.5% (*n* = 23) were described as "other", 2.9% (*n* = 5) were described as having specific learning disability, 1.2% (*n* = 2) were described as having a speech or language impairment, 1.2% (*n* = 2) were described as having a visual impairment, 1.2% (*n* = 2) were described as having an emotional disturbance, 0.6% (*n* = 1) were described as having an orthopedic impairment (see Table 4-3).

Since this study utilized a small portion of school based agricultural education population these results are not generalizable to the larger population. Demographic data of the students in this study serve to compare the classes in this study to larger studies of agricultural education students and determine if the sample represents the population of students in school based agricultural education.

Table 4-3. Summary of IEP classifications

Learning Disability	*n*	%
Other	23	13.5
Specific learning disability	5	2.9
Speech or language impairment	2	1.2
Visual impairment	2	1.2
Emotional disturbance	2	1.2
Orthopedic impairment	1	0.6

Objective 2 Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.

By comparing means and standard deviations, inquiry-based instruction proved to consistently improve test scores from the pre to post assessments. For test one the mean score increased by 27.92 points. For test two the mean score increased by 30.52 points. For test three the mean score increased by 37.06 points. For test four the mean score increased by 40.63 points. For test five the mean score increased by 43.22 points. For test six the mean score increased by 47.92 points. For test seven the mean score increased by 51.41 points (see Table 4-4).

While mean score increase does not provide a statistical significance for the basis of validation for this method, it is important to note that an increase in score did occur. Since a control teaching method was not used the precise comparative impact of inquiry-based instruction cannot be calculated.

Table 4-4. Summary of central tendency measures for the seven unit content knowledge achievement pre and post assessments

	Pre Test		Post Test	
Source	M	SD	M	SD
Test 1	35.57	11.68	63.49	17.86
Test 2	35.72	12.78	66.24	14.86
Test 3	31.20	11.06	68.26	15.86
Test 4	36.19	13.88	76.82	13.67
Test 5	35.82	11.89	79.04	12.74
Test 6	33.72	13.78	81.65	10.32
Test 7	29.27	11.74	80.68	10.61

Gender differences were analyzed using an analysis of covariates [ANCOVA] measures. Several factors were considered to determine what demographic factors influenced content knowledge achievement. The post-test measuring content knowledge achievement served as the dependent variable being measured, the pre-test served as the covariate, and the fixed variable was the demographic factor being analyzed. A *p* value less that .05 was determined to be significant.

For all seven tests gender was not a significant fixed variable, and did not explain a significant amount of the difference in post-test scores when pre-test scores were controlled for (see Table 4-5).

Table 4-5. Summary of ANCOVA measures for content knowledge achievement for gender

Source	*df*	*F*	*p*
Test 1	1	0.33	.57
Test 2	1	0.42	.52
Test 3	1	1.32	.25
Test 4	1	0.00	.96
Test 5	1	0.82	.37
Test 6	1	0.02	.88
Test 7	1	1.60	.21

Note: Pretest is the covariate

Ethnicity differences were measured using ANCOVA measures. For test one (p = .00), test three (p = .02), and test four (p = .05), a significant difference was evident with a partial eta squared significance of 0.09, 0.06, and 0.05 respectively (see Table 4-6). Using Bonferroni correction of pairwise comparisons a significant difference of .01 was found between Caucasion and Other, with a mean difference of -20.44 on the for the first post-test. A significant difference of .03 with a mean difference of 10.49 was found between Caucasian and Hispanic groups for post-test three. A significant difference of .04 with a mean difference of 9.58 was found between Caucasian and Hispanic groups for post-test four. No other pairwise comparisons on the other tests yielded a significant difference of less than .05 using a Bonferroni comparison. No significant difference was evident for the remaining tests (see Table 4-6).

Table 4-6. Summary of ANCOVA measures of content knowledge achievement for ethnicity

Source	*df*	*F*	*p*	η^2
Test 1	3	5.48	.00	.09
Test 2	3	1.88	.13	.03
Test 3	3	3.57	.02	.06
Test 4	3	2.62	.05	.05
Test 5	3	2.51	.06	.04
Test 6	3	0.93	.43	.02
Test 7	3	0.81	.49	.02

Note: Pretest is the covariate

While a comparison of means does not provide statistical significance, it does provide some insight into how groups scored on the posttests for each unit. The mean scores for the black group are similar to those of the Caucasian group. When comparing the Hispanic the Caucasian group, the mean scores for the Hispanic group are lower. The other group mean posttest scores are higher than the Caucasian on five of the seven posttests (see Table 4-7)

Table 4-7. Summary of central tendency measures for the seven unit content knowledge achievement post-assessments separated by ethnicity

	Caucasian		Black		Hispanic		Other	
	n = 139		*n* = 8		*n* = 16		*n* = 7	
	M	SD	M	SD	M	SD	M	SD
Test 1	63.76	17.21	60.10	14.96	53.85	19.20	84.02	15.10
Test 2	66.79	14.96	68.00	17.24	57.75	12.65	72.57	15.90
Test 3	69.78	15.29	61.50	22.32	57.50	13.46	70.29	15.81
Test 4	77.83	12.71	79.25	11.80	68.00	20.34	74.29	10.03
Test 5	79.14	12.05	83.25	7.40	72.63	19.47	86.86	3.80
Test 6	82.45	9.93	78.50	13.34	78.00	11.22	77.71	11.28
Test 7	81.04	10.88	80.50	10.13	76.50	8.25	83.43	9.91

The mean scores for the earlier posttests seem to have more variance among the groups when the mean scores are viewed on a line graph (see Figure 4-1). By the final posttest the scores seem to have normalized, which is evident by the line graph (see Figure 4-1) and the standard deviations (see Table 4-7).

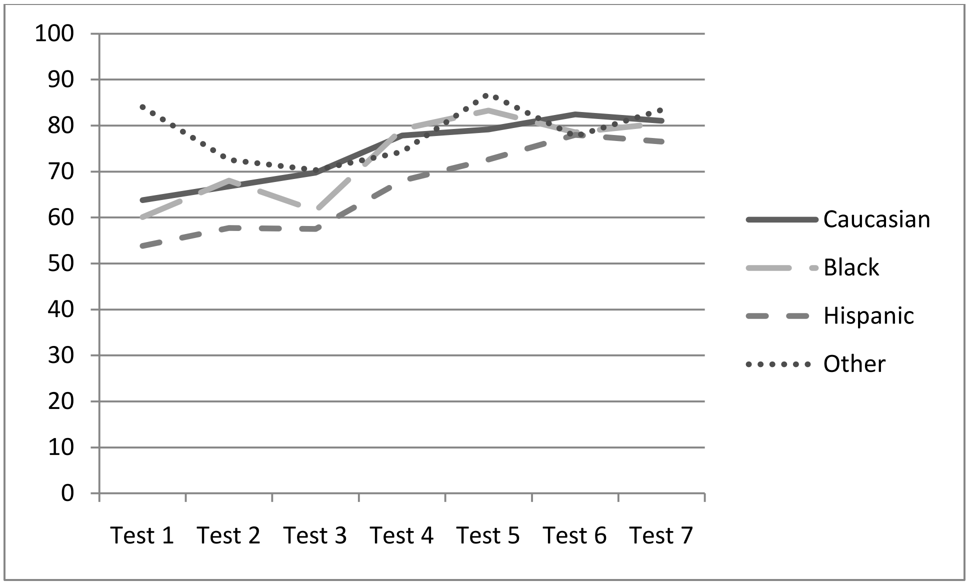

Figure 4-1 Comparisons of mean scores for the content knowledge achievement post tests

A low *n* can result in a false significant influence. Since black (*n* = 8), Hispanic (*n* = 16), and other (*n* = 7) were all low, an ANCOVA was performed grouping other ethnicities besides Caucasian in one group resulting in a *n* of 31. According to Israel (2009) a *n* of at least 20 must be present for comparative analysis of subgroups to prove significance. When the ethnicities were grouped together, there was a significant different for post-test 3 and post-test 4 when the pre-test 3 and pre-test 4 were controlled for as a covariate respectively and had and partial eta squared effect size of 0.04 and 0.02 respectively. For post-test 3 the Caucasian group mean score was 6.92 percentage points higher than the other combined groups. For post-test 4 the Caucasian group mean score was 5.32 percentage points higher than the other combined groups.

Table 4-8. Summary of ANCOVA measures of content knowledge achievement for ethnicity

Source	*df*	*F*	*p*	η^2
Test 1	1	0.18	.68	.00
Test 2	1	1.04	.31	.00
Test 3	1	6.12	.01	.04
Test 4	1	3.83	.05	.02
Test 5	1	0.06	.81	.00
Test 6	1	2.78	.10	.02
Test 7	1	0.88	.35	.01

There was no significant difference for the other assessments when ethnicity was a fixed variable (see Table 4-8).

Since ethnicity was significant at the .05 level it was combined with IEP status to determine if any difference existed on the variable of interest. No significance was found when both variables were considered (see Table 4-9).

Table 4-9. Summary of ANOVA measures of content knowledge achievement for ethnicity with IEP status

Source	*df*	*F*	*p*
Test 1	1	.47	.50
Test 2	1	.09	.76
Test 3	1	1.10	.30
Test 4	1	1.14	.29
Test 5	1	.10	.75
Test 6	1	.19	.66
Test 7	1	.36	.55

When free or reduced lunch status served as the fixed variable no significant difference was found in post-test scores when pre-test scores were controlled as the covariate. According the ANCOVA measurement free or reduced lunch status does not have a significant impact on content knowledge achievement (see Table 4-10).

Table 4-10. Summary of ANCOVA measures of content knowledge achievement for free or reduced lunch status

Source	*df*	*F*	*p*
Test 1	2	0.76	0.47
Test 2	2	0.41	0.66
Test 3	2	0.63	0.53
Test 4	2	0.24	0.79
Test 5	2	0.01	0.99
Test 6	2	0.93	0.40
Test 7	2	1.38	0.26

Objective 3 Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

IEP status was analyzed using ANCOVA measures. The post-test measuring content knowledge achievement served as the dependent variable being measured, the pre-test served as the covariate, and the fixed variable whether or not the student had an IEP. A *p* value less that .05 was determined to be significant. For all seven tests IEP was not a significant fixed variable, and did not explain a significant amount of the difference in post-test scores when pre-test scores were controlled for (see Table 4-10).

Table 4-11. Summary of ANCOVA measures for content knowledge achievement post assessments for IEP status

Source	*df*	*F*	*p*
Test 1	1	0.51	.48
Test 2	1	0.13	.72
Test 3	1	1.39	.24
Test 4	1	1.38	.24
Test 5	1	0.11	.74
Test 6	1	0.27	.60
Test 7	1	0.30	.59

IEP status had no significant impact on students' content knowledge achievement scores, which implies that students with special needs learn as much as their peers without special needs through inquiry-based instruction. While a comparison of means does not indicate a statistical significance, a comparison of means and standard deviations shows that there is little difference between the IEP and no IEP groups (see Table 4-11).

Table 4-12. Summary of central tendency measures for the seven unit content knowledge achievement pre and post assessments

	IEP		No IEP	
Source	M	SD	M	SD
Test 1	61.98	16.55	63.88	18.22
Test 2	64.69	13.70	66.64	15.17
Test 3	65.37	16.80	69.01	15.59
Test 4	74.40	18.53	77.01	12.11
Test 5	78.43	12.94	79.19	12.73
Test 6	80.57	8.52	81.93	10.75
Test 7	81.14	9.53	80.56	10.90

Summary

This chapter outlined the findings from the one group pretest posttest quasi-experimental design. A *n* of 170 students was used for this study. 204 were originally selected for participation in the study, the remaining 34 were removed due to non-participation and missing more than 25% of the instructional time. In order to determine the reliability of the instruments, a Kuder-Richardson [KR20] for dichotomous data was used to determine the coefficient alpha (Gall et al., 1996). The seven instruments have a coefficient alpha of: .94, .93, .91, .86, .87, .89, and .91 respectively. For this study 57.6% were male and 42.4% were female and 20.6% of students had an IEP. When comparing posttest scores based on demographic factors using an ANCOVA no difference existed in genders, free and reduced lunch status but a difference was evident for ethnicity for three of the seven posttests. There was not a difference when comparing content-knowledge achievement based on students IEP status.

CHAPTER 5
CONCLUSIONS AND RECOMENDATIONS

Introduction

Purpose and Objectives

The purpose of this study was to determine if inquiry-based instruction impacts content knowledge achievement for students with special needs. The research aimed to determine if students with special needs in school based agricultural education learn content through inquiry-based instruction the same as students without special needs. In order to achieve the desired purpose this research was guided by the following objectives:

- Describe the population of special needs School Based Agricultural Education students.
- Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.
- Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

Methods

The study utilized a one-group pre-test post-test pre-experimental design, outlined by Campbell and Stanley (1963). A total of 10 instructors taught one class of inquiry-based instruction and administered a set of seven pre and post test cycles for each unit. For this study graduates of the National Agriscience Teacher Ambassador Academy [NATAA] delivered the treatment to their students. Threats to validity including history, maturation, testing, instrumentation, regression, subject selection, and mortality were addressed and controlled for when possible. During the study 8-10 week inquiry-based lessons were taught. The lessons were broken into 7 separate units. Demographic data was collected as well as pretest and posttest scores on a content knowledge achievement instrument. The results were analyzed using

SPSS® and analysis of covariates [ANCOVA] were used to determine content knowledge achievement.

Summary of Findings

Objective 1: Describe the population of special needs School Based Agricultural Education. Students

The study included 170 students from seven different schools nationwide. Of that, 57.6% (*n* = 98) were male and 42.4% (*n* = 72) were female. Eighty one point eight percent (*n* = 139) were Caucasian and 18.2% (*n* = 31) were non-Caucasian. Seventy-one point eight percent (*n* = 122) did not qualify for free or reduced lunch, 15.3% (*n* = 26) qualified for reduced lunch, and 12.9% (*n* = 22) qualified for free lunch. Seventy-nine point four percent (*n* = 135) did not have an IEP assigned to them, 20.6% (*n* = 35) did have an IEP assigned to them.

Objective 2: Determine the impact of inquiry-based instruction on student content knowledge based on demographic factors.

The difference in mean scores between the seven pretests and posttests were 27.92, 30.52, 37.06, 40.63, 43.22, 47.92, and 43.22 respectively. Gender and free or reduced lunch status did not show a significant difference in posttest scores when pretest scores were controlled for. Ethnicity presented a significant difference on posttest scores for test 1, 3, and 4, to a .05 significance level. No significant difference existed on any of the other exams. When ethnic groups other than Caucasian were grouped together and compared to the Caucasian group a significant difference was evident for posttest 3 and 4 when pretest was controlled for.

Objective 3: Determine if inquiry-based instruction impacts student content knowledge achievement differently based on students IEP status.

For all tests IEP status was not a significant fixed variable that determined posttest scores when controlling for pretest scores. Moreover, IEP status had no significant impact on students' content knowledge achievement scores.

Conclusions

Based on the sample size of this study and the scope of the entire population the results cannot be generalized outside of the scope of the population of the study. The following conclusions were drawn from the results of this study.

- Inquiry-Based Instruction does not adversely affect content knowledge achievement for students with special needs.
- Inquiry-Based Instruction leads to knowledge gain for all students regardless of IEP status.
- The IEP makeup of the population in this study is similar to those found in previous studies.
- Ethnic differences existed in content knowledge achievement for Inquiry-Based Instruction in some areas/topics.

Discussion and Implications

Conclusion 1: Inquiry-Based Instruction does not adversely affect content knowledge achievement for students with special needs.

No difference existed in posttest scores when comparing students without IEPs to students with IEPs, which indicates that Inquiry-based instruction does not adversely affect content knowledge achievement for students with special needs. While Merchand-Martella, Slocum, and Martella (2004) indicate that direct instruction should be used to overtly present content for students with special needs, this study indicates that students with special needs can learn the content of the lesson through inquiry-based instruction. These results match the findings of Scruggs, Mastropieri, Bakken, and Brigham (1993) who found that inquiry-based instruction was an effective teaching method for students with special needs.

Conclusion 2: Inquiry-Based Instruction leads to knowledge gain for all students regardless of IEP status.

According to the findings of this study, inquiry-based instruction is an effective method of instruction for all student, regardless of IEP status. This conclusion corresponds with the findings of Fuller (2001), who found that students involved in special education performed comparably to other students in inclusion settings using inquiry-based settings. This study concludes that inquiry-based instruction is an effective method of instruction regardless of IEP status.

Conclusion 3: The IEP makeup of the population in this study is similar to those found in previous studies.

In this study 20.6% of the students had IEPs. Dromody, Seevers, Andreasen, and VanLeeuwen (2006) found 19% of New Mexico school based agricultural-education [SBAE] students had IEPs, compared to 23% in Illinois as was found by Pense (2008). This study reflected those previous studies population of students with special needs in the SBAE classroom.

Conclusion 4: Inquiry-Based Instruction has no difference in effectiveness for different genders.

This study found that there was no difference in content knowledge achievement for males and females, which contradicts the findings of Geier et al. (2008), Wolf and Fraser (2007), and Von Secker and Lissitz (1999) who found that inquiry-based instruction had more of a benefit for males that females. Geier et al. (2008) noted that inquiry-based instruction helped males close the achievement gap that females had. Since there was not a difference in males and females pretest or posttest mean scores, a gender gap was not an issue.

Conclusion 5: Ethnic differences existed in content knowledge achievement for Inquiry-Based Instruction in some areas/topics.

This study indicated that ethnic differences in content knowledge achievement did exist. These results correspond to the findings of Rodriguez (1997) who claimed that standards inquiry-based instruction omits ethnic issues. Since a difference only existed on three of the seven posttests individual lessons or posttests could have had an unintentional ethnical bias. These unintentional ethnical biases should be further explored so they can be avoided in SBAE inquiry-based instruction. Although a significant difference was significant level for each test was below 10% for each assessment

Recommendations

Recommendations for Practice

Based on the findings and conclusions the following recommendations for practice should be considered.

- School-Based Agricultural Education instructors should use Inquiry-Based Instruction when appropriate.
- Professional development should be conducted to help train School-Based Agricultural Education instructors to make modifications to instruction based on the students IEP status.

Recommendation for practice 1: School-Based Agricultural Education instructors should use Inquiry-Based Instruction when appropriate.

Since other researchers (Grier, Blumenfield, Marx, Krajcik, Fishman, Soloway et al., 2008; Wolf and Fraser, 2007; Gibson and Chase, 2002; Von Secker, 2002; Huber, Smith, and Shotsberger, 2000; Yerrick, 2000; Von Secker and Lissitz, 1999) found benefits to inquiry-based instruction prior to this study, inquiry-based instructions merits are apparent. The findings of this study confirm that inquiry-based instruction is an effective teaching method and should be used when appropriate. Inquiry-based instruction is effective for all students, including those with special needs, as long as their needs are accommodated for.

Recommendations for Further Inquiry

Based on the results and conclusions the following recommendations should be an emphasis for further inquiry.

- A larger study with more participants should be conducted.
- A sample should be selected based on ethnicity to determine the impact of Inquiry-Based Instruction for students with different ethnicities and cultural backgrounds.
- A sample should be selected based on IEP types to determine the impact of Inquiry-Based Instruction for students with different special needs.
- Research should be done to compare Inquiry-Based Instruction to other teaching methods using these variables.
- Research should be done to determine the impact of a more open inquiry teaching style for students with special needs.
- Research should be done to determine if Inquiry-Based Instruction is related to and can coexist with Differentiated Instruction.
- Research should be done to determine how Inquiry-Based Instruction affects content knowledge achievement for other subject matters.
- Research should be done to determine how Inquiry-Based Instruction affects content knowledge achievement for other settings.
- Research should be done to determine if Inquiry-Based Instruction makes differentiation of instruction a more automatic process for instructors.

Recommendations for Further Inquiry 1: A larger study with more participants should be conducted.

This study did have enough participants to make some comparisons of statistical value however some comparisons could not be made due to the low number in the subgroups. A larger study could provide some insight into how students with different ethnicities, socio-economic status, and special needs sub groups learn through inquiry-based instruction.

Recommendations for Further Inquiry 2: A sample should be selected based on ethnicity to determine the impact of Inquiry-Based Instruction for students with different ethnicities and cultural backgrounds.

Since this study found a difference between different ethnic groups, more research should be done with larger subgroups of different ethnic groups to understand how students in different ethnic groups respond to inquiry-based instruction. Since this study focused on students with special needs, this was not a significant variable of interest for this study, but ethnicity should be a variable of interest for future inquiries.

Recommendations for Further Inquiry 3: A sample should be selected based on IEP types to determine the impact of Inquiry-Based Instruction for students with different special needs.

This study did have enough statistical strength to determine that no difference exists in content knowledge achievement between students with special needs and students without special needs being taught using inquiry-based instruction, however there was not enough statistical significance to make comparisons between subgroups of special needs. This comparison of subgroups would be useful in gaining further insight in how students with different needs respond to inquiry-based instruction. A larger study with more in-tact classes would be beneficial to the body of research surrounding inquiry-based instruction in SBAE.

Recommendations for Further Inquiry 4: Research should be done to compare Inquiry-Based Instruction to other teaching methods using these variables.

This study did not compare the effectiveness of inquiry-based instruction to other methods of instruction. Future studies should focus on these comparisons to determine if inquiry-based instruction is a more effective method of instruction than other methods used in SBAE.

Recommendations for Further Inquiry 5: Research should be done to determine the impact of a more open inquiry teaching style for students with special needs.

This study focused on a specific style of inquiry-based instruction designed by the instructor and done the same by all of the instructors participating in this study. To control the presage variables, the inquiry-based instruction lesson was fairly structured. For future studies, a more open form of inquiry should be used to determine if students with special needs can learn as effectively through an open inquiry approach.

Recommendations for Further Inquiry 6: Research should be done to determine if Inquiry-Based Instruction is related to and can coexist with Differentiated Instruction.

Since the assumption was made that instructors are modifying their instruction for students with special needs while teaching using inquiry-based instruction more research should be done to determine what types of modifications were made for students. Differentiated instruction was identified in chapter 2 as an effective way to modify instruction for students with special needs. Since inquiry-based instruction and differentiated instruction are both student centered approaches for learning, further research should be done to determine if the two can coexist in the classroom and to determine what similarities and differences they have.

Recommendations for Further Inquiry 7: Research should be done to determine how Inquiry-Based Instruction affects content knowledge achievement for other subject matters.

This study was limited to SBAE, since inquiry-based instruction could be beneficial to other science oriented courses more research should be done to determine the effectiveness of inquiry-based instruction for other subject matters.

Recommendations for Further Inquiry 8: Research should be done to determine how Inquiry-Based Instruction affects content knowledge achievement for other settings.

Many studies, including this study have identified the benefits of inquiry-based instruction in formal education settings, however little research exists on the effectiveness of inquiry-based instruction in other educational settings like informal education or adult education.

Recommendations for Further Inquiry 9: Research should be done to determine if Inquiry-Based Instruction makes differentiation of instruction a more automatic process for instructors.

This study operated under the assumption that teachers were differentiating instruction for students with special needs but did not explore how the instructors were differentiating instruction. Further research should be done to determine if inquiry-based instruction makes the differentiation process easier or more difficult for instructors than differentiating instruction using other methods. Research should also examine if inquiry-based instruction leads to a natural differentiation as scaffolding.

APPENDIX A
SCIENCE TEACHING INQUIRY RUBRIC (STIR)

Directions: Reflect on the science lesson that you taught today. In your reflection, consider each of the following categories and the six statements on the left, written in bold. After looking at each bold statement, assess today's science instruction based on the categories delineated for statement. Place one "X" in the corresponding cell for each bold-faced statement. If there is no evidence of one of the statements in today's lesson, place a slash through the bold-faced statement. When you are finished, you should have 6 total responses.

Learner Centered ⟷ Teacher Centered

Learners are engaged by scientifically oriented questions.					
Teacher provides an opportunity for learners to engage with a scientifically oriented question.	Learner is prompted to formulate own questions or hypothesis to be tested. ☐	Teacher suggests topic areas or provides samples to help learners formulate own questions or hypothesis. ☐	Teacher offers learners lists of questions or hypotheses from which to select. ☐	Teacher provides learners with specific stated (or implied) questions or hypotheses to be investigated. ☐	No evidence observed. ☐
Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.					
Teacher engages learners in planning investigations to gather evidence in response to questions.	Learners develop procedures and protocols to independently plan and conduct a full investigation. ☐	Teacher encourages learners to plan and conduct a full investigation, providing support and scaffolding with making decisions. ☐	Teacher provides guidelines for learners to plan and conduct part of an investigation. Some choices are made by the learners. ☐	Teacher provides the procedures and protocols for the students to conduct the investigation. ☐	No evidence observed. ☐
Teacher helps learners give priority to evidence which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	Learners determine what constitutes evidence and develop procedures and protocols for gathering and analyzing relevant data (as appropriate). ☐	Teacher directs learners to collect certain data, or only provides portion of needed data. Often provides protocols for data collection. ☐	Teacher provides data and asks learners to analyze. ☐	Teacher provides data and gives specific direction on how data is to be analyzed. ☐	No evidence observed. ☐
Learners formulate explanations and conclusions from evidence to address scientifically oriented questions.					
Learners formulate conclusions and/or explanations from evidence to address scientifically oriented questions.	Learner is prompted to analyze evidence (often in the form of data) and formulate own conclusions/ explanations.	Teacher prompts learners to think about how analyzed evidence leads to conclusions/explanations, but does not cite specific evidence.	Teacher directs learners' attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to draw conclusions and/or formulate explanations.	Teacher directs learners' attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to lead learners to predetermined correct conclusion/explanation (verification).	No evidence observed.

Figure A-1. Science Teaching Inquiry Rubric (STIR)

Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.					
Learners evaluate their conclusions and/or explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.	Learner is prompted to examine other resources and make connections and/or explanations independently. ☐	Teacher provides resources to relevant scientific knowledge that may help identify alternative conclusions and/or explanations. Teacher may or may not direct learners to examine these resources, however. ☐	Teacher does not provide resources to relevant scientific knowledge to help learners formulate alternative conclusions and/or explanations. Instead, the teacher identifies related scientific knowledge that could lead to such alternatives, or suggests possible connections to such alternatives. ☐	Teacher explicitly states specific connections to alternative conclusions and/or explanations, but does not provide resources. ☐	No evidence observed. ☐
Learners communicate and justify their proposed explanations.					
Learners communicate and justify their proposed conclusions and/or explanations.	Learners specify content and layout to be used to communicate and justify their conclusions and explanations. ☐	Teacher talks about how to improve communication, but does not suggest content or layout. ☐	Teacher provides possible content to include and/or layout that might be used. ☐	Teacher specifies content and/or layout to be used. ☐	No evidence observed. ☐

Figure A-1. Continued

APPENDIX B
INQUIRY-BASED INSTRUCTIONAL PLANS

Nature of Soil
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1: Explain how the resources soil provides help in supporting life.

- Ask the entire class: What do humans need to survive?
    - Expected answers: (write answers on the chalk board)
        - Food
        - Water
        - Shelter
        - Others
- Take student answers and ask students what food provides.
    - Expected they will answer with the providing of nutrition
- Ask students how plants differ from humans in this regard.
    - Expected answers: They are plants, they need sunlight, they need soil (although this is not 100% true b/c of hydroponics) plants need water, plants need nutrients.
    - If students cannot develop the answer nutrients, ask them what plants use for food.
    - Ask student: In regard for shelter, how can soil provide this to plants? Possible answers: foundation for germination and roots. Lead students into the need for the correct temperature of the soil for germination of plants. Soil provides temperature through absorbing heat from the sun. (This can be demonstrated by turning light on and facing it close to the soil before the lesson begins.) Turn off the light and pass the soil around to show students the soil is holding the heat from the light bulb. After students have felt the heat in the soil ask them to place their hand under the light bulb (the heat will be gone). This will demonstrate that soil holds heat after the "sun" has gone down for the day or in the case that the sun is not out for a couple days.
    - To have students develop the answer carbon – ask them what the building block of life is. If they do not know have a student look the answer up on the internet.
- Once students have developed this set of answers they have achieved the answers for objective one.
    - Review: What are the resources that soil helps provide in supporting life.
        - Oxygen
        - Temperature
        - Water
        - Carbon
        - Nutrients
- Ask students to develop their own list of why the above 5 are important. Allow for up to (5 minutes for students to develop their answers)

- Have students explain their answers to the class; asking others to expand on or share their thoughts. Allow students to discuss answers and their reasoning out loud.
    - Guide students and indicate:
        - Oxygen – for root growth
        - Temperature – seed germination and plant growth
        - Water – for growth
        - Carbon – for growth
        - Nutrients – minerals that is provided from other decaying plants that provides for plant growth

Objective 2: Examine the components of soil.

- Place students into groups suitable for your classroom.
- Provide a flat of potting soil or a flat of soil from your area for each group of students. (Provide at least one of each example. Groups do not need both examples.)
- Ask students to investigate the soil making note and pulling out examples of different contents in the soil. Ask students to estimate the percentage of each component contained in the soil. Allow students to look through the soil for 5 minutes.
    - Students should provide examples of sand, silt, and clay in the soil. They may not call the soil particles sand, silt, and clay at this time.
    - Students also pull out samples of decaying plant material or animal matter. They may not identify this material as organic matter, but they will know it is different than the other soil particles of sand, silt, and clay. Ask them to estimate the percentage of these particles on the soil.
- Once students have completed the above steps have them examine other groups' soil, findings, and estimations.
- After students have examined other group's findings allow time for students to make adjustments to their findings.
- In their groups have students reason what the components they have identified in the soil. You may allow a group member to consult other groups or a computer. Allow up to 10minutes for students to develop their list.
    - At this time you can expect students to develop a list consisting of: Sand, silt, clay, other dead plants (or organic matter).
    - As the teacher guide the students to organize sand, silt, and clay into a category called mineral matter because they derived from rocks.
    - As the teacher guide student to organize decaying plant material into organic matter.
- Ask students to note the color of the sand, silt and clay. What color are those particles? Are they lighter or darker than the soil as a whole? (this answer should be: they are lighter)
- Lead students into the explanation that the organic matter is what gives the soil a darker color.
- In the examination of pore space (50% of the soil volume).
    - Provide students with a wide mouth jar or glass.
    - Ask students to fill up the jar with their soil, but not to compact the soil.

- Ask them if there is any moisture in the soil. (there will always be some moisture in the soil – how much depends on the conditions of the soil)
- To determine the amount of air in the soil provide the students with water.
- Ask the students to determine the percentage of air in the soil and to document their hypothesis, steps of their experiment, results, and conclusions.
  - Students should compact their soil and not use the water at the beginning (but do not tell them that from the start).
  - Once students have compacted their soil they will want to place water on the soil and the soil will further compact. (Students should not empty too much water on the soil; if they do they will need to pour out the access).
- Have students document their results and present to other peer groups to determine a final answer they wish to share with you.
- You will then guide the students to determine air and water make up about 50% of the soil's volume while mineral matter and organic matter make up the other 50% (the results may vary somewhat depending on where you live).
- Review: Soil consists of mineral matter: sand, silt, clay (45%); Organic matter: dead plant and animal matter (5%); Pore Space – Air (25%) & Water (25%).

Objective 3: Identify the organisms found in soil and recognize their benefits to the soil.

- After objective 2 ask students if there is anything else in the soil (perhaps students found living organisms in the soil already).
  - Have students identify types of life in the soil. Guide students to think about what breaks down plant and animal matter (to have students determine bacteria and fungi).
  - What purpose does each provide? Guide students into a discussion of symbiosis
  - Have students use the remaining soil in the flat to demonstrate advantages earthworms and other organisms can provide for plant growth. (students should connect holes in the soil provide easier air and water movement. You can explain the term tilth during this process.

Objective 4: Describe four ways plants use soil.

- From the above objectives have students explain 4 basic needs plants require of soil. Ask students to draw off of their prior experience to develop their own list and reasons why. Allow at least 5 minutes for students to look over notes and gather their own thoughts.
- Ask students to present their rational of their thoughts.
- Guide students to develop the list provided in objective four.

Objective 5: Describe some agricultural uses of soil. **&**
Objective 6: Describe some nonagricultural uses of soil.

- Appoint students into a production agriculturists and non production agricultural.
  - Have students develop a list of how they would use soil.
  - Have each group(s) present their answer and reasoning.
  - Lists will probably be larger than provided and that is fine as long as they are accurate. Make sure students take note of each use and explanation.

Soil Formation
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Prior to this lesson identify different places on or near the school grounds that has different topography and ground cover. You will want to prepare these areas to contain a few different factors. You may place rocks in the soil or on a soil surface (which will slow movement and lead to less runoff. You may place several holes in one area to represent holes from earthworms and other insects. You may wet down one area of investigation. If there is a place on the school ground that has a wash or other unique features use them also. Each of these areas may only need to be 2 feet long by 1 foot wide. Preparing 3 samples for each group to investigate will be sufficient.

Supply students with a timer, water, paper towels, weigh scale, and a liquid measuring device to design an experiment that leads to the explanation factors effecting soil formation.
Hint: Student will want to pour the water down a slope, time the runoff, collect the runoff in the paper towels, and weight the paper towels. Groups may develop a different process to investigate. At the end you should discuss the processes each group chose.

Students will need to report on observations that would affect soil formation. Explain to students that their observations and experiment would happen over many years so they will need to observe and predict what may happen with each sample area. Each group should look for factors that affect soil formation. In the discussion after their investigation guide students through the objectives (students will identify rocks, slope, and worm holes as factors but you will need to discuss and indentify terms “parent material” for them or guide them to use those terms through questions).

Soil Color
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Display several different samples of soil (one sample should be potting soil). Allow students to investigate each sample making notes on what they find as differences in the soil. Provide soil samples and water. Have students document their findings.

- Students will identify key terms in objective one. From the students' observations guide them to focus on color. Ask why the potting soil is so much darker, and have students develop reasons why potting soil is used rather than regular soil and the reason it is darker.
- Question students about the differences in color and what color might mean for drainage.
- If possible take students to a few soil pits. Have soil pits dug in different locations. One location being in a well drained area (perhaps on the side of a hill or incline; another in a low area that holds water from time to time; and finally a moderately drained flat area).
- Ask students to identify differences in color and guide students to make connections with soil color and drainage.
- You may wish to show students two pieces of similar unpainted metal. For a period of a few days, allow one of the pieces to become wet or damp. Place the other piece in the bottom of a pail of water for the same period of time. Students should see that the metal allowed to be wet and dry will oxidize or rust, whereas the metal that is kept under water will not. Explain that the iron will only oxidize if both moisture and air are present. Relate these findings with the iron compounds found in the soil. The status of the iron compounds in the soil indicates the type of natural drainage found in the soil.

Soil Texture and Structure
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1: Describe the concept of soil texture and its importance.
Provide students with sand, silt, and clay samples of soil. Place students in groups that work best for your class.

- Provide students with water, measuring cups, cups and coffee filters.
- Ask students to make observations and design a soil that has the best Water-holding capacity, Permeability, and soil workability (documenting proof of each).
- Give students the definitions of each term before they begin.
- Students should examine each sample then create a mix of all three to achieve the best soil. Each group should prepare a soil sample and document the percentage of each used to present to the class.
- Allow students to share ideas and present why their mix is the best and allow other to challenge their reasons.
- Have student groups answer why soil texture is important. They should also note the structures of the sand, silt and clayy – size, water holding, and what happens when the soils become saturated with water.
- This objective may take one class period.

Objective 2: Determine the texture of a soil sample.
- In consideration of Objective 2: After completion of the above activity (which may take an entire class period) present the soil texture triangle (VM-C) to students and demonstrate the ribbon method to the students. Students should conduct the ribbon method on their created soil to determine their created soils texture.

Objective 3&4: Explain soil structure, its formation, and importance. Differentiate various soil structures.
- Use soil samples, draw or use (VM-D) to teach objectives 3&4. Ask students to note differences in the soil structures and develop positives and negatives for each structure. Guide them to think about water, plant roots, and nutrients.

Soil Profile
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1: Explain the soil profile.

- Ask the entire class: To identify different aspect of a soil profile from their past experiences.
    - Expected answers: (write answers on the chalk board)
        - Surface is contained of decaying plant matter
        - Top soil – Horizon A
            - Has a darker color due to organic matter; contains roots and organisms
        - Subsoil – Horizon B
            - Lighter soil with more fine soil particles, fewer roots
        - Subsoil – Horizon C
            - Parent material, rocks, and some leached materials
        - Horizon R – Bedrock

Objective 2&3: Use lesson plan outline to guide students

- Construct a soil profile to predict a changing soil profile over time.
- Have student groups construct a soil profile using the internet or any objects they wish to express the profiles.
    - Potential ways to construct are pictures of differing soil types and weathering such as the soil in the badlands, black top soil in central Illinois, or sandy soil in Florida.
    - Student groups may choose to construct an actual soil profile by gathering leaves, top soil, sand, clay, rocks…
    - Have groups explain their soil profile using the correct terms
    - Allow groups to critique each other's construction of the soil profile and also the selection of materials used.
    - Direct groups to reason through and explain why they chose the materials and also why they constructed their soil profile the way they did.

Moisture Holding Capacity
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1 and 2: Describe moisture holding capacity. Explain what determines soil moisture-holding capacity.
Provide students with two or three dry soil samples (each group may have different soil samples). If possible heat soil in an oven or enclave to remove existing moisture.

- Have students to make observations and design a soil that has the best water-holding capacity.
- Give students the definitions of each term before they begin.
- After they read objective one and two have students design an experiment to determine what the main components in their soil are.
- Students should document their experiment and results and report back to the group.
- Supply student groups with stopwatch, coffee filters, measuring cups, soil samples, water, a balance, paper towels, a balance (electronic scale), and collection bowl. Facilitate if groups believe they need more materials.
- The groups' goal should be to demonstrate the terms in objective one to the rest of the class.
- It is anticipated groups will place soil samples in coffee filters and pour water over the sample. Measure the water (in weight) before and after pouring it over the soil, also measuring the weight of the soil before and after. This will determine the soil water holding capacity. It is anticipated each group will determine gravitational water by timing the flow of the water through the soil. The paper towels can be used to extract water from the soil, after drained, to explain the water available to plants. The final weight is water unavailable to plants (hygroscopic moisture).

Objective 3: Determine the moisture-holding capacity in a soil profile.
- Use (VM-B) to allow students to calculate their soils moisture-holding capacity.
- Students should determine what texture their soil is using previous knowledge and also knowledge gained from the previous experiment.
- Tell students the soil sample they have is their top soil and in a soil profile it would be 9 inches thick.
- The B horizon soil is a texture of clay loam and is 31 inches thick
- Finally, C horizon is clay texture and is 20 inches thick.
- Students should calculate the soil moisture holding capacity and present to the class and explain why they reached the results they did.

Soil Erosion and Management
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objectives 1 - 6:

Allow students to see the content in the original lesson plan. Organize students in groups suitable for your learning situation (groups of 3 or 4 suggested).

Student groups should organize and collaborate with each other and divide up the content in the lesson plan. Each group should then make a model describing their portion of the lesson. Models could be computer generated, using posters and other material, or actual soil.

Upon completion students should then teach their peers. This can be done as a class presentation or may be set up as a display and students present to small groups as in a science fair setting.

Soil Chemistry
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1, 2, 3, 4: Identify soil chemistry issues.

- Hold a round table discussion using students' previous knowledge from subsequent lessons to answer the following problem.
  - Give the student the following scenario:
    - A local gardener is trying to grow tomatoes in her garden. She has been having all kinds of trouble getting the tomatoes to establish in the spring and by mid-summer the fruit they are producing is substantially less than the neighbor's tomato plants. She and her neighbor share fertilizer and have applied nearly the same amount as her neighbor they even bought the tomato plants at the same time and the same store from the FFA chapter. Nonetheless, her plants simply do not produce the same amount of fruit. People in the community have told her that she should talk to your agricultural class about this problem and that you will help her solve the problem. She appears in your class with a soil sample asking for help today.
    - What could the problem be?
      - (TEACHER NOTES): USE the content from lesson one to guide student through their thinking of possible problems.
    - Potential problems: Soil pH, Soil Fertility, Poor drainage, insects, drought, compaction, too much organic matter, not enough organic matter, insects….others.
    - Potential answers:
      - Soil pH – You check the soil pH and it is 6.3
        - Is this an acceptable soil pH for tomatoes? Have a group of students find out. Asked them to report to the group about soil pH and what soil pH means. (They can use the lesson plan for notes, but it would be better they research soil pH for themselves using resources or internet).
      - Organic matter – It student bring this issue up, the local gardener spreads manure from her rabbits on her garden year around and each fall puts all her leaves in the garden and during the spring she tills the soil to work in all the leaves.
      - Soil Fertility – you could give a group of students a soil test kit and a soil sample. If not the soil is found to have correct soil fertility levels.
      - Poor drainage – After talking with her you find out that the soil contains a lot of clay at a depth of 8 inches. She uses a tiller that only goes about 8inches. Direct a group of students to investigate this issue and how to overcome it they believe this is a problem.

One place to begin research is to identify how deep tomato plants' roots go in the soil.

        - Too wet or too dry – she waters the same amount at the neighbor and the neighbor's plants are just fine. Does this mean it is not a problem? Possible explanations for why it is or isn't.
        - Compaction – soil is clay at a depth of 8in with a heavy layer of organic matter on top due to the leaves and rabbit manure. She tills the garden 3 to four times a year and has had the garden in the same place for 25 years. Possible solutions with compaction? If this is an issue
        - Not noticeable insect damage on the plants leaves. Not sure about soil insect though. She knows nothing about potential soil insects. What are some possible answers for insects?
      - Direct students to "trouble shoot" the problem. Students can naturally break into groups or work on potential problems individually (depending on the class size). If the student(s) choose to tackle a potential problem/solution they MUST present everything they learn to the entire class and argue for or against WHY this is or isn't the problem the gardener's faces.
  - YOU AS THE TEACHER: Can choose the "correct" answer at the end, but allow the students to discuss possible answers. THE TEACHER MAY HAVE TO PROVIDE OTHER INFORMATION TO GUIDE STUDNETS to achieve an answer. This content provided may not be direct enough to provide a single answer. However, it MAY be several factors that are involved. Direct students to formulate a plan of action the gardener should take.
- Once the group has found possible solutions have the group discuss what they will present to the gardener. The students should not appear that they do not know how to solve the gardener's problem. The class should prioritize action items in an order "steps the gardener should take" in order to reach a conclusion. Students must reason why the steps are in the correct order (It may be more feasible to have students develop a plan and explain individually then form the round table discussion to finalize a report to the gardener for the final presentation.
- Use the content from the subject-matter lesson plan to guide students.
- Conduct labs attached in this lesson when needed for student understanding of the content.

Fertilizer Formulations
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1 and 2: Explain the development of a nutrient management plan. Describe organic and inorganic fertilizers

- Use the previous tomato garden lesson to expand on the need for a management plan. What are things the gardener could have done to prevent the problem in the first place. Help her make a plan for her garden. What about a nutrient management plan of action so she does not over utilize organic and inorganic fertilizers?
- Students should be able to answer the first portion of the plan from previous knowledge. However, most students will have a felt need to understand organic and inorganic fertilizers. Use lesson plans notes to guide the learners or allow students to seek information about organic and inorganic fertilizers. This could be an individual activity and have student report back to the class.
    - When students report on the types of fertilizers be sure they understand and maintain notes on the specific pieces in the lesson plan and other important items you have determined.

Objective 3, 4, 5: Explain fertilizer analysis, grade, and ratio, mixing fertilizer, correct selection

- Maintain the same gardener example with your students.
- In directing the gardener about fertilizer students will need to explain to the gardener mineral elements, fertilizer analysis, grade, and ratio.
- Split the class into six groups and have them research these components and create a report and presentation (that they present to the rest of the class on the topic they were given).
    - Mineral elements
    - Fertilizer analysis
    - Fertilizer grade
    - Fertilizer ratio
    - Mixing fertilizers
    - Selection of the correct fertilizer for a crop
- Student may use portions of the lesson plan if you want to provide copies or they can research in text books or internet.

Finally utilize Lesson plan labs to work through calculation with the class.

Applying Fertilizers
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1: Explain the application of fertilizers to field crops and urban areas.

- Have students read the following article (either print or have students read on-line)
    - http://www.sptimes.com/2007/03/29/State/Florida_may_go_green_.shtml
- Use this article to discuss overuse of fertilizers and describe the levels presented in the lesson plan for objective one.
- If there are shortages (typically a concern in agricultural commodity production) three methods can help determine: Visual, Tissue testing, and soil testing.
    - Ask students distinguish between the 3 methods: noting which is easiest, which is most effective, most efficient.

Objective 2 & 3: ID methods of fertilizer application, Explain rate of fertilizer application

- Present students objective two and three as suggested in the subject-matter lesson plan.
- Break students into groups or have them work individually (depending on class size). Assign different crops essential to your area. Have student groups research and present fertilizing methods as referred to as identified terms in objective 2

Nutrient Deficiencies
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1: Students should research nutrient deficiencies and create a dichotomous key (flow chart) that explains how they could narrow the nutrient deficiency problems plants face.

You could supply them with as much knowledge as they need or they could use the internet or university documents to build their dichotomous key. I have attached an example of a dichotomous key.

Allowing students to create their dichotomous key will allow them to learn the deficiencies in plants. Then they will apply their key to a situation that is attached as a PowerPoint you can work through with the students.

After students complete their dichotomous key use the following lesson plan and attached PowerPoint (or create handouts from the PowerPoint).

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Situation:

Instructional Objectives:

1) Students will be able to propose logical solutions to the problem based on the given information.
2) Students will be able to adapt their proposed answers based on changing information.
3) Students will be able to visually analyze plants specimens and determine nutrient deficiency.
4) Students will be able to define basic terms associated with the diagnosis of nutrient deficiencies in plants.

Materials Needed:
Student Handouts: Scenario, What We Know, Nutrient Deficiency Diagnosis Charts, Helpful Hints
Plant specimens (pictures or real)
Interest Approach:
Explain to the students that I urgently need their help – all of our plants are dying and I don't know why.
Transition directly in to the scenario and the students' tasks. (determine the problem, recommend how to fix it)
Lesson:

- Present students with the scenario
- Have them work in small groups to brainstorm a list of possible causes
- Write all of the possible causes on the board
- Distribute "What We Know"
- Have students modify their lists

- Determine the most likely cause (Nutrient Deficiency)
- Distribute “Nutrient Deficiency Diagnosis Chart” *explanation may be required*
- Distribute “Helpful Hints” *if needed*
- Show plant specimens *encourage class to take notes*
- Have students use the specimens and the chart to determine what nutrient is deficient.
- When each group has reached a conclusion have them present their findings and recommendations.
- Record each group’s findings and recommendations on the board
- Reveal the final answer
- Review the process of how the correct answer was reached.

What Happened to Our Plants?

Scenario

- Our class has is currently growing sweet corn and beans hydroponically. The plants started out looking fine but they have recently started looking very poor.
- In small groups, your job is to determine what the problem is and make recommendations of how to fix it.

Scenario

- All of the plants were germinated in pots and then transplanted into the hydroponic system.
- Plants that did not look healthy at transplanting time were discarded; only healthy plants were put into the hydroponic system.

Directions

- In your groups brainstorm a list of possible causes for the recent decline in the plants' appearance.
- When you have completed your list you will report back to the class.

What We Know

- The plants appear to be free of any pests or diseases.
- All of the other plants in the greenhouse (the ones in pots) seem to be doing fine.
- The hydroponic system is functioning properly and being properly maintained.
- The species of plants we are using can be successfully grown using hydroponics.
- The hydroponic solution we are using was formulated by a chemistry class here at school.

Now What?

- What are our possible problems?
- What else do you need to know?

Figure B-1. What happened to our plants power point

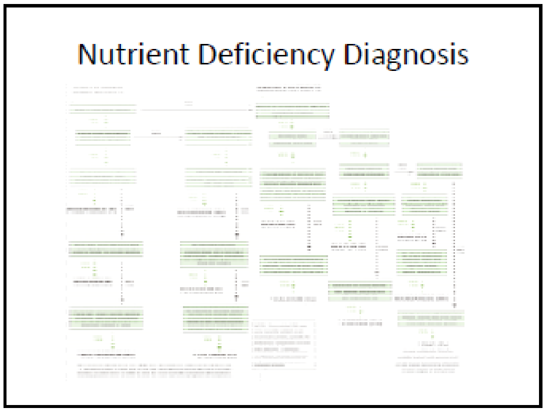

Figure B 1. Continued

Conclusions

- What's wrong?
- How do we fix it?

Figure B-1. Continued

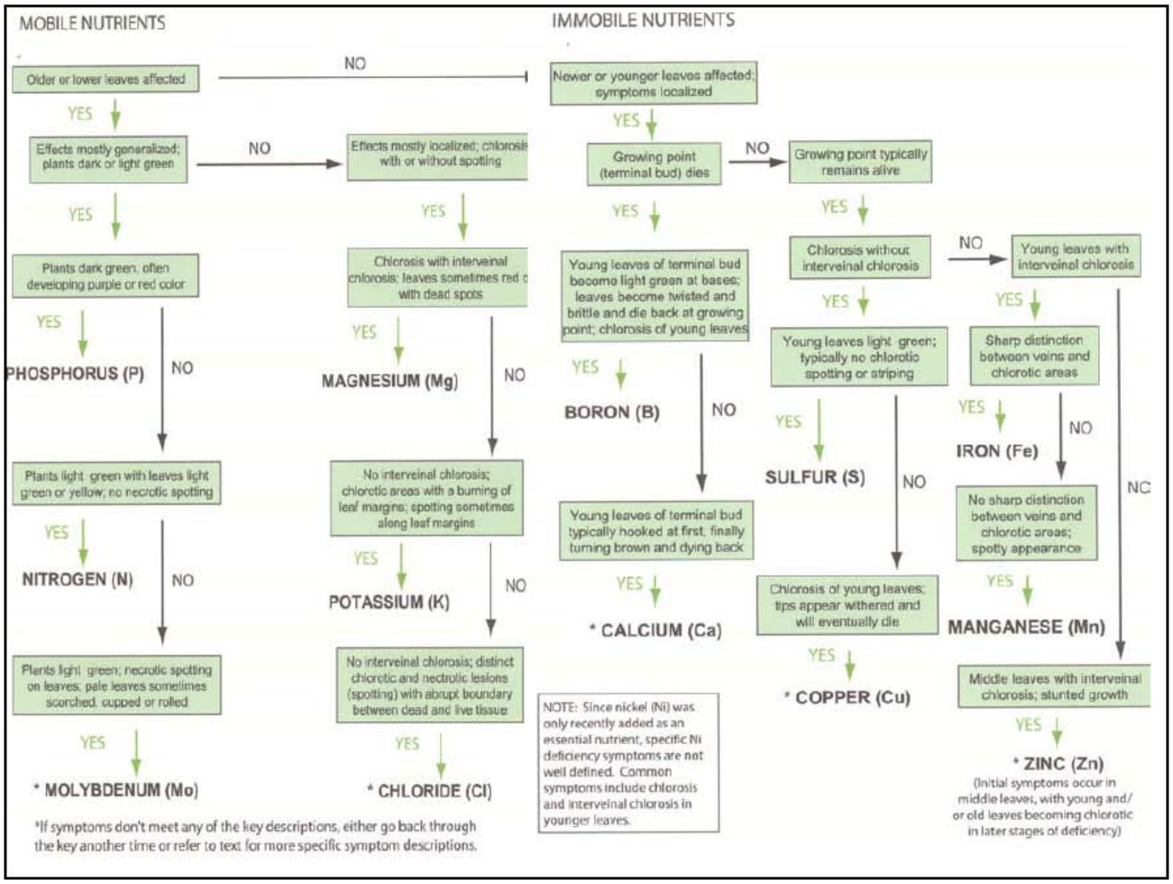

Figure B-2. Nutrients flow chart

Seed Germination Processes and Requirements
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1, 2 and 3: Design and conduct an experiment that explains the seed germination process.

- Lead a discussion about seed germination. Students should have some level of prior knowledge about how seeds germinate. Utilize student knowledge and guide them through the contents of the subject-matter lessons plan.

- Students should then utilize LS B but develop their own steps to conduct a warm germination test. They should develop their methods and procedures of investigation. You should push students to reason and defend their methods based on a scientific approach considering any flaws they might have in their experiment and how they are addressing them. Do they have a control? Do they have the same seeds? What is different about their locations? How many seeds to they need to test? These are just a few questions suggested.

- Allow students monitor their seeds on day 2, 5, and 7 and document results.

- Students should then present their hypothesis, research methods, results, and findings to the class in the form of a poster or PowerPoint presentation.
    - Peer students should evaluation and ask questions based on data and the presentation.
    - The groups presenting should be able to acknowledge and defend their answers and ways to address anticipated questions.

Plant Life-Cycles
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1, 2, 3 and 4: Identify differences between plant life cycles

- Ask students about their favorite flower.
- Why is it their favorite flower?
- Ask them details about their favorite flower.
- Be prepared with pictures of flowers if they do not have a favorite flower or plant.
- What makes flowers different?
- When does their flower bloom?
- How often?
- How long?
- Why?

This should lead into a discussion about plant life cycles. Use these questioning strategies to lead and teach about plant life cycles. Have students develop ways to determine ways they can determine one type from another. Also, guide students to think about advantages and disadvantages of the different life cycles and applications for horticulture and agricultural production. Example: how expensive would roses be it they were simply annuals? How profitable would raising corn be if it were a perennial?

Photosynthesis
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1, 2, and 3: Evaluate research that focuses on improving photosynthesis in plants.

- Allow students to have a copy of the lesson plan or create guided notes.
- Group students up according to what is best for your class.
- The group task is to find research that supports better production (higher yields) from crops due to more efficient plants. Suggested to browse Google scholar and university agronomy web-sites.
    - Groups have 2 options and should choose one of the following:
        - Design a research study that investigates improved methods of photosynthesis. (They need to address the following)
            - How will they develop this research?
            - How will it be conducted?
            - What results do they anticipate?
            - How will they report the results?
            - Who are the results important too?
            - What impact does this have on the agricultural industry?
        - Design and describe the process of photosynthesis and how the study they researched improves the production of the crop/plant?
            - They need to use technical terms as much as possible.
            - Explain in detail the study and the terms and the meanings of those terms.
            - Explain the products of photosynthesis and how the factors effecting the process have been altered or changed in the study they researched.
            - Encourage this group to conduct lab A in the subject-matter lesson plan and include descriptions in their presentation to the class. (LS – A)

- Both (types) of groups should turn in their results and present their findings to the entire class.
- Conduct lab (LS – B) with the inquiry group. Do not tell the inquiry which coleus plant was in the dark room and which plant was in the light. Have groups develop reasoning and defend their decisions based on what they have learned. If you want an extension activity experiment with the amount of days without sunlight.

Respiration
Inquiry-based Lesson Outline

Students should maintain notes, reasoning, and observations in a notebook.

Objective 1, 2, and 3: Define, describe and identify cellular respiration.

- Ask students to develop ideas as to why few deciduous trees grow at high altitudes.
  - Ask students what they base their answer/beliefs on.
  - Ask students about oxygen levels and how that may affect plant type and growth.
    - Use this to lead them into aerobic respiration and anaerobic respiration.
  - So do plants breathe?
    - It is called respiration
    - Ask students to describe what they believe takes place during respiration.
      - Expect confusion between photosynthesis and respiration.
    - Use these questions and student misconceptions to teach objective 2
    - Use the "do plants breathe during germination" question to lead into students (entire class) designing a way to find out the answer. You can use LS-1 as a guide to guide student thinking or provide hints as to how they many find this out. BUT allow students to brainstorm as a class to seek the answer to their inquiry.
    - If there are a couple different options provided by the group direct them to acknowledge faults and/or good aspects of the research question, and conduction of the experiment. Remind them to determine and record observations or ways they will observe or tables/measurements they will conduct.
    - Allow students to conduct the experiment at the end of the following content.
  - Factors affecting cellular respiration (objective 3)
    - Ask students what makes them breathe faster. Use this to determine the content in objective 3 on the subject-matter lesson plan.

APPENDIX C
PRETESTS/POSTTESTS

All assessments were taken through the MYCAERT testing service and appeared in a different format and scores uploaded via the computerized testing system. Questions were asked in a random order.

Assessment 1- Nature and Formation of Soil

Instructions: Circle the best answer to the following questions.

1. _____________ is/are utilized in the form of organic matter in the soil.
    a. Nutrients
    b. <u>Carbon</u>
    c. Oxygen
    d. Zinc

2. The following are resources, provided by the soil, which allow for the growth of plants and animals.
    a. carbon, nutrients, oxygen, water, and zinc
    b. oxygen, and water
    c. nutrients, oxygen, temperature, and water
    d. <u>carbon, nutrients, oxygen, temperature, and water</u>

3. The primary components that make up soil are:
    a. organic matter, air, and water
    b. <u>organic matter, mineral matter, air and water</u>
    c. organic matter and mineral matter
    d. organic matter and sand

4. What term is used to describe partially decayed plant and animal matter?
    a. <u>organic matter</u>
    b. mineral matter
    c. natural matter
    d. decay matter

5. Pore space make up approximately _____% of soil.
    a. 5%
    b. 25%
    c. 45%
    d. <u>50%</u>

6. Organic matter makes up approximately _____% of soil.
    a. <u>5%</u>
    b. 25%
    c. 45%
    d. 50%
7. What effects do soil organisms have on soil?
    a. They have almost no effect.
    b. The activities increase the available mineral matter.
    c. <u>They enhance drainage and improvement of air exchange.</u>
    d. They deplete the soil of essential elements for plant growth.

8. Bacteria and fungi in the soil ___________________.
    a. will eventually cause plants to die
    b. <u>break down organic matter and release nutrients</u>
    c. beak down mineral and organic matter
    d. cause reduced root growth from plants

9. Symbiosis is the living of together unlike ____________.
    a. <u>organisms</u>
    b. plants
    c. fungi
    d. nutrients

10. Plants depend on soil for:
    a. <u>anchorage, water, air, and nutrients</u>
    b. anchorage, water and nutrients
    c. water and air
    d. water and nutrients

11. Oxygen provides __________ for the soil.
    a. <u>aeration</u>
    b. dark color
    c. symbiosis
    d. tilth

12. An example of an agricultural use of soil is:
    a. forestry
    b. cropland
    c. water structures
    d. <u>all of the above</u>

13. An example of a non-agriculture use of soil is:
    a. grazing land
    b. vegetable production land

c. <u>waste disposal</u>
d. pond

14. What are the five factors that affect soil formation?
    a. temperature, moisture, plant type, organic matter, organisms, and pore space
    b. <u>climate, topography, organic material, parent material, and time</u>
    c. glaciers, lakes, wind, bedrock, and organic deposits
    d. alluvium, parent material, loess, glacial till, and chemical weathering

15. Soils formed by former shallow ponds with swamp vegetation are __________.
    a. glacial till
    b. alluvial
    c. loess
    d. <u>organic</u>

16. What type of water holding capacity does loess soils have?
    a. worst of any soil
    b. poor
    c. average
    d. <u>excellent</u>

17. Which living organisms have the greatest effect on soil formation?
    a. ants
    b. burrowing animals
    c. earthworms
    d. <u>native plants</u>

18. What gives soil its dark color and is found primarily in the surface layer of the soil?
    a. alluvium
    b. loess
    c. mineral matter
    d. <u>organic matter</u>

19. What is a large long-lasting river of ice that is formed on land and moves by gravity?
    a. alluvium
    b. <u>glacier</u>
    c. loess
    d. outwash

20. Timer soils tend to have _________________.
    a. a deep organic layer
    b. an average organic layer
    c. <u>a thin organic layer</u>
    d. no organic layer

21. Weathering by wind, water, and temperature is known as __________ weathering.
    a. alluvial weathering
    b. <u>physical weathering</u>
    c. climatic weathering
    d. chemical weathering

22. Freezing, thawing, rainfall, wind, and sunlight are all examples of which soil forming factor?
    a. climate
    b. loess
    c. topography
    d. <u>weathering</u>

23. Soils that have a steep topography are ____________________.
    a. subject to ponding
    b. poorly drained
    c. moderately drained
    d. <u>well drained</u>

24. Soils formed from soil particles that have not been layered from the effects of wind and water are called _____________.
    a. alluvium
    b. bedrock
    c. <u>glacial till</u>
    d. outwash

25. Prairie soils are high in _________________.
    a. bedrock
    b. living matter
    c. mineral matter
    d. <u>organic matter</u>

26. Soils in _________ regions are subject to leaching.
    a. arid
    b. glacial
    c. <u>humid</u>
    d. windy

Assessment 2 – Soil Color, Texture, & Structure

1- What determines the colors found in the surface layer of soil?
   a. Drainage
   b. <u>Organic matter</u>
   c. Oxidation
   d. Reduction
2- Subsoil colors are determined by the degree of ______________________ present when they are forming.
   a. <u>Drainage</u>
   b. Earthworms
   c. Sandiness
   d. Organic Matter
3- Why are prairie soils dark in color?
   a. <u>Partially decayed roots over a long period of time.</u>
   b. Water drained rapidly from the soil surface trough the soil.
   c. High iron content
   d. Course soil texture
4- Poor drainage creates subsoil that is ____________ in color.
   a. Brown
   b. Reddish Brown/Yellowish Brown
   c. Mottled
   d. <u>Gray/Olive</u>
5- Which is not a physical feature used to differentiated soil?
   a. Texture
   b. Structure
   c. <u>Moisture</u>
   d. Color
6- What percentage of organic matter in soil will yield a very dark color?
   a. 0%
   b. 2%
   c. 3.5%
   d. <u>5%</u>
7- Organic matter on the surface (such as leaf litter) decays ____________ than organic matter in the soil (roots of plants)
   a. Slower
   b. <u>Faster</u>
   c. The same
   d. None of the above- Leaf litter and roots do not decay
8- Mottled refers to ___________________.
   a. <u>Bright and dull colored soil mixed together</u>
   b. Soil with red and grey colors mixed
   c. Brightly colored soil
   d. Dull colored soil
9- What causes a soil to form mottled coloration?

a. Good Drainage
b. Poor Drainage
c. <u>Somewhat poor drainage</u>
d. No drainage

10- Soils on a hill tend to have color that is ____________________ than soils on flat ground.
a. Darker
b. <u>Lighter</u>
c. Deeper
d. Mottled

11- Which is not one of the three particle sizes of soil.
a. Sand
b. Silt
c. Clay
d. <u>Loam</u>

12- The largest soil particle is ___________.
a. <u>Sand</u>
b. Silt
c. Clay
d. Loam

13- The smallest soil particle is ____________.
a. Sand
b. Silt
c. <u>Clay</u>
d. Loam

14- The 12 classes of soil can be identified using the _____________.
a. Soil finder
b. <u>Textural triangle</u>
c. Soil map
d. Topography map

15- What type of soil produces the longest ribbon using the ribbon method?
a. Course -textured
b. <u>Fine-textured</u>
c. Medium-textured
d. Moderately-course textured

16- What term refers to clumps of soil that are caused by tillage?
a. <u>Clods</u>
b. Crumbs
c. Peds
d. Prisms

17- What textural class contains some of each size of soil particle?
a. <u>Loam</u>
b. Sandy clay
c. Silt
d. Silt clay

18- What two types of soil structure appear structureless?
a. Blocky and crumb

b. Columnar and granular
c. <u>Massive and single grain</u>
d. Platy and primatic

19- Good soil structure does all of the following except ________________.
a. Improves tilth
b. Improves permeability
c. Minimizes the formation of crusts
d. <u>Limits water infiltration</u>

20- Which soil structure has the poorest water permeability?
a. Granular
b. Crumb
c. Prismatic
d. <u>Platy</u>

21- Blocky aggregates are three dimensional aggregates with *at least* how many sides?
a. 3
b. <u>6</u>
c. 9
d. 12

22- Plant roots, freezing and thawing, soil tillage and ____________ clump soil together loosely.
a. <u>Fungal activity</u>
b. Acid rain
c. Compaction
d. Air

23- All of following act as cementing agents for soil except ________________.
a. <u>Water</u>
b. Clay
c. Iron oxides
d. Organic matter

24- What term is used to describe the ability of the soil to retain water for plants?
a. Soil Workability
b. Soil Structure
c. Soil Texture
d. <u>Water Holding Capacity</u>

25- Using the soil textural triangle what type of soil has 30% clay 30% Silt and 40% Sand?
a. <u>Clay Loam</u>
b. Silt Loam
c. Silty Clay Loam
d. Silty Clay

Assessment 3 – Explaining Soil Profile & Moisture Holding Capacity

1. A vertical cross section of soil is known as ______________
   a. A horizon
   b. A profile
   c. A substratum
   d. An illuvium
2. What term is used to define materials being altered in the soil?
   a. Additions
   b. Losses
   c. Translocations
   d. Transformations
3. What term is used for the A horizon?
   a. illuvium
   b. Subsoil
   c. Substratum
   d. Topsoil
4. What makes up the O horizon?
   a. Clay
   b. Iron
   c. Organic matter
   d. Silt
5. Which horizon consists of underlying bedrock?
   a. O
   b. B
   c. C
   d. R
6. Which horizon is best suited for growth of plant roots?
   a. A
   b. B
   c. C
   d. E
7. The standard depth of the soil profile is ____________.
   a. 1-2 feet
   b. 3-5 feet
   c. 8-10 feet
   d. 1 mile
8. Fallen leaves on the soil will eventually be ____________.
   a. Addition**s**
   b. Losses
   c. Translocations
   d. Transformations
9. The correct order (from top to bottom) of soil horizons is _____.
   a. A - B - C - E - R - O
   b. A - E - C - R - O - B
   c. O - A - E - B - C - R

d. O - A - B - C - E – R

10. The substratum is also known as ____________ and usually consists of parent material.
   a. The solum
   b. <u>The C horizon</u>
   c. The R horizon
   d. The subsoil
11. What is the solum?
   a. <u>The A, E, and B horizons</u>
   b. The C and R horizons
   c. The entire soil profile
   d. The substratum
12. Illuviation occurs when __________.
   a. Leached minerals form an E horizon between the A and B horizons
   b. <u>Chemicals are leached from the A and E horizons</u>
   c. Organic matter accumulates in the O horizon
   d. The C horizon weathers to make the B horizon
13. The E horizon is usually very light and occurs in forest soils high in _______.
   a. <u>Sand</u>
   b. Clay
   c. Organic matter
   d. Silt
14. Organic matter is most likely to be found in which horizon?
   a. <u>A</u>
   b. B
   c. C
   d. R
15. Erosion is an example of (a/an) _____________.
   a. Addition
   b. <u>Loess</u>
   c. Translocation
   d. Transformation
16. What is the primary factor in determining how much moisture a soil can hold?
   a. Color
   b. Profile
   c. <u>Texture</u>
   d. Structure
17. Which soil holds the most plant available moisture?
   a. Clay
   b. <u>Silt Loam</u>
   c. Sand
   d. Sandy-Clay
18. What is the soil water that tightly clings to soil particles called?
   a. Available
   b. Capillary
   c. Gravitational

d. <u>Hygroscopic</u>

19. Which soil type would hold the least amount of water?
   a. Fine textured
   b. Moderately fine textured
   c. Medium textured
   d. <u>Course textured</u>
20. What happens as the water in the soil us used by plants?
   a. <u>Soil moisture tension increases</u>
   b. Soil moisture tension decreases
   c. Soil water becomes more available
   d. Plants extract water more easily
21. The process of water soaking into the soil is known as ___________.
   a. <u>Infiltration</u>
   b. Percolation
   c. Permeation
   d. Soil moisture tension
22. Clay soils hold water more tightly due to _______________.
   a. Hygroscopic moisture
   b. Leaching
   c. Infiltration
   d. <u>Capillary action</u>
23. Available water holding capacity depends on _______________.
   a. Soil profile depth
   b. Soil texture
   c. Neither A or B
   d. <u>Both A and B</u>
24. Calculate the total water-holding capacity of this soil.

   A horizon 9” medium textured
   B horizon 23” moderately fine textured
   C horizon 28” medium textured

   a. 14.85
   b. <u>16.85</u>
   c. 18.25
   d. 18.35
25. Calculate the total water-holding capacity of this soil.

   A horizon 7” fine textured
   B horizon 18” medium textured
   C horizon 35” course textured

   a. <u>10.30</u>
   b. 12.22
   c. 12.85
   d. 14.25

Assessment 4 – Understanding Soil Erosion and Chemistry

1. Soil erosion is the process by which ________________________.
    a. Soil is moved
    b. Soil become polluted
    c. Water is infiltrated into the soil
    d. Gasses are exchanged in the soil
2. What is a ridge or row of earth mound called that is placed across a slope to allow a gradual drop for the flow of water in order to reduce erosion?
    a. Diversion ditches
    b. Grassed strips
    c. Terrace
    d. Windbreak
3. What is the process that involves planting crops with little or no plowing and leaving crop residue on the surface to protect the soil?
    a. Conservation tillage
    b. Crop rotation
    c. Stripped cropping
    d. Vegetation cover
4. What is runoff?
    a. The deposition of soil in the bottom of streams, riverbeds, ditches etc.
    b. Erosion that occurs on slopes that are saturated with water and slips down the hillside or mountain
    c. When the front edge of a glacier pushes soil, rocks, fallen trees, and other materials
    d. When rain falls faster than it can be absorbed into the soil and the water flows over the surface into streams and rivers
5. What type of erosion results when thin layers of soil are removed from the surface and often go unnoticed?
    a. Gully
    b. Rill
    c. Sheet
    d. Surface creep
6. Erosion that occurs on land not impacted by humans is _________________.
    a. Accelerated erosion
    b. Land slippage
    c. Anthropomorphic erosion
    d. Geologic erosion
7. Wind erosion is likely to occur in all of the following except which?
    a. Newly-plowed fields
    b. Construction sites cleared by equipment
    c. Land where vegetation had been grazed too closely
    d. A field with a cover crop planted on it
8. Another name for a landslide is:
    a. Glacial erosion
    b. Gully erosion
    c. Land slippage

d. Saltation

9. Which is not a commonly used erosion management practice?
    a. Mulching
    b. Silt fences
    c. Cover crops
    d. <u>Heavy grazing</u>
10. Erosion that happens when small rills continue to wash away and become more sever is known as:
    a. Complex rill erosion
    b. Sheet erosion
    c. <u>Gully erosion</u>
    d. Ditch erosion
11. The process of wind lifting medium size particles into the air, but are too heavy to remain in suspension is:
    a. <u>Saltation</u>
    b. Suspension
    c. Surface creep
    d. Rill erosion
12. A row of trees planted to slow wind and help prevent wind erosion is knows as:
    a. Terrace
    b. Diversion hedges
    c. Vegetative break
    d. <u>Windbreaks</u>
13. A natural soil pH is:
    a. 2
    b. 4
    c. <u>7</u>
    d. 10
14. A soil with a pH of 1 is considered:
    a. <u>A strong acid</u>
    b. A strong base
    c. A weak acid
    d. A weak base
15. A soil with a pH of 6.0 has _____________active H+ than 7.0.
    a. <u>10 times more</u>
    b. 10 times less
    c. 100 times more
    d. 100 times less
16. Soils formed under rainy conditions are typically ________________than soils formed under dry conditions.
    a. <u>More acidic</u>
    b. More basic
    c. Have a higher pH
    d. Has more calcium and magnesium
17. As a general rule soil acidity generally _______________ with soil depth.

a. Increases
b. Decreases
c. Stays the same
d. Varies

18. Nitrogen fertilizers typically __________ soil pH.
a. Raises
b. Lowers
c. Does not change
d. Initially raises then lowers

19. Cation exchange capacity is the ability of a soil to:
a. Move water through the soil
b. Prevent erosion
c. Change its pH to promote plant growth
d. React to chemicals added to the soil

20. What is the effect of adding lime to a soil with a pH of 5?
a. Will lower the pH
b. Will raising the pH
c. Will increase water holding capacity
d. Will decrease water holding capacity

21. Which is not a type of liming agent?
a. Calcium oxcide (CaO)
b. Calcium hydroxide [Ca(OH)2]
c. Calcium carbonate (CaC)
d. Calcitic limestone (CaCo3)

22. Soils that have a high cation exchange capacity (CEC) have a high _______ content.
a. Clay
b. Sand
c. Silt
d. Parent material

23. A soil with a high cation exchange capacity:
a. Retains a high amount of cations
b. Likely has a high clay content
c. Likely has a relatively high organic matter content
d. All of the above

24. Organic matter contains about a ______% nitrogen
a. 2
b. 5
c. 20
d. 80

25. If the soil permits, roots will extend ______ in depth.
a. 1-2 feet
b. 3-6 feet
c. 9-10 feet
d. 15-20 feet

Assessment 5 – Fertilizer Formulations, Applications, and Nutrient Deficiencies

1.) __________________ is considered an organic fertilizer.
   a. Blood meal
   b. Dried and ground sewage sludge
   c. Cottonseed meal
   d. All of the above
2.) A sensitive area that might need special consideration when applying fertilizer is _______________.
   a. 20 acres of soy beans
   b. An open hay field
   c. A drainage ditch
   d. All of the above
3.) Fertilizers that come from non-living sources are called ____________________.
   a. Inorganic fertilizers
   b. Organic fertilizers
   c. Green fertilizers
   d. Complete fertilizers
4.) Water-insoluble nitrogen (WIN) can also be referred to as ______________.
   a. Quick release nitrogen
   b. A complete fertilizer
   c. Turf fertilizer
   d. Slow-release nitrogen
5.) How many **pounds** of nitrogen are in a 50 lb bag of 10-25-5
   a. 5
   b. 10
   c. 12.2
   d. 25
6.) Which of the following fertilizers have a 1-1-1 ratio?
   a. 10-15-5
   b. 6-12-12
   c. 10-10-10
   d. 10-6-6
7.) Which fertilizer grade is least likely to be found at a feed and seed store?
   a. 10-10-10
   b. 30-40-30
   c. 5-15-30
   d. 20-0-5
8.) Which adds more nitrogen to a field?

a. 1/2 lb of 20-30-10
b. 1 lb of 10-10-10
c. 2 lbs of 5-5-5
d. <u>They all have the same amount of nitrogen</u>

9.) Which of the following is not a complete fertilizer?
a. 10-10-10
b. 20-3-8
c. <u>10-5-0</u>
d. All of the above are complete

10.) Which of the following is a single grade fertilizer?
a. <u>10-0-0</u>
b. 5-5-5
c. 20-5-3
d. None of the above

11.) Which level of nutrients is most desirable?
a. Level I
b. Level II
c. <u>Level III</u>
d. Level IV

12.) What can be done to determine the nutrient levels in the soil?
a. <u>A soil test</u>
b. Tissue testing
c. A soil injection
d. Top dressing

13.) The simplest way to fertilize is to _________.
a. <u>Broadcast</u>
b. Inject
c. Top dress
d. Site-specific application

14.) Which type of fertilizer application is applied on the growing crop rather than mixed into the soil?
a. <u>Top dressing</u>
b. Side dressing
c. Chiseling
d. Post-emergence

15.) Which type of fertilizer application is applied directly to the leaf of the plant?
a. Top dressing
b. Side dressing
c. <u>Foliar feeding</u>
d. Broadcast

16.) Which type of fertilizer application is applied after planting but before the crop begins to grow?

a. Top dressing
b. Side dressing
c. Pre-emergence
d. Post-emergence

17.) Fertigation is ________________?

a. Fertilizing the field before crops are planted
b. Injecting the fertilizer into the ground
c. Applying the fertilizer directly to the plant
d. Injecting fertilizer into the irrigation water

18.) Site-specific application (variable rate technology) involves ______________ to apply fertilizer to a field.

a. Lasers
b. Computers/GPS
c. Foliar feeding
d. Fertilizer injectors

19.) Build up is the amount of fertilizer that ________________________.

a. Is required to increase the soil nutrients to its desired level
b. Is the amount that will be moved when the crop is grown
c. Amount needed to reach the desired level plus what will be removed when the crop is grown
d. Should be applied every year (1 ton of lime per acre)

20.) The rate of fertilizer of application depends on ________________.

a. What is typical for farmers in the area
b. What has been done on the farm
c. The fertilizer applied the previous year
d. The soil sample

21.) How many macronutrients are there?

a. 3
b. 6
c. 9
d. 16

22.) What are the primary nutrients?

a. Calcium, Magnesium, & Sulfur
b. Nitrogen, Phosphorus, & Potassium
c. Chlorine, Iron, & Boron
d. Copper, Molybdenum & Zinc

23.) A plant with light green or yellow leaves could have a ____________ deficiency.

a. Nitrogen

b. Phosphorus
c. Sulfur
d. Potassium

24.) A plant with yellow/brown discoloration and scorching along the outer margin of the leaves could have a ________________ deficiency.

a. Nitrogen
b. Phosphorus
c. Sulfur
d. <u>Potassium</u>

25.) A plant with purple cast to leaves and stems, and stunted leaves could possibly have a ________________.

a. Nitrogen
b. <u>Phosphorus</u>
c. Sulfur
d. Potassium

26.) A plant with yellowing colors of the bottom/oldest leaves could have a ___________________ deficiency.

a. Copper
b. <u>Magnesium</u>
c. Sulfur
d. Calcium

27.) A plant with yellow, almost white, leaves with green veins could have a/an _______________ deficiency.

a. Zinc
b. Iron
c. Magnesium
d. <u>Iron</u>

28.) An acidic soil ___________________ the amount of available calcium, magnesium, sulfur, potassium, phosphorus, and molybdenum.

a. <u>Reduce</u>
b. Increase
c. Neither reduce or increase
d. Increase some while decreasing others

29.) A deficiency of boron, copper, and potassium can be caused by ________________.

a. Wet soil
b. <u>Dry soil</u>
c. Deep soil
d. Shallow soil

30.) Soils with hardpans require ________________ and _______________ to increase fertility.

a. Lime and iron
b. Calcium and manganese
c. Phosphorus and potassium
d. Chlorine and sulfur

Assessment 6 – Seed Germination & Plant Life Cycles

1.) What term defines the beginning growth of the seed embryo?
    a. <u>Germination</u>
    b. Stratification
    c. Scarification
    d. Imbibitions
2.) Seeds with a stratification dormancy mechanism must experience _____________ to germinate?
    a. Fire
    b. Acid
    c. Water and Oxygen
    d. <u>Cold</u>
3.) What enzyme breaks down proteins and changes them to amino acids?
    a. Amylase
    b. Acids
    c. <u>Protease</u>
    d. Phytochrome
4.) Most seeds are ______ water?
    a. 1-2%
    b. <u>5-10%</u>
    c. 20-30%
    d. 40-50%
5.) Water becomes imbedded into the seed during the first phase of germination through a process known as:
    a. <u>Imbibition</u>
    b. Turgidity
    c. Stratification
    d. Scarification
6.) The radicle is another term for:
    a. The first leaves
    b. The seed coat
    c. The water in the cell
    d. <u>The first root</u>
7.) What triggers the germination process?
    a. Temperature
    b. <u>Water content</u>
    c. Soil nutrients
    d. Pressure
8.) Seeds germinate at a temperature of 32 -105 F but the generally accepted optimal temperature for germination is:
    a. 32-44
    b. 45-60
    c. <u>65-80</u>
    d. 85-100
9.) Seeds that are light sensitive have _____________ found on the seed coat.

a. Photosynthesis
b. Phytochrome
c. Stomata
d. Pores

10.) Viability refers to the _______________.

a. Seeds ability to germinate under optimal conditions
b. Ability of the seed to germinate under different conditions
c. Ability of the seed to germinate when it is cold
d. Ability of the seed to germinate with little water

11.) What temperatures are best to store seeds?

a. 20 F
b. 40 F
c. 60 F
d. 80 F

12.) What humidity is best to store seeds?

a. 15%
b. 40%
c. 60%
d. 100%

13.) All of the following are life cycles of plants except for which of the following?

a. Annual
b. Biennial
c. Herbaceous
d. Perennial

14.) A plant that completes its growing cycle in one year is known as a/an:

a. Annual
b. Biennial
c. Herbaceous
d. Perennial

15.) A plant that completes its growing cycle in two years is known as a/an:

a. Annual
b. Biennial
c. Herbaceous
d. Perennial

16.) A plant that completes its growing cycle each year is known as a/an:

a. Annual
b. Biennial
c. Herbaceous
d. Perennial

17.) A typical annual plant will require _________ days from germination to produce a seed.

a. 60
b. 80
c. 120
d. 160

18.) An example of a summer annual is ____________.

a. <u>Corn</u>
b. Wheat
c. Strawberries
d. Carrots

19.) An example of a winter annual is _______________.
a. Corn
b. <u>Wheat</u>
c. Strawberries
d. Carrots

20.) An example of a biannual is _______________.
a. Corn
b. Wheat
c. Strawberries
d. <u>Carrots</u>

21.) An example of a perennial is _______________.
a. Corn
b. Wheat
c. <u>Strawberries</u>
d. Carrots

22.) Trees and shrubs that lose their leaves in the fall are:
a. Evergreen
b. Annuals
c. Herbaceous perennials
d. <u>Deciduous</u>

23.) Plants that have shoots that die back in the winter but has roots that survive are known as:
a. Woody perennials
b. Deciduous
c. Evergreen
d. <u>Herbaceous perennials</u>

24.) During winter perennials go through a ____________period.
a. Germination
b. Growth
c. <u>Dormancy</u>
d. Latency

25.) A typical evergreen leaf lasts __________ before dropping.
a. 1-2 months
b. 4-6 months
c. <u>1-3 years</u>
d. 3-5 years

Assessment 7 – Examining Photosynthesis & Respiration

1.) The green pigment in leaves is known as
   a. <u>Chlorophyll</u>
   b. Chloroplasts
   c. Mesophyll
   d. Stroma
2.) The fluid filled region within the chloroplast is known as the __________.
   a. Chlorophyll
   b. Grana
   c. Mesophyll
   d. <u>Stroma</u>
3.) The most important type of chlorophyll is _______________.
   a. Carotenoids
   b. <u>Chlorophyll a</u>
   c. Chlorophyll b
   d. Grana
4.) The yellow green chlorophyll is ______________.
   a. Carotenoids
   b. Chlorophyll a
   c. <u>Chlorophyll b</u>
   d. Grana
5.) Interconnected sets of flat, disk like sacks are ____________.
   a. Grana
   b. Mesophyll
   c. Stroma
   d. <u>Thylakoids</u>
6.) A group of thylakoids are known as _________.
   a. Stroma
   b. <u>Grana</u>
   c. Mesophyll
   d. Cartenoids
7.) The chlorophyll transfers the energy in sunlight into high energy compounds known as ____________.
   a. ATP
   b. NADPH
   c. Cellulose
   d. <u>All of the above</u>
8.) During the light-independent reaction (dark reaction)
   a. ATP is produced
   b. <u>ATP and NADHP are used to make high-energy carbohydrates</u>
   c. Photophosphorulation occurs
   d. 6 carbon molecules are split into 2 three carbon molecules that join with simple sugars
9.) Which of the following is not a C_4 plant?
   a. Corn

b. Crab grass
c. <u>Sugar beets</u>
d. Sugar cane

10.) Which is not a trait of a C_4 plant?
a. Bundle sheath cells
b. High levels of carbon dioxide
c. High rate of photosynthesis
d. <u>Calvin cycle takes place</u>

11.) What will happen to a plant during a lack of water?
a. Bundle sheath cells rapidly produce carbon dioxide
b. NADPH and ATP are rapidly produced
c. Chlorophyll levels decrease
d. <u>Stomates close</u>

12.) Can photosynthesis occur without sunlight?
a. Yes, at a very high rate
b. Yes, but at a very low rate
c. <u>Not at all</u>
d. Depends on how much water is present

13.) Which statement is the most correct?
a. A C_3 plant grows slightly faster than a C_4 plant
b. <u>A C_4 plant grows much faster than a C_3 plant</u>

14.) Respiration takes place in which organelle?
a. <u>Mitochondria</u>
b. Nucleus
c. Ribosome
d. Nucleotide

15.) When oxygen is in short supply, plants must rely on:
a. Aerobic respiration
b. <u>Anerobic respiration</u>
c. Glycolysis
d. Cytosol

16.) The process of plants removing oxygen is known as:
a. Cellular respiration
b. Fermentation
c. Glycolysis
d. <u>Reduction</u>

17.) The fluid of a cell in which the organelles are suspended is known as:
a. Mitochondria
b. The golgi complex
c. <u>Cytosol</u>
d. Ribosome

18.) Carbohydrates are broken down in the plant to form all of the following except:
a. <u>Oxygen</u>
b. ATP
c. Carbon dioxide
d. Water

19.) An example of anaerobic cellular respiration is:

a. Tricarboxylic acid (TCA) cycle
b. Ctylosol
c. Glycolysis
d. <u>Fermentation</u>

20.) During the third stage of the aerobic respiration ______________ enter the mitochondria.

a. <u>Pyruvate molecules</u>
b. Cytosol fluid
c. Tricarboxylic acid (TCA)
d. Bacteria

21.) During the third stage of aerobic respiration, the _______________ takes place, releasing Carbon dioxide and hydrogen.

a. <u>Tricarboxylic acid (TCA) cycle</u>
b. Glycolysis
c. Reduction
d. Fermentation

22.) As temperature increases respirations ______________.

a. <u>Increases</u>
b. Decreases
c. Stays the same
d. Varies

23.) What type of plant has the highest respiration rates?

a. A young plant in a very wet (water logged) soil
b. An old plant in a very wet (water logged) soil
c. <u>A young plant in an average soil</u>
d. An old plant in an average soil

24.) Respiration occurs:

a. In the light
b. In the dark
c. <u>In the light and dark</u>
d. In the absents of carbon dioxide and water

25.) Low levels of carbohydrates = ____________________.

a. High rates of respiration
b. <u>Low rates of respiration</u>
c. High temperatures
d. Low temperatures

APPENDIX D
CONTENT KNOWLEDGE ASSESSMENT PLANNING MATRICS

Lessons 1 & 2

Lesson#/Objective #	% Instructional time (lessons combined)	% of the Assessment	Questions
1/1	7	7	1,2
1/2	18	21	3,4,5,6,7,8
1/3	7	7	9,10
1/4	6	3	11
1/5	11	7	12,13
2/1	12	14	14,15,16,17
2/2	13	14	18,19,20,21
2/3	13	14	22,23,24,25
2/4	13	14	26,27,28,29

Lesson 3 & 4

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
3/1	5	4	5
3/2	5	4	6
3/3	10	8	1,3
3/4	10	12	2,4,8
3/5	5	4	9
3/6	10	8	7,10
4/1	20	20	11,12,13,19,24
4/2	15	16	14,15,17,25
4/3	10	12	16,22,23
4/4	10	12	18,20,21

Lesson 5 & 6

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
5/1	10	8	1,7
5/2	10	12	2,8,15
5/3	40	40	3,4,5,6,9,10,11,12,13,14
6/1	15	16	18,21,22,23
6/2	10	8	17,20
6/3	15	16	16,19,24,25

Lesson 7 & 8

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
7/1	5	8	1,6
7/2	5	8	4,8
7/3	10	8	3,11
7/4	10	8	5,10
7/5	5	8	7,9
7/6	10	12	2,3,12
8/1	5	0	
8/2	20	20	13,14,15,16,17
8/3	10	12	19,22,23
8/4	20	20	18,20,21,24,25

Lesson 9, 10, & 11

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
9/1	5	4	2
9/2	5	2	1,3
9/3	15	16	4,5,6,7
9/4	10	12	8,9,10
10/1	5	8	11,12
10/2	20	24	13,14,15,16,17,18
10/3	5	8	19,20
11/1	20	20	21,22,23,24,25
11/2	5	4	26
11/3	5	8	27,28
11/4	5	8	29,30

Lesson 12 & 13

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
12/1	25	24	1,2,3,4,5,6
12/2	10	12	7,8,9
12/3	10	12	10,11,12
13/1	5	0	
13/2	15	16	14,17,18,19
13/3	5	8	15,20
13/4	30	32	13,16,21,21,22,23,24,25

Lesson 14 & 15

Lesson#/Objectives#	% Instructional time (lessons combined)	% of the assessments	Questions
14/1	25	24	1,2,3,4,5,6
14/2	25	24	7,8,9,10,11,13
14/3	5	4	12
15/1	5	8	14,15
15/2	25	24	16,17,18,19,20,21
15/3	15	16	22,23,24,25

APPENDIX E
INTRODUCTION LETTER

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College of Agricultural and Life Sciences

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Telephone: (352) 392-0502 ext. 238
Fax: (352) 392-9585
athoron@ufl.edu

Department of Agricultural Education and Communication
Andrew Thoron, Graduate Teaching / Research Assistant

September 1, 2009

Thank you for your participation in this study. Yes, this study conducted well will earn me my Ph.D. and that is a large driving force for me, but perhaps most importantly is the value I believe this study could have on agriscience education. I am excited you are willing to be a part of this study.

I find this study exciting and a strong interest I have in agricultural education as I believe we can deliver a context unprecedented in American high schools. Furthermore, we compose the style of teaching that is effective to aid "core" academics and provide a naturally integrated curriculum in science and math. I choose to focus on the science portion of things and that is the focus of this study.

I believe I have enclosed all information you will need for the study. If there are any questions at anytime feel free to call me or Brian. You can reach me anytime on my cell phone (217) 556-3635 or the office number is (352) 392-0502 Ext. 238. I will answer my cell phone day or night or get back to you quickly.

I will be sending an e-mail with details on the MyCAERT testing system and MyCAERT web-site. The company, MyCAERT, has allowed us access to use their materials for the study. You will also have some access to their curriculum until the end of the year. I encourage you to use the website and take some time to investigate what they have to offer because it is a free peek at what you get if you would like to buy or subscribe to their curriculum materials. I will have details available soon for you.

Finally, I feel like I should let you know a little bit about me. I am a Ph.D. candidate at the University of Florida. I plan to prepare high school agriscience teachers after I obtain my Ph.D. I grew up on a small farm in central Illinois about 35 miles straight south of Springfield. I attended Illinois State University for my bachelor degree in AgEd and taught at Mt. Pulaski High School. Mt. Pulaski was a small rural farm community with others working in nearby Springfield (many state jobs) or Decatur (which is more industrial with Caterpiller, ADM, Staley's, and other metal manufacturing). I loved teaching high school and grew the program and when I left they created a two teacher program (If I would have known this was going to happen I would probably still be teaching at Mt. Pulaski). I then worked for the state of Illinois for one year as a regional state staff in AgEd with the Illinois State Board of Education. I was located in the Chicago-land area and worked with the NE quadrant of Illinois. If you know Illinois my area was basically everything East of Route 51 and everything north of Interstate 74. I worked with about 100 teachers in nearly 70 schools on developing curriculum and aiding grants as well as program support. It never crossed my mind that I would be wanting to get or getting my Ph.D. but one day I called Brian Myers because ISU had an opening in teacher education and I knew he was from Illinois. I wanted to recruit him to come "home" and teach at ISU. Instead, he recruited me to come to Florida. Now, I do have to admit that by this time I had thought about getting my Ph.D.

In short there is nothing more important to me than what you do on a daily basis. I hope what I can do as a young future professor can aid your teaching, help clear a path to your success in the classroom, and discover some great ways to educate our youth. I became interested in this type of research because studies indicate and data shows youth are still lacking in science. I believe agriculture has something to offer when science is discussed in our public schools.

If you have any questions anytime please call.

Thank you for your participation and I can't wait to see the results.

Andrew Thoron
Ph.D. Candidate
University of Florida

APPENDIX F
EXPLANATION AND DESIGN OF THE STUDY

Explanation of the Study

To the teacher:

Thank you for agreeing to participate in this study. I hope this study not only tells us information about the two teaching methods but also allows me to share valuable information with NATAA stakeholders, teacher preparation programs, fellow agriscience teachers and science teachers, and administrations. I hope the lessons and lab investigations are something you find useful along with the data and results I gather. I hope your classes will work through this study and find the units and topics interesting.

It is anticipated you will read over all content information and instruct the lessons as described in the lesson plans. In order for this study to have validity, it is important each person teach the lessons in the same manner. Please look over the lessons and labs as there may be items you have to order. If you could order the material needed, I will likely write you a personal check and pay you back for the materials you had to purchase. I know from being an Ag teacher sometimes we can be creative on how to get the materials we need….so I know there are a couple times I am asking you to do that. However, if you are paying for something out of your personal money please let me know and I will pay you for it. I appreciate your participation, but I don't want you to have to pay to participate in this study. I hope you understand the value the study can bring to the profession, but I cannot willingly ask you to pay for some of it with your own money.

Setting up the study is very important. All teachers/schools involved in the study have at least 2 sections of Agriscience. Please set up the following arrangement: If the instructor has 3 sections, please have the 3rd section follow the same schedule as Group 1. If the instructor has 4 sections please have the 4th group follow the same schedule as group 2.

Design of the Study

(you can use the ✓ down the center so you know where you are in the study and what is next)

Step #	Inquiry-based instruction (Group 1)	✓	Subject-matter approach (Group 2)
1	Assign students ID#'s, Introduce them to the computerized testing system, Student take Pretest 1		Assign students ID#'s, Introduce them to the computerized testing system, Student take Pretest 1
2	Teach lesson 1		Teach lesson 1
3	Teach lesson 2		Teach lesson 2
4	Students take Posttest 1		Students take Posttest 1
5	Students take Pretest 2		Students take Pretest 2
6	Teach lesson 3		Teach lesson 3
7	Teach lesson 4		Teach lesson 4
8	Students take Posttest 2		Students take Posttest 2
9	Students take Pretest 3		Students take Pretest 3
10	Teach lesson 5		Teach lesson 5
11	Teach lesson 6		Teach lesson 6
12	Students take Posttest 3		Students take Posttest 3
13	Students take Pretest 4		Students take Pretest 4
14	Teach lesson 7		Teach lesson 7
15	Teach lesson 8		Teach lesson 8
16	Students take Posttest 4		Students take Posttest 4
17	Students take Pretest 5		Students take Pretest 5
18	Teach lesson 9		Teach lesson 9
19	Teach lesson 10		Teach lesson 10
20	Teach lesson 11		Teach lesson 11
21	Students take Posttest 5		Students take Posttest 5
22	Students take Pretest 6		Students take Pretest 6
23	Teach lesson 12		Teach lesson 12
24	Teach lesson 13		Teach lesson 13
25	Students take Posttest 6		Students take Posttest 6
26	Students take Pretest 7		Students take Pretest 7
27	Teach lesson 14		Teach lesson 14
28	Teach lesson 15		Teach lesson 15
29	Students take Posttest 7		Students take Posttest 7
30	Students take the argumentation instrument (I will e-mail this to you – same for both groups)		Students take the argumentation instrument (I will e-mail this to you – same for both groups)
31	Students take the scientific reasoning instrument (Included on jump drive – same for both groups)		Students take the scientific reasoning instrument (Included on jump drive – same for both groups)

I know the design and the above table can be overwhelming. Basically, there are 15 lessons you will be teaching. As I think you will agree, I found it is better to assess students in smaller chunks. The lessons break down well to assess students after each pair of lessons with the acceptation of lesson 9, 10, & 11. Lessons 9, 10, & 11 go together for one assessment. I can understand that it looks like I am testing the students often. The reason for the pretest (which is the same as the posttest) is to establish a prior knowledge of the student and the groups. I will use the pretest to control for differences between the groups, thus allowing me to find which method is more successful despite differences in student prior knowledge.

I am randomly assigning your class section to inquiry-based instruction or subject-matter teaching (traditional method). The random selection is the best way to determine what group receives each teaching method. It is of GREATEST importance that you do not cross the two styles of teaching. This is the reason that I ask you to audio tape your class, I need to assure my committee and the people I present the results of the study to that the two methods were different and separate. Therefore, each group (class) needs to be taught under one method the entire length of the study. Example: You have your Agscience Class 3rd and 6th period. Third hour you teach using the subject-matter the entire length of the study and 6th period you teach using inquiry-based instruction the entire length of the study

At the end of the study the students will take an argumentation instrument I created. The purpose of this instrument is to assess students' ability to work through a problem and explain the choices they made to develop their answer, why it is the best answer developed, as well as other potential answers. The scientific reasoning instrument will also be given to students at the end to establish if the group has developed a better scientific reasoning. Have students write their school, method taught, and student ID number at the top of the page on all the instruments. I will likely have you mail the hard copies of the instruments back to me. The argumentation instrument is not included on the jump drive. I will e-mail you the argumentation instrument later in the study.

I anticipate the study to be 100% complete by Thanksgiving break.

APPENDIX G
EXPLANATION OF INQUIRY-BASED INSTRUCTION AND SUBJECT-MATTER LESSON PLANS

Explanation of Inquiry-based Instruction and Subject-matter Lesson Plans

Your participation in the study will provide valuable information to the NATAA, DuPont and other stakeholders involved in the program, fellow teachers in the NATAA program, teacher preparation programs, fellow inservice teachers, administrators, and the research community in agriscience education and science education.

You will be selecting <u>one class to receive the inquiry-based instruction</u> and <u>one class to receive the subject-matter lessons</u>. Once I have randomly assigned ONE method or the other you will not be able to switch. This is an important part of the study. Each group will receive the same method the entire study. I will be comparing the two groups. Students will take a pretest to establish previous knowledge and thus allow me to statistically control for difference between the groups' prior knowledge.

When teaching the Subject-matter lessons there are suggested ways to teach each objective below the content. You will need to follow the teaching methodology as best you can for the subject-matter approach to teaching. The Inquiry-based instruction lesson plans are truly a supplement to the subject-matter lessons. You will not teach the material the same way as the subject-matter approach; instead you will use the inquiry-based instruction supplement to guide the inquiry method of instruction. There are times the inquiry-based instruction asks you to guide students to obtain the content contained in the subject-matter lessons. Furthermore, there will be times the inquiry supplement may ask you to provide students with the technical terms or information as they investigate beyond the scope of the subject-matter lesson. Please follow the directions as closely as possible allowing students the ability to obtain the knowledge level material because they are assessed on the knowledge level exams.

Inquiry-based instruction students should be pushed and expected to maintain a notebook of their observations, learning, content knowledge level material, reasoning, and reflections. I know you are familiar with the notebook style used at NATAA. The subject-matter students should be asked to use the traditional method you direct.

It is possible at times the two groups will not be learning the same lesson. This is okay for this to occur. I know it may be difficult to keep the two groups at the same place and taking the tests on the same day. This is fine, just keep the two groups separate in your teaching. Overall, the two groups will finish approximately at the same time.

As you know the inquiry-based instruction develops an instructor as a facilitator role. Please guide students when needed toward the objectives of the lesson so they stay on track.

APPENDIX H
EXPLANATION OF SCHOOL, METHOD, STUDENT ID NUMBER, DEMOGRAPHIC SHEET, AND COMPUTER-BASED TESTING SYSTEM

Explanation of School, Method, and Student ID Number
Demographic Sheet
Computer-based Testing System

Each school is given an ID number, each method is given an ID number, and each student is given an ID number.

To maintain the highest level of confidentiality for the students I do not need to see student names. Your jump drive identifies your school number. On your jump drive you will find a word document that has your school identification number.
Example: School12

This means you are school 12 of the study. You will use this for all purposes during the study. When asked about school ID number you would enter 12. If your jump drive has a word document named: School7, you are school 7 for all purposes. You can find the information on your jump drive in the folder titled school ID # and click on the folder and a word document will be named with your ID # and inside and contains your name, address, and e-mail address I intend to use during the study.

The method of instruction will be 01 and 02. 01 means the inquiry method and 02 means the subject-matter method. You should have every student in the inquiry-method class be 01 and every student in the subject-matter method be 02

Finally, student ID#. Each student should have an ID number. You can designate students a number alphabetically or however it is easiest for you to remember. I assume you have students listed in your grade book alphabetically. So the first student in each section (inquiry and subject-matter) is number 1. The second student is number 2 etc. You can have the student ID number begin at 1 for each section. This is fine because the previous number designates what method the student is being taught.

Final example:
ID# 010113
The first two numbers (01) means school number 1 of the study.
The second pair of numbers means the method (01). 01 means this student is receiving the inquiry method
The third pair of numbers denotes the student ID in his/her section. 13 means this student is the 13 student in the section.

One for practice:
ID#080215
What does this mean?

Answer: School eight, subject-matter method, and student fifteen

Demographic sheet

In completing the demographic sheet you will find the ID#'s useful. You will place your school ID number in every cell, or you may chose to identify it on the first cell. The following cell you will enter the method used, followed by the student ID number. Please indicated the grade the student is in during the instructional time, keep track of the days the student is absent and enter this into the next column. In the next five cells there are drop down items to select from. You may have to obtain help from your school administrator to complete all the information. If there is NO IEP then there is NO need to complete the last cell. If there is an IEP, please identify the nature of the student's IEP. We are interested in IEP data b/c a Master student is completing his master's degree requirements studying the IEP data of my dissertation study.

What do students need to know?

Students will need to know AND remember their ID# when logging onto the testing system to take their pretests and posttests. They will need to remember their entire ID number. So if your school number is 05 and they are being taught with the inquiry approach, and you have identified that student as 18 their number is ID#: 050118. I suggest you give them a piece of paper that has their ID number on it or a place where they can write their ID number on in their notebook.

Computer-Based System

I will e-mail you a log in and ID to log into ***MyCAERT.*** Once logged in you on the left side of the page you will see an icon you can click that says Thoron's study in the area of "My Courses". Click Thoron's study. Once you click Thoron's study the 15 lessons will appear. The pdf icon will allow you to access the pdf document that is included on your jump drive. You will also notice near the center of the gray box a PPT files and can click on the APSS icon and access a PowerPoint for your use during the subject-matter portion of the study. There is also an icon to the right of the PowerPoint that will allow you access to an E-unit. E-units are not used in this study, but could act as a reference or you could download them for use after completion of the study.

Computer-Based Testing

I will be sending out an e-mail in the future to explain the testing system. You will likely get the e-mail explaining the testing system before this packet arrives. However, you will have to assign each student their ID # (as explained above) and password. The students will use the assigned number and password to access the test. The student will have to click on the test that they are to take. Once into the testing system they will click the correct answer. Once they complete the 25+ question multiple choice exam they will be finished. You will have to make sure the student clicks the correct assessment to complete the correct test. If they are taking Pretest one please ensure they select Pretest one. If a student is taking the Posttest one they need to select Posttest one and so on.

APPENDEX I
STUDENT DEMOGRAPHICS SHEET

Student Demographics Sheet

DIRECTIONS: Please complete the following information for all students in the class.

School ID#	Student ID#	Grade	Days Absent	Gender	Ethnicity	National School Lunch Program	IEP Status	Nature of IEP
				☐ Male ☐ Female	☐ Black ☐ Hispanic ☐ White ☐ Other	☐ Does not participate ☐ Reduced lunch ☐ Free lunch	☐ IEP ☐ No IEP	☐ Mental Retardation ☐ Hearing Impairment ☐ Speech or Language Impairment ☐ Visual Impairment ☐ Emotional Disturbance ☐ Orthopedic Impairments ☐ Autism ☐ Traumatic Brain Injury ☐ Deaf-Blindness ☐ Specific Learning Disability ☐ Developmental Delay ☐ Other ________
				☐ Male ☐ Female	☐ Black ☐ Hispanic ☐ White ☐ Other	☐ Does not participate ☐ Reduced lunch ☐ Free lunch	☐ IEP ☐ No IEP	☐ Mental Retardation ☐ Hearing Impairment ☐ Speech or Language Impairment ☐ Visual Impairment ☐ Emotional Disturbance ☐ Orthopedic Impairments ☐ Autism ☐ Traumatic Brain Injury ☐ Deaf-Blindness ☐ Specific Learning Disability ☐ Developmental Delay ☐ Other ________
				☐ Male ☐ Female	☐ Black ☐ Hispanic ☐ White ☐ Other	☐ Does not participate ☐ Reduced lunch ☐ Free lunch	☐ IEP ☐ No IEP	☐ Mental Retardation ☐ Hearing Impairment ☐ Speech or Language Impairment ☐ Visual Impairment ☐ Emotional Disturbance ☐ Orthopedic Impairments ☐ Autism ☐ Traumatic Brain Injury ☐ Deaf-Blindness ☐ Specific Learning Disability ☐ Developmental Delay ☐ Other ________

APPENDIX J
EXPLANATION OF JUMP DRIVE, AUDIO RECORDING, AND IRB

UF UNIVERSITY of FLORIDA
College of Agricultural and Life Sciences

Department of Agricultural Education and Communication
Andrew Thoron, Graduate Teaching / Research Assistant

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athoron@ufl.edu

Jump Drives and Audio Recording
Read after Explanation of School, Method, and Student ID Number
Demographic Sheet
Computer-based Testing System

Thank you for your participation in this study. I hope this study not only tells us information about the two teaching methods but also allows me to share valuable information with NATAA stakeholders, teacher preparation programs, fellow agriscience teachers and science teachers, and administrations. I hope the lessons and lab investigations are something you find useful along with the data and results I gather. I hope your classes will work through this study and find the units and topics interesting.

I have enclosed a couple other documents and some jump drives (thumb drives) for you to use. Each document, including the electronic copies of the hard copies in this mailing are enclosed in the 16gig jump drive. The 16gig jump drive is yours to use during the study, once the study is complete the jump drive is yours to keep. I have also enclosed an audio recorder. I ask that you audio record both class sessions. After each day please load the class sessions onto the 8gig jump drive. Name the file using the following: school number, method number, lesson number and the number of the day you have been teaching the lesson.

For example: school number six, inquiry-based instruction, lesson five, second day of teaching lesson five. You would name the audio file: 06010502 That means school six, inquiry method, lesson five, second day of instruction of that lesson.

For practice: You are school 12 and you are teaching the subject matter approach of lesson 8 and you are on your first day of that lesson.

Answer:

File name: 12020801

Please audio record your class each period. This is to ensure that you are delivering the content as intended. I will be randomly reviewing the files and will probably ask if you could send me some electronically during the study. If you simply place the audio recorder on your desk it should pick up the classroom speaking well. I don't want you to draw attention to it and please don't feel bad or embarrassed if a day of teaching does not go well or some things are said you would rather people not hear. I will be the only one listening to the audio recordings and I know what being a high school teacher is like. Once the study is complete the audio recorder is yours to keep.

Finally, enclosed in the jump drive in the Teacher papers section you will find the IRB student participation form and a parental form. I have University approval to conduct this research. Basically what that means is that the Institutional Review Board (IRB) states that no students will be harmed or disadvantaged in the classroom due to this study. There are 2 IRB "informed consent" forms. The IRB signed by students are for students over 18 the other is for use for students under the age of 18.

APPENDIX K
IRB APPROVAL

UF | **Institutional Review Board**
UNIVERSITY *of* FLORIDA

PO Box 112250
Gainesville, FL 32611-2250
352-392-0433 (Phone)
352-392-9234 (Fax)
irb2@ufl.edu

August 11, 2009

TO: Andrew Charles Thoron; Ralph G. Easterly III
PO Box 110540
Campus

FROM: Ira S. Fischler, PhD; Chair ISFdl
University of Florida
Institutional Review Board 02

SUBJECT: **Approval of Protocol #2009-U-0820**

TITLE: Investigation of teaching methods effect on student content knowledge, scientific reasoning, and argumentation skills

SPONSOR: None

I am pleased to advise you that the University of Florida Institutional Review Board has recommended approval of this protocol. Based on its review, the UFIRB determined that this research presents no more than minimal risk to participants. Your protocol was approved as an expedited study under category 7: *Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.* Given your protocol, it is essential that you obtain signed documentation of informed consent from the parent or legal guardian of each participant. When it is feasible, you should obtain signatures from both parents. Enclosed is the dated, IRB-approved informed consent to be used when recruiting participants for the research.

> It is essential that the parents/guardians of your minor participants sign a copy of your approved informed consent that bears the IRB approval stamp and expiration date.

If you wish to make any changes to this protocol, ***including the need to increase the number of participants authorized***, you must disclose your plans before you implement them so that the Board can assess their impact on your protocol. In addition, you must report to the Board any unexpected complications that affect your participants.

If you have not completed this protocol by August 10, 2010, please telephone our office (392-0433), and we will discuss the renewal process with you. It is important that you keep your Department Chair informed about the status of this research protocol.

ISF:dl

APPENDIX L
INFORMED CONSENT FOR STUDENTS

Informed Consent for Students

Protocol Title: Investigation of teaching methods effect on student content knowledge, scientific reasoning, and argumentation skills.

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study:
The primary purpose of this study is to determine the effect of using Inquiry–based instruction's effect on content knowledge, scientific reasoning, and argumentation skills.

What you will be asked to do in this study:
You will be asked to participate in lessons in your Agriscience course. In addition, you will be asked to complete a series of assessment instruments.

Time Required:
Lesson plans have been developed to take 10 weeks of classroom instruction.

Risks and Benefits:
There are no anticipated risks or benefits to your participation in this study.

Confidentiality:
Your identity will be kept confidential to the extent allowed by law.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from study:
You have the right to withdraw from the study at any time without consequence.

Whom to contact if you have questions about the study:
Andrew Thoron, Graduate Student, Agricultural Education and Communication Department, P.O. Box 110540, P: (352) 392-0502, F: (352) 392-9585, athoron@ufl.edu
or
Brian E. Myers, PhD, Assistant Professor, Agricultural Education and Communication Department, P.O. Box 110540, P: (352) 392-0502, F: (352) 392-9585, bmyers@ufl.edu

Whom to contact about your rights as a research participant in the study:
UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; P: (352) 392-0433

Agreement:
I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ______________________________ Date: ______________

Principal Investigator: Andrew Thoron Date: 8/31/09

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2009-U-0820
For Use Through 08-10-2010

APPENDIX M
INFORMED CONSENT FOR PARENTS

UNIVERSITY of FLORIDA
IFAS
Department of Agricultural Education and Communication
Andrew Thoron, Ph.D. Candidate

305 Rolfs Hall
PO Box 110540
Gainesville, FL 32611-0540
Telephone: (352) 392-0502 ext. 238
Fax: (352) 392-9585
athoron@ufl.edu

Dear Parent or Guardian,

Your child's Agriscience class has been selected to participate in a research study to measure the effect of teaching methods. The results of this study will be used to improve the instruction received by students in agriscience programs. These results may not directly help your child today, but will benefit future students. With your permission, I would like to ask your child to volunteer to participate in this research.

In addition to the normal classroom lessons and assessments, your child will be asked to complete a scientific reasoning assessment and an argumentation assessment, taking approximately 25minutes each at the end of the study. Your child's identity will be kept confidential to the extent allowed by law. Also, participation in this study will not affect their grades in the course.

You and your child have the right to withdraw consent of your child's participation at any time without consequence. There are no known risks or immediate benefits to the participants. No compensation is offered for participation.

If you have any questions about this research protocol, please contact Andrew Thoron (athoron@ufl.edu) or Dr. Brian Myers (bmyers@ufl.edu) at (352) 392-0502. Questions or concerns about your child's rights as a research participant may be directed to the UFIRB Office, University of Florida, Box 112250, Gainesville, FL 32611, (352) 392-0433.

I have read the procedure described above. I voluntarily give consent for my child,

_________________________, to participate in this study. I have received a copy of this description.

Parent/Guardian: ________________________________ Date: ________________

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2009-U-0820
For Use Through 08-10-2010

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BIOGRAPHICAL SKETCH

R. G. Easterly III (Tre) grew up in Mars Hill, North Carolina. During high school at Madison High in Marshall, North Carolina he decided that he wanted to be an agriculture teacher to help students learn more about their natural world around them and to have an appreciation and respect agriculturalists. In 2008 he graduated Cum Lade from North Carolina State University where he received his Bachelors of Science in Agricultural Education with a concentration in Animal Sciences. He completed his student teaching at Triton High School in Dunn, North Carolina with John Hardee as part of the requirement for teaching certification. He was provided an opportunity to have an assistantship at the University of Florida to study Agricultural Education. Upon graduation he plans to teach Agriscience in a public secondary school.