ASSESSMENT OF TEACHERS' ABILITY TO INTEGRATE SCIENCE CONCEPTS INTO SECONDARY AGRICULTURE PROGRAMS

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

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I dedicate this work to my wife and family.

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ASSESSMENT OF TEARCHERS' ABILITY TO INTEGRATE SCIENCE CONCEPTS INTO SECONDARY AGRICULTURE PROGRAMS

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ABSTRACT

For the past two decades, the idea of integrating more science concepts into the agricultural education curriculum has been gaining support. The purposes of this study were two fold: 1) To assess the knowledge base and interest levels among agriculture instructors in teaching concepts related to science; 2) To assess how such a change in the curriculum would impact current agricultural education programs. The sample was derived from the population of agriculture instructors teaching in Missouri secondary schools. For this descriptive correlational research, an instrument was developed to assess the instructors' perceived level of competence to teach selected science grade level expectations (GLE) and their relationship to the agricultural education curriculum and programs. A second instrument, solicited from the American Board for Certification in Teacher Excellence, was used to assess the general biological science knowledge of the teachers.

Agriculture instructors perceive that they are competent to teach and integrate science GLEs into the agriculture curriculum. However, their scores on the examination of knowledge of biological science brings into question their competence to teach this subject matter. Teachers believe integrating science into the agriculture curriculum will benefit their program and their students; however, they unsure if their classes should count for science credit or if FFA programs and activities are a good match for a more science-based curriculum.

CHAPTER I

INTRODUCTION

During the past 150 years, agricultural education has gone through several metamorphoses. In 1906, Chamber's Encyclopedia stated, "Agricultural education, as at present understood, is a comprehensive term, including instruction in chemistry, geology, botany, zoology, mechanics-embracing, in short the science as well as the practice of agriculture" (as cited in Hillison,1996. p #). With the passage of the Smith Hughes Act in 1917, the definition of agricultural education changed to include content that was designed for "farm boys." Specifically, the act stated:

> …that the controlling purpose of such education shall be to fit for useful employment; that such education shall be of less than college grade and be designated to meet the needs of persons over fourteen years of age who have entered upon or who are preparing to enter upon the work of the farm or of the farm home (Smith-Hughes Act, p. 20).

During the last two decades, the content and purpose of the curriculum of secondary agriculture programs has been shifting. With the passage of multiple vocational education acts, such as the four Carl Perkins Acts (Carl D. Perkins, 1998), programming content, students' backgrounds, and funding has evolved. Today, another shift is occurring. Specifically, leaders in agricultural education are insisting that the curriculum be infused with more academic rigor and science content (Balschweid & Thompson, 2002).

In 1988, the National Research Council (NRC) released *Understanding Agriculture New Directions for Education.* In the report, they referred to agricultural education becoming education *about* agriculture, rather than simply education *in* agriculture. Specifically, this report stated that "new curriculum components must be developed and made available to instructors addressing the sciences basic to agriculture, food, and natural resources… and tools to improve the efficiency of production agriculture" (National Research Council, 1988, p. 35). In 1998, the Missouri Department of Elementary and Secondary Education (DESE), released *Reinventing Agricultural Education for the year 2020*, wherein a vision for agricultural education was presented. Three vision themes were compiled to create goals for agricultural education. Of most importance here, theme three, goal three, was to "focus on the sciences of food, fiber, and natural resources" (DESE, 1998, p. 7).

Further, in the *2005 – 2006 Annual Report of Agricultural Education*, The National Council for Agricultural Education formed a task force to develop curriculum frameworks for agriscience curriculum (Team Ag Ed, 2007). Through this process, a curriculum model called Curriculum of Agriculture Sciences Education (CASE) was designed, which was specifically intended to "align with sciences, technology, engineering, and mathematics" (Team AgEd, 2007, p. 20).

Recommendations to integrate science into the agriculture curriculum are not a new phenomenon, however. As early as 1989, Norris and Briers produced research describing the perceptions of agriculture instructors regarding the integration and collaboration of science concepts into the secondary agriculture curriculum. Since that time, many other researchers have analyzed the perceptions of various stakeholders about integrating science with the agriculture curriculum. In 1993, Mississippi administrators, guidance counselors, and science instructors were found to support the idea of offering science credit for the newly piloted agriscience courses being taught in Mississippi (Johnson & Newman, 1993). In 2000, Dyer and Osborne found that parents of students enrolled in biological applications in agriculture and physical science applications believed that agriculture was a scientific field with a plethora of career opportunities. More recently, Balschweid and Thompson (2002) found that Indiana agriculture science and business instructors perceived that they were prepared to teach integrated physical and biological science concepts.

To summarize, the idea of integrating science into the agricultural education curriculum has been around for many years and a number of researchers have analyzed the integration of science into the agricultural education curriculum. However, are instructors interested in and prepared for the integration of science into the agricultural education curriculum? Are instructors equipped with the knowledge base to integrate science and teach the concepts accordingly? Have teachers considered the consequences of such a change? These are the premises underpinning this study.

Problem Statement

While there is increasing support for the integration of science concepts into the agricultural education curriculum, little research has been conducted to investigate agriculture instructors' ability to implement those concepts into their programs.

Purposes of the Study

The purposes of this study were: 1) to assess the knowledge base and interest levels among agriculture instructors in teaching concepts related to science; 2) To assess how such a change in the curriculum would impact agricultural education programs.

Research Objectives

1. Describe selected personal and professional characteristics of secondary agriculture instructors in Missouri.
2. Describe agriculture instructors' self-perceived competence to teach selected grade level expectations related to science for students in grades 9 - 11.
3. Describe agriculture instructors' knowledge of principles of science associated with selected grade level expectations related to science for students in grades 9 - 11.
4. Describe agriculture instructors' sources of motivation for teaching selected grade level expectations related to science for students in grades 9 - 11.
5. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the instruction and curriculum of secondary agricultural education programs.
6. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the student leadership organization of agricultural education.
7. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon supervised agricultural experiences of students.

8. Describe relationships between and among selected variables (demographic characteristics, confidence to teach selected GLE strands, competence in science.)

Definitions

The following terms have been operationally defined for this study:

Agriculture Instructors: Secondary level instructors (grades 9 -11) of agriculture, food, fiber and natural resources systems education (National Council for Agricultural Education, 2000).

Agriscience Fair: Open to students in grades 7-12. Students participate in research projects in their local communities and then prepare a scientific report and display for judging at the national level. Competition is divided into five categories: Botany, Engineering, Environmental Sciences, Zoology, Biochemistry/Food Science/Microbiology (FFA, 2007).

Graduate Exit Examination: Exams to be completed by high school senior students as a requirement for graduation. A passing grade is required.

Missouri Assessment Program: Exam used to benchmark learning in selected grades in the state of Missouri.

Science Grade Level Expectations (GLE): Targets for instruction derived from the Missouri Show Me Standards.

Supervised Agriculture Experience (SAE): Agriculture activities conducted outside of class time by the student enrolled in agricultural education.

The National FFA Organization (FFA): The career and technical student organization for students enrolled in agricultural education

Assumption

1. The respondents provided accurate ratings of their self-perceived competence to teach the selected science grade level expectations.

Limitations

1. The population of the study was limited to secondary (9-12) agriculture instructors in Missouri.
2. The findings of the study should not be generalized beyond a similar population.
3. Respondents for the science competency exam were those in attendance at the Missouri Association of Career and Technical Education (ACTE) Conference, July 2007.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to present a review of literature relevant to this research. The literature areas included in this chapter are: Historical Purposes of Agricultural Education; Integration of Science Principles into Agricultural Education; and Preparation of Agriculture and Science Teachers.

Historical Purposes of Agricultural Education

Agricultural Education Prior to the Smith Hughes Act

Agricultural education has been in existence since men and women first planted fields, domesticated beasts for food and sought more efficient ways to produce food and fiber. Formal education in agriculture, however, is somewhat new to the history of man. Alfred Charles True (1969), who was the director of the Office of Experiment Stations from 1893 to 1923, recorded the history about the formal beginnings of agricultural education. He stated that agricultural education was rooted in the development of means to improve and move agriculture forward that lay stagnant for many years. He traced the modern foundation of this discipline to Bohemia in the 1700s where agriculture, music, and religion were taught with reading, writing and arithmetic. He wrote that agricultural education in America was jump-started after the Revolutionary War and promotion of agriculture began through various ways at that time.

In 1887, the Hatch Act was passed. This legislation provided federal funding for true experimental and scientific research about agriculture (Hillison, 1996). Through this act, scientific education in agriculture was born "… to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture …" (Hillison, p#). This diffusion of useful and practical knowledge was taken very seriously by leaders in agriculture (Moore, 1987). From this time on, the Office of Experiment Stations, under the U.S. Department of Agriculture, was very instrumental in the development and promotion of agricultural education (Hillison). Leadership provided by A. C. True and D. J. Crosby increased the number of schools offering coursework in agricultural education (Moore). This growth started in 1906, soon after the Nelson Amendment was passed which allocated monies for states to provide courses for the preparation of instructors of agriculture and mechanical arts (Hillison).

During this time, the secondary agriculture curriculum was also guided and aided by the U. S. Department of Agriculture through the development of teaching materials directly related to the experiment stations (Hillison, 1996). This continued until 1929 when the USDA ended its support of these efforts.

The momentum for secondary education in agriculture in public schools started in 1893 in the Office of Experiment Stations. An article in *Yearbook of the United States Department of Agriculture for 1897* noted that there were schools for education in agriculture but claimed that their distance from the farmers' children rendered them too expensive for most farm families and that the children would therefore be better used on the farm (True, 1969). As a result, the Office of Experiment Stations took great measures to infuse agricultural education into secondary school curricula. As a consequence, tremendous growth occurred in secondary agricultural education. By the 1915 – 1916 academic school year, agricultural education had grown to the point that there where more than 3,600 secondary schools were offering instruction in agricultural education of which 2,760 were public schools without state aid (True). Curriculum at this time was rooted in science, as can be gleaned from the committee's notes that "special provisions should be made for instructors in service in secondary schools to acquire knowledge of the science and practice of agriculture" (True, p. 333). Interestingly, the notion that instructors of agriculture be trained in the sciences was not novel at that time. In 1908, Liberty Hyde Bailey requested, in a U.S. Bureau of Education bulletin, that people who were going to be teaching agricultural education have a strong science background along with schooling in the practice of agriculture. In fact, in that era, the nature of agriculture education was general and academic rather than vocational (Moore, 1987).

Agricultural education once again changed with the passage of the Smith-Hughes Act of 1917. This legislation shifted the administration of agricultural education, moving it from the Department of Agriculture to the Federal Board of Vocational Education. This change, in turn shifted the direction of agricultural education from an academic, science-based curriculum to a vocational curriculum (Chiasson & Burnett, 2001, Brister &, Swortzel, 2007). The applicable language in the 1917 Smith – Hughes Act created this shift, designating the preparation of students for "useful employment" as opposed to college level preparation coursework (Brister & Swortzel, 2007).

Agricultural Education in the 1980s

After several decades where the emphasis of secondary agricultural education programs was vocational and career education, interest in the integration of science into the curriculum was rekindled in the 1980s (Phipps, Osbourn, Dryer, and Ball 2008). In 1988, the Committee on Agricultural Education in Secondary Schools of the Board on Agriculture of the National Research Council (NRC) released its report *Understanding*

Agriculture: New Directions for Education. This document was the outcome of a task set forth by the U.S. Secretaries of Agriculture and Education to conduct a comprehensive assessment of agricultural education programs in America (NRC, 1988). Specifically, the committee focused it work upon:

- goals for instruction
- the subject matter and skills that should be stressed in curricula for difference groups of students; and
- policy changes that needed at the local, state, and national levels to facilitate the new and revised agricultural education programs in secondary schools. (NRC, p. v)

Through this exercise, the idea of "agricultural literacy" was born and was defined as learning "about agriculture" (NRC, 1988). The report stimulated much discussion and debate on a wide variety of topics including defining the purpose of agricultural education programs in secondary schools Evidence of this debate can be found in an issue of the *Agricultural Education Magazine* in which the theme was focused upon exploring the purpose of the discipline. While some authors of articles in that issue stated that the program is vocational in nature, Terry, Jr. (2004) as well as Bellah, Dyer and Casey (2004) contended that agricultural education should be about agricultural literacy rather than vocational skills. Moore (2004) proposed that agricultural education can be more than vocational or literacy based. More precisely he suggested that agricultural education could have six purposes which are:

- To prepare people for work
- To reinforce academic skills and prepare people for work

- To serve special needs students
- To promote agriculture literacy
- To promote the development of leisure time
- To provide an alternative for students who do not do well in school (Moore, p. 4)

In their report, the Committee on Agricultural Education in Secondary Schools proposed numerous changes that have had a lasting impact on agricultural education, including their recommendation to broaden the agricultural education curriculum by "addressing the sciences basic to agriculture, food, and natural resources…" (NRC, 1988, p. 35). Following the 1988 NRC report, there has been a plethora of research examining the integration of science into the agricultural education curriculum including questions of consequent benefits from doing so. In 1989, Norris and Briers found that agriculture instructors in Texas recognized the need for change in their programs. Further, in a study conducted in 1993, agriscience instructors in Mississippi supported pilot courses in agriscience (Newman & Johnson). This same study found that guidance counselors and science instructors supported this notion, as well as the granting of science credit for such courses in Mississippi (Newman & Johnson).

Perceptions of Stakeholders for Integration of Science Within Agricultural Education

The *2005 – 2006 Annual Report on Agricultural Education* proposed the goal to establish 10,000 quality agricultural education programs in the United States by 2015 (Team AgEd, 2007). The goal is commonly referred to as *10 X 15*. To help meet this goal, initiatives were established, including the Curriculum of Agricultural Sciences Education (CASE) model; the national standards program; national curriculum content standards; and a national research agenda for agricultural education. Incorporated within the initiatives were goals to align curriculum such as the CASE model with the Science, Technology, Engineering, and Mathematics (STEM) curriculum. Furthermore, one of the outcomes for the National Curriculum Content Standards Committee was to have the curriculum cross-walked with the standards in math, science, and communication arts (Team AgEd). State standards in education, college entrance requirements, and enrollments are also changing and causing concerns (Thompson, 2001). Research regarding the perceptions of instructors, counselors, and administrators with respect to this concept was prevalent in the *Journal of Agricultural Education* between the years 1998 - 2002. Ten papers were found on the topic in a review of volumes 39 – 43.

Since publication of *Understanding Agriculture: New Directions for Education,* many researchers have studied stakeholders perceptions of science integration in agricultural education (NRC, 1988). In 1999, Dyer and Osborne found that counselors in schools where applied science in agricultural education courses were taught had a positive perception of this practice, as did other students and instructors. Research has also been conducted to describe perceptions of principals regarding the integration of science within agricultural education. For instance, a study conducted in Oregon found that principals responded positively to the integration of science in the agricultural education programs (Thompson, 2001).

Newman and Johnson (1993) found that agriculture instructors enjoyed teaching the agriscience curriculum and that they believed science credit should be awarded to students completing the course. Thompson and Balschweid, (1999) found that instructors agreed that they were prepared to teach integrated biological sciences within agriculture curriculum. Agriscience instructors in Indiana also perceived that they were prepared to teach integrated biological and physical science concepts (Balschweid & Thompson, 2002). However, this same study found that instructors were unsure about how stakeholders within the school and community would respond to the integration of sciences in the agriscience curriculum.

Barriers to Integrating Science into Agricultural Education

While there is strong support for integrating science concept into the agriculture curriculum, studies have shown that agriculture instructors perceive that there are barriers preventing them from fully integrating science within the curriculum (Balschweid & Thompson, 2002; Thompson, 2001; Thompson, & Balschweid, 1999; Warnick, Thompson & Grummer, 2004). Some of the perceived barriers described in these studies include a lack of appropriate equipment; a lack of funding from federal, state, and local sources; a lack of in-service workshops; a lack of integrated science curriculum; a lack of preparation (prior to enrolling in agricultural education); a lack of science competence; and a lack of close proximity to high tech firms.

Studies have supported the notion that academic equipment is one of the largest barriers to integrating science in agriculture classes (Balschweid & Thompson, 2002; Thompson, 2001; and Thompson, & Balschweid, 1999). However, when science instructors were asked about this problem, they responded that their own lack of knowledge about agriculture was the biggest barrier and that equipment ranked third (Warnick, Thompson & Grummer, 2004).

Benefits of Integrating Science into Agricultural Education

Several interesting benefits to integrating science concepts into the agricultural education curriculum have been indentified. Dyer and Osborne (1999) found that integrating science into the agriculture curriculum has a positive impact on students' retention and performance in science. Hillison (1996) stated that all students should have an understanding of basic science concepts. A study by Whent and Lansing (1988) found that agriscience students who have been compared to general science students on general biology tests have achieved slightly higher scores than did general bio science students. Students in Georgia who had completed two years of agriscience had a passing rate of 78% on the Georgia High School Graduation Test compared to the state average of 68% (Rickets, Duncan & Peake, 2006). In a study by Chiasson and Burnnett (2001) higher achievements were also found in Louisiana when all 11th grade students participated in a Graduate Exit Examination (GEE). Agriscience students scored higher than their non-agriscience students on three of the five domains tested.

Besides the academic achievement on state tests, there are other benefits for students. According to Stephenson, Warnick, and Tarpley (2007), when science and agriculture instructors work together cooperatively, curriculum is broadened, separation between instructors is reduced and students develop a better understanding of the relationship between agriculture and science. Additionally, a study by Dormondy (1992) found that agriculture instructors and science instructors collaborated with the use of resources. Resources were defined as microscopes and other equipment; however, the same study showed curriculum sharing was low.

Another benefit of integrating science within the agriculture curriculum is higher enrollments in agriculture courses. Osborne and Dyer (2000) found that after implementing biological applications in agriculture and physical science applications in agriculture, enrollments in Illinois' secondary agriculture programs rose by 40% in the 1990s.

Availability of Science Credit from Agricultural Education

Offering science credit for agriculture courses has been recommended by the National Research Council (1988) and studies have been conducted to support this notion. Louisiana has offered science credit in exchange for students completing two agriscience courses (Chiasson & Burnett, 2001). The University of Missouri also accepts agriculture classes in exchange for entrance requirements for science and economics (University of Missouri, 2007). However, as noted by Belcher, McGaslin and Headley (1996), for this arrangement to be successful, there needs to be more thought given to how much more science to add to the curriculum and how to place more emphasis those concepts.

A study conducted by Johnson (1996) found that 84.7% of the parents polled in Arkansas supported the notion of granting science credit for agriscience courses. Johnson also found that 76% of the administrators polled in Arkansas agreed that they would support the granting of science credit for agriscience courses.

Just as support exists for the granting such credit, there are also studies questioning the validity behind the credit and questioning the content students are learning. Thompson and Balschweid (1999) and Newman and Johnson (1993) called for further research in the area of science achievement among agriscience students. No literature was found regarding performance on standardized tests of science of students who used agriculture courses as a substitute for science courses. However, a study conducted in Utah found that agriculture students with a lower overall GPA score consistently higher on the Biology Core Test than traditional biology students (Warrick & Stratquadine, 1998).

Preparation of Agriculture Teachers

Prior to the Smith Hughes Act of 1917, the question of who should teach agriculture courses and how agriculture instructors should be prepared had been greatly debated (True, 1969). Since the passage of that act, which offered a clear definition of vocational agricultural education, teacher preparation programs have focused on preparing teachers in three key areas: general studies (English, mathematics, fine arts, etc.), content studies (technical agriculture), and professional and pedagogical studies (the art of teaching) (Cruickshank, 1996).

Current Climate of Teacher Preparation Programs in Agricultural Education

The most recent study of the status of pre-service agricultural education programs in the United States was conducted by Boone in 2002. He found that agriculture teacher preparation programs, on average, require 52.4 hours of agriculture and that core technical agriculture totaled 27.9 hours (Boone). Coursework in this area consisted of agricultural economics, animal science, crop science, environmental science, forestry, horticulture, plant science, and soil science. Expectation 2c of the *National Standards for Teacher Education in Agriculture,* developed by the American Association for Agricultural Education (AAAE), states:

> Programs are designed so that teacher candidates attain a basic competence in principles, concepts, and experiential practices in agriculture science and natural resources related to
>
> a. Business, Management, and Economic Systems
> b. Agriculture and Mechanical Systems
> c. Plant, Animal, and Food Systems
> d. Natural Resources and Environmental Systems
>
> (AAAE, 2001, p. 3 - 4).

Goecker (1992) expressed concern that “the scientific and technical competence of today’s agriculture education graduate does not compare to his or her counterpart of the 1970s” (p. 3).

Agricultural Education and Unified Science Certification Program Standards in Missouri

Cruickshank (1996) defined four areas of teacher preparation: general studies, content studies, professional education, and integrative studies. He contended that instructors need content knowledge as well as pedagogical knowledge of their subject discipline agreeing with Broudy (1972) who suggested that instructors need technical knowledge to teach.

In Missouri, institutions that certify instructors in agricultural education adhere to certification requirements set by the Missouri Department of Elementary and Secondary Education (DESE). Certification requirements for agricultural education teachers incorporate the expectation of perspective teachers to complete 45 semester hours of course work in technical agriculture (DESE, 2007) including:

- Animal Science (3),
- Agronomy (3),
- Agricultural Business (3),
- Agricultural Economics (3),
- Agricultural Mechanics (3),
- Horticulture (3),
- 12 hours of electives within the 6 primary areas,
- 15 hours of electives in the following suggested areas Forestry, Natural Resources, Agricultural Journalism, and Integrated Pest Management.

A census review of the institutional requirements for a degree in agricultural education in the state of Missouri (see Appendix A) was completed. It revealed that in addition to the state requirements, there was a range of four to ten hours required in chemistry and biology courses.

Changes in teacher certification in the sciences have resulted in the state certifying instructors under the Unified Science certificate with emphasis in biology, chemistry, earth science, and physics. In each of the certification areas, a candidate must earn 59 semester hours of coursework in science, Figure 1 displays the requirements for the Unified Science teacher certification.

General education requirements at the five institutions that prepare agriculture instructors do require students certifying to take some combination of courses in the sciences. Prior to the land grant institutions developing programs to certify teachers, there was debate about who should teach agriculture and what courses individual should take

Course Title	**Hours Required**
History/philosophy of sciences and technology	3
Biology (to include zoology and botany with labs)	8
Chemistry (with labs)	8
Physics (with labs)	8
Earth science (to include geology and meteorology	8
Environmental science	4

For a biology certificate, an additional twenty (20) semester hours in biology to include coursework in:

1) Zoology	2) Botany	3) Genetics
4) Cell/Biochemistry	5) Microbiology	6) Anatomy and Physiology
7) Ecology	8) Evolution	

For a chemistry certificate, an additional twenty (20) semester hours in Chemistry to include course work in:

1) Biochemistry	2) Organic Chemistry	3) Physical Chemistry
4) Quantitative Analysis	5) Qualitative Analysis	6) Advanced Analysis
7) Environmental Chemistry		

For an earth science certificate, an additional twenty (20) semester hours in earth science to include coursework in:

1) Geology/Physical Geography	2) Astronomy	3) Meteorology
4) Paleontology	5) Oceanography	

For a physics certificate, an additional twenty (20) semester hours in physics to include coursework in:

1) Quantum Physics	2) Atomic/Nuclear Physics	3) Heat/Thermodynamics
4) Health Physics	5) Optics	6) Electricity/Magnetism
7) Statistics/Mechanics		

Figure 1. General requirements for the unified science certificate.

for certification in agricultural education (True, 1929). It was thought that the best instructors would be those trained in the sciences, especially biology (True, 1929).

Summary

Prior to 1917, there were more than 3,600 secondary schools offering agricultural education in the United States (True, 1969). With passage of the Smith-Hughes Act, agricultural education changed from an academic program rooted in the sciences to one that focused on vocational and career education (reference). The release of the publication *Understanding Agriculture: New Directions for Education,* (NRC) in 1988 called for the program to once again become more science oriented.

Research has shown that stakeholders have positive perceptions about science being integrated back into the agriculture curriculum (Balschweid, 2002, Balschweid & Thompson, 2002, Chaisson & Burnett, 2001, Dyer & Osborne, 1999, Johnson, & Newman, 1993, Newman & Johnson, 1993, Norris & Briers 1989, Osborne & Dyer, 1998, Thompson, 2001, and Thompson & Balschweid, 1999). Research has also found barriers and benefits to the integration of science in agriculture curricula. The literature shows that the agriculture instructors and stakeholders consider the integration of science to be positive for agricultural education programs and their students. They agree that science credit should be awarded students successfully completing agriculture classes. However, no research has shown if agriculture instructors have the knowledge base to adequately integrate the science in their perspective curricula.

CHAPTER III

METHODOLOGY

Introduction

This chapter describes the methods and procedures used to conduct this research. The research design and variables of interest are identified. Additionally, the population, sample, data collection procedures and methods of analysis are described herein.

Purposes of the Study

The purposes of this study were: 1) to assess the knowledge base and interest levels among agriculture instructors in teaching concepts related to science; 2) To assess how such a change in the curriculum would impact agricultural education programs.

Research Objectives

1. Describe selected personal and professional characteristics of secondary agriculture instructors in Missouri.
2. Describe agriculture instructors' self-perceived competence to teach selected grade level expectations related to science for students in grades 9 - 11.
3. Describe agriculture instructors' knowledge of principles of science associated with selected grade level expectations related to science for students in grades 9 - 11.
4. Describe agriculture instructors' sources of motivation for teaching selected grade level expectations related to science for students in grades 9 - 11.
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7. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon supervised agricultural experiences of students.
8. Describe relationships between and among selected variables (demographic characteristics, confidence to teach selected GLE strands, competence in science.)

Research Design

The design of this research was descriptive correlational as defined by Ary, Jacobs, and Razavieh (2002). That is, descriptive research is "asking questions about the nature, incidence, or distribution of variables" (Ary et al, p. 558), whereas, correlational research seeks to "determine the extent and direction of the relationship between two or more variables" (Ary et al, p. 557). Descriptive correlational research allows the researcher to summarize characteristics and measure attitudes and opinions of the population while comparing different variables of interest. However, the data only represent the population that the sample was drawn from and should not be inferred on another.

Population

The target population for this study was Missouri secondary agriculture instructors. The 447 instructors of this population were identified from the *2006 – 2007 Agriculture Teacher Directory* produced by the Agriculture Division of the Missouri Department of Elementary and Secondary Education (DESE). Since the directory is a complete listing of all instructors in the state of Missouri, it was determined to be the best resource to substantially reduce frame error. Probability sampling was used in which no one person had a zero chance of being selected to participate in the study (Ary et al, 2002). The representative sample size for this population was determined utilizing Krejcie and Morgan's Small-Sample Techniques (1960). This procedure yielded a sample size of 210 (n=210). To eliminate the chance of selection error the population of instructors, derived from the directory, each teacher name was numbered for random selection. An online program, Randomizer.org, was used to identify the 210 random numbers to be used in selecting the sample. A list of instructors was developed from the numerical list and then organized by district. Once the list was developed, the members of the sample group were coded for data analysis.

Instrumentation

Two instruments were used, in series, to collect data for this study. The first instrument was an Internet based instrument that utilized Simple Survey Builder hosted by the University of Central Missouri (see Appendix B). The second instrument was a 20 question biology certification practice exam obtained from the American Board for Certification of Teacher Excellence (see Appendix C). The intent for utilizing two instruments was to collect data on self perceived competence of Missouri agriculture instructors to teach selected science grade level expectation (GLEs). The second instrument ascertained agriculture instructors' content knowledge in science concepts.

Perceived Competence to Teach Selected Science Grade Level Expectations

Collection of the self-perceived competence data was completed utilizing concepts from three strands within the science GLEs selected for their relevance to agricultural education and validated using a panel of experts (n = 5). Members of the panel of experts were chosen for their mastery in agricultural education curriculum and research design and methodology as well as their level of experience in agricultural education. For this study, Strand 3 – Living Organisms, Strand 4 – Ecology, and Strand 7 – Scientific Inquiry were utilized. The 27 concepts associated with those strands for grades 9, 10, and 11 were used in the instrument. The phrase "I feel competent to teach…" was the stem used for each concept. The following five-point Likert-type scale was used as the response choice for each item: 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree. The real limits for the scaled responses were defined as: 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree; 2.50 – 3.49 Neutral; 3.50 – 4.49 = Agree; and 4.50 – 5.00 = Strongly Agree.

Demographics, Characteristics, and Attitude Toward the Integration of Science Grade Level Expectations

Age and years taught were self-reported by respondents. All other pertinent demographic information, such as gender and geographical information, was derived from the *2006 -2007 Missouri Agricultural Education Directory* (DESE, 2006).

Attitudes regarding science GLEs impact on instruction, Supervised Agriculture Experience (SAE), FFA, and the agricultural education program were assessed with multiple questions. For this part of the questionnaire, two types of scaled responses were used. The following scale was used for items used to collect data assessing the teachers' agreement with statements: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. The second scale was used for items to collect data that were time oriented: 1 = Greatly Increase, 2 = Slightly Increase, 3 = No Change, 4 = Slightly Decrease, and 5 = Greatly Decrease.

Other types of questions asked the respondent to identify responses that identified their attitude toward the integration of science GLEs. Respondents were asked to indicate the level at which science GLEs should be incorporated into the agriculture curriculum and classes in which they have and plan to integrate science GLEs.

Sources of Motivation to Integrate Science GLEs

Eleven items were used to assess instructors' sources of motivation for integrating science concepts into their curriculum. Instructors were asked to choose between four alternatives to indicate what they considered to be the primary purpose of their agricultural education program. The response choices were based upon purposes presented by Moore (2004) in his article from the *Agricultural Education Magazine*, "The Blind Man, the Elephant and Agricultural Education." Using yes/no response choices, teachers were asked to indicate whether or not DESE staff or school administrators had encouraged them to integrate science concepts into their courses. Similar response choices were used for teachers to indicate if they had attended professional development activities or worked with science teachers to implement science into their curricula. The remainder of the questions used scaled responses of 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

The instrument used to assess general knowledge about science was obtained from the American Board for Certification Teacher Excellence (ABCTE, 2006). The 20-question practice exam was selected for its relevance to the GLEs investigated in this study. Questions were numbered 1 – 20 and response choices were labeled: a, b, c, and d (see Appendix C). All tests were labeled with the instructors' name to aid the state supervisors with the delivery of the test. Respondents recorded their answers to the test on Scantron forms that were coded to ensure anonymity.

Reliability

Reliability refers to the consistency of an instrument's results (Ary et al, 2002), expressed mathematically using the classical test theory, $X = T + E$. The classical test theory is comprised of two components true score (T) and error or measurement (E), when added together their sum equals the observed score (X). True score is the "error-free value of an individual" (p. 252). Within the true score there are two types of errors, systematic and nonsystematic, which can be categorized as random and nonrandom errors. Random errors are caused by items that the researcher has no control over, such as personal pressure, or other influences on the respondent that are not controlled by the researcher. However, nonrandom/nonsystematic errors can be controlled by the researcher through proper instrument development and controlling face, content, and construct validity (Ary et al, 2002).

Reliability for the questionnaire used to collect data for objectives 1, 2, 4, 5, 6, and 7 was determined through the use of a pilot study. A pilot study was conducted using 36 instructors who were not included in the sample group. Members of this group were purposefully selected to accurately simulate the population. All instructors in the pilot study were contacted though email. The email contained an introduction about the purpose the research, instructions to complete the questionnaire and an Internet link to the website with the questionnaire. The pilot study yielded (n = 18) responses. Completed questionnaires were then reviewed and the Cronbach's alpha statistic was used to measure the homogeneity of items. That procedure yielded reliability coefficients of: Strand 3 = 0.91, Strand 4 = 0.84, and Strand = 0.89. These coefficients were considered to be acceptable.

Face validity indicates whether or not the instrument "appears" to measure what it is purports to measure and can be assessed by utilizing a panel of experts (Torres, 2004) (see Appendix E). Minor changes to the appearance of the instrument were made based upon the suggestions of the panel.

Reliability and validity for the instrument used to collect data for objective 3 were determined by the American Board for Certification in Teacher Excellence (ABCTE, 2007). To determine the reliability of the exam, the Kuder-Richardson formula 20 was chosen because of it is appropriate for use on tests with only correct and incorrect responses (Ary et al, 2002). Reliability was determined by ABCTE by working with subject matter experts, classroom instructors, administrators, teacher educators, policymakers and business leaders to ensure that the instrument was valid (ABCTE, 2006).

Data Collection

After the sample was selected, the researcher solicited email addresses from the Agriculture Division of DESE. An email message was sent to each of the participants in the study (see Appendix D). The email message contained an introductory statement about the study with specific instructions to be followed for them complete the data collection instrument. All participants were given a code number so that the two instruments used could be correlated and to track respondents for follow up procedures while protecting their confidentiality. A link to the Internet site that hosted the instruments was also included in the email.

The members of the sample group were initially contacted on July 18, 2007 with an email message that included information about the study, instructions, Internet link to the questionnaire and a code to be used to complete it. Instructors were asked to complete the questionnaire during the week prior to the 2007 Missouri Vocational Agriculture Teachers Association (MVATA) Conference in Springfield, Missouri. A packet containing the questionnaire was prepared for those respondents who did not complete the online questionnaire prior to the conference. After the conclusion of the conference, a second email was sent on August 3, 2007 (see Appendix F) to all members of the sample group who had not completed the questionnaire, requesting that they complete the instrument within two weeks.

The instrument used to assess general knowledge of science was administered during the 2007 MVATA Conference in Springfield, Missouri on July 24, 2007 after the district meetings of the agriculture instructors. Packets were prepared that included the science knowledge assessment for participants who had completed the other instrument. Copies of both instruments were included for those respondents who had not completed either questionnaire prior to the conference. An additional packet (see Appendix G) was prepared for state supervisors who were asked to facilitate the administration of the questionnaire(s) during conference. The packet included instructions for the administrators as well as names of the participants. To increase the response rate, participants were entered into a drawing for a $50 Visa gift card. A drawing was held for each of the six districts.

After the conference, non-respondents were identified and contacted on July 30, 2007 by the researcher via email to complete the instruments. This step was repeated two weeks later on August 13, 2007. Data collection ceased on August 27, 2007. In all, questionnaires from 175 of the participants were collected. After review, data from141 respondents were deemed to be usable yielding a response rate of 67.14%.

Data Analysis

Multiple scales of measurement were used for this research. Objective one (instructors' age and years taught) was collected as interval and ratio data allowing for the use of means, medians, and modes as central tendencies. Standard deviations were used to report variability. Furthermore, instructors were categorized into three levels of teaching experience: Novice = 1 – 5 years teaching experience, Experienced = 6 – 15 years teaching experience, and Seasoned = more than 15 years teaching experience.

Summated scales were used in collecting data for objectives two (perceived competence to teach science GLEs); three (actual knowledge); six (science GLE's impact upon the leadership organization); and seven (science GLE's impact upon SAE's). For objectives four (sources of motivation to teach science GLEs) and five (science GLEs impact on SAE), both summated scales (interval and ratio) and nominal data were collected and reported. Nominal data is mutually exclusive (Ary et. al, 2002) and can be recorded as frequencies (Torres, 2004). Reverse coding was used when performing statistical analyses for summated scales.

Objective eight sought to describe the relationships between and among variables. For this analysis, appropriate correlation coefficients were used, depending upon the data type for the variables being analyzed. The magnitude of the correlation was represented by the term *r*, and reported the direction of the correlation as being positive or negative. To determine the level of magnitude that exists between two variables, Davis' (1971) conventions were applied (see Table 1). Significance was set *a priori* at .05.

Table 1

Davis' Convention for Correlation Coefficient

Convention	Correlation Coefficient
Perfect	1.00
Very High	0.70 – 0.99
Substantial	0.50 – 0.69
Moderate	0.30 – 0.49
Low	0.10 – 0.29
Negligible	0.01 – 0.09

CHAPTER IV

FINDINGS

Introduction

The purpose of this chapter is to report the findings of the study, which are organized by the objectives investigated in this study. Narrative discussions and tables of are presented for each objective.

Purposes of the Study

The purposes of this study were: 1) to assess the knowledge base and interest levels among agriculture instructors in teaching concepts related to science;
2) To assess how such a change in the curriculum would impact agricultural education programs.

Research Objectives

1. Describe selected personal and professional characteristics of secondary agriculture instructors in Missouri.
2. Describe agriculture instructors' self-perceived competence to teach selected grade level expectations related to science for students in grades 9 - 11.
3. Describe agriculture instructors' knowledge of principles of science associated with selected grade level expectations related to science for students in grades 9 - 11.
4. Describe agriculture instructors' sources of motivation for teaching selected grade level expectations related to science for students in grades 9 - 11.

5. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the instruction and curriculum of secondary agricultural education programs.
6. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the student leadership organization of agricultural education.
7. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon supervised agricultural experiences of students.
8. Describe relationships between and among selected variables (demographic characteristics, confidence to teach selected GLE strands, competence in science.)

Research Objective One

Objective one sought to identify selected personal and professional characteristics of secondary agriculture instructors in Missouri. Among the 141 respondents, there were 41 (29.08%) females and 100 (70.92 %) males (see Table 2).

Table 2

Personal Nominal-Level Characteristics of Missouri Agriculture Instructors (n = 141)

	Female		Male	
Characteristic	*f*	%	*f*	%
Gender	41	29.08	100	70.92

Table 3 displays additional data related to the characteristics of the respondents. The mean age of the instructors was 35.34 (*SD* = 8.52) years with a range of 22 to 61 years. The average number of years of teaching experience was 10.25 (*SD* = 10.09), ranging from a low of 0 years and a high of 34 years. The average age of female respondents was 29.73 (*SD* = 7.69) with 5.89 (*SD* = 5.36) years of teaching experience. The average age of male respondents was 37.67 (*SD* = 10.09) with 12.76 (*SD* = 8.80) years of teaching experience.

Table 3

Selected Personal Characteristics of Missouri Agriculture Instructors (n = 141)

Characteristic	*M*	*SD*	*Range*
Female			
Years Taught	5.89	5.36	0 - 22
Age	29.73	7.69	22 - 49
Male			
Year Taught	12.76	8.80	0 – 34
Age	37.67	10.09	22 - 61
Grand *M*			
Years Taught	10.75	8.53	0 – 34
Age	35.34	10.09	22 - 61

Research Objective Two

Objective two sought to determine agriculture instructors' self-perceived competence to teach selected GLEs related to science for students in grades 9 - 11. Instructors were provided with the concepts for three strands of the science GLEs that were related to content taught in agriculture courses. Respondents were asked to rate their competence to teach each concept using a five-point, Likert-type. Frequency distributions of the ratings are shown in Appendix H.

Table 4 shows the instructors' level of confidence to teach science GLEs related to Strand 3 – Living Organisms. The mode for all concepts was 4. Instructors strongly agreed (*M* = 4.49, *SD* = 0.58) that they are competent to teach the GLE concept "Reproduction can occur asexually and sexually." Instructors also agreed that they feel competent to teach eleven other concepts, including "Photosynthesis and cellular respirations are complementary processes necessary to the survival of most organisms on Earth" (*M* = 4.31, *SD* = 0.64); "All living organisms have genetic material (DNA) that carries hereditary information" (*M* = 4.30, *SD* = 0.71); "Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction" (*M* = 4.13, *SD* = 0.79); "There is heritable variation within every species of organism" (*M* = 4.01, *SD* = 0.78); "Cells are the fundamental units of structure and function of all living things" (*M* = 3.97, *SD* = 0.79); "Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds" (*M* = 3.78, *SD* = 0.87); "Biological classifications are based on how organisms are related" (*M* = 3.77, *SD* = 0.84); "Organisms progress through life cycles unique to different types of organisms" (*M* = 3.74, *SD* = 0.85); "The pattern of inheritance for many traits can be predicted by using the principle of Mendelian genetics" (*M* = 3.70, *SD* = 1.05); "The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means" (*M* = 3.70, *SD* = 0.85); and "Protein structure and function are coded by the DNA (Deoxyribonucleic Acid) molecule" (*M* = 3.61, *SD* = 0.92). Instructors were neutral about their competence to teach "Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis)" (*M* = 3.47, *SD* = 0.92).There was no concept in which the teachers, as a group, felt incompetent to teach.

Table 4

Agriculture Instructors' Perceived Level of Competence to Teach Science Grade Level Expectations Strand 3 – Living Organisms (n = 141)

Science Grade Level Expectations Strand 3 Living Organisms	Mode	*M*	*SD*
Reproduction can occur asexually or sexually.	4	4.49	0.58
Photosynthesis and cellular respirations are complementary processes necessary to the survival of most organisms on Earth.	4	4.31	0.64
All living organisms have genetic material (DNA) that carries hereditary information.	4	4.30	0.71
Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction.	4	4.13	0.79
There is heritable variation within every species of organism.	4	4.01	0.78
Cells are the fundamental units of structure and function of all living things.	4	3.97	0.79
Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds.	4	3.78	0.87
Biological classifications are based on how organisms are related.	4	3.77	0.84
Organisms progress through life cycles unique to different types of organisms.	4	3.74	0.85
The pattern of inheritance for many traits can be predicted by using the principle of Mendelian genetics.	4	3.70	1.05
The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means.	4	3.70	0.85
Protein structure and function are coded by the DNA (Deoxyribonucleic acid) molecule.	4	3.61	0.91
Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis).	4	3.47	0.92
Grand *M*		3.92	0.60

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree;

2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

As shown in Table 5, instructors agreed that they are confident to teach eight of the nine concepts (88.89%) related to ecology (Strand 4). The modal response for each concept was 4, except for "Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record" which had a mode of 3. The concept with the highest level of agreement was "Reproduction is essential to the continuation of every species" had (*M* = 4.21, *SD* = 0.69), followed by "As energy flows through the ecosystem" (*M* = 3.74, *SD* = 0.93), while "All organisms capture a portion of that energy and transform it to a form that they can use" had the lowest level of agreement (*M* = 3.73, *SD* = 0.93). Instructors were neutral (*M* = 3.02, *SD* = 0.95) regarding their competence to teach the concept of "Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record" (*M* = 3.04, *SD* – 0.95). There were no concepts for which the instructors indicated they were incompetent to teach.

Table 5

Agriculture Instructors' Perceived Level of Competence to Teach Science Grade Level Expectations Strand 4 – Ecology (n = 141)

Science Grade Level Expectations Strand 4 Ecology	Mode	*M*	*SD*
Reproduction is essential to the continuation of every species.	4	4.21	0.69
Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem.	4	4.06	0.70
All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.	4	4.04	0.81
All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem.	4	4.01	0.81
The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.	4	4.01	0.87
Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.	4	3.90	0.94
Matter is recycled through an ecosystem.	4	3.74	0.93
As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form that they can use.	4	3.73	0.93
Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record.	3	3.02	0.95
Grand *M*		3.86	0.68

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree; 2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

Instructors agreed that they are confident to teach the concepts related to Strand 7 - Scientific Inquiry in that all modal responses were 4. The mean levels of agreement ranged from a high of *M* = 3.68 (*SD* = 0.86) for "Evidence is used to formulate explanations," to a low of *M* = 3.56 (*SD* = 0.85) for "The nature of science relies upon communication of results and justification of explanations." These data are displayed in Table 6.

Table 6

Agriculture Instructors' Perceived Level of Competence to Teach Science Grade Level Expectations Strand 7 – Scientific Inquiry (n = 141)

Science Grade Level Expectations Strand 7 Scientific Inquiry	Mode	*M*	*SD*
Evidence is used to formulate explanations.	4	3.68	0.86
Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.	4	3.60	0.79
Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings).	4	3.60	0.83
Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.	4	3.59	0.82
The nature of science relies upon communication of results and justification of explanations.	4	3.59	0.82
Grand *M*		3.61	0.68

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree; 2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

Research Objective Three

Objective three sought to determine agriculture instructors' knowledge of principles of science associated with selected GLEs related to science for students in grades 9 – 11. A biological science practice certification exam from the American Board for Certification in Teacher Excellence (ABCTE) was used to assess this objective. The maximum score for this examination was 20. The mean score for the agriculture instructors was 8.35 (*SD* = 3.19), which is 41.25% of the maximum score. Scores ranged from 0 (0.00%) – 16 (80.00%). The mean score for female teachers was a

9.44 (*SD* = 3.24) and the mean score for males was 7.97 (*SD* = 3.08). Further analysis showed novice instructors, defined as those teachers with fewer than 5 years of experience, scored the highest (*M* = 9.24, *SD* = 3.23) followed by experienced instructors (*M* = 7.95, *SD* = 3.10) and seasoned instructors (*M* = 7.92, *SD* = 3.15). These data are displayed in Table 7.

Table 7

Agriculture Instructors' Knowledge of Principles of Science Associated with Selected Grade Level Expectations Related to Science (n = 141)

	Score		
Group	*M*	*SD*	*% Correct*
Novice Instructors	9.24	3.23	46.20
Experienced Instructors	7.95	3.10	39.75
Seasoned Instructors	7.92	3.15	39.60
Females	9.44	3.24	47.20
Males	7.97	3.08	39.85
Overall score	8.40	3.19	42.00

Note: Novice = 1 – 5 years teaching experience, Experienced = 6 – 15 years teaching experience, Seasoned = 16 and greater years teaching experience

Research Objective Four

Objective four sought to determine sources of motivation for agriculture instructors to teach selected GLEs related to science for students in grades 9 - 11. Respondents were asked to define the purpose of agricultural education. More then half (77, 48.22%) of the instructors indicated that they believe the purpose of agricultural education is to prepare students for work in agriculturally related areas. Of the 77 instructors 18 (12.72%) were female and 51 (36.17%) were males. Further analysis indicated that 21 (14.89%) were Novice instructors, 28 (19.86%) were Experienced instructors, and 28 (19.86%) were Seasoned instructors. Fifty-two (36.87%) instructors, 17 (12.32%) females and 35 (24.82%) males, indicated that the purpose is to promote agriculture literacy while the remaining 7 (4.96%) indicated that they believe the purpose is to reinforce academic skills or to provide enrichment for students. These data are shown in Table 8.

Table 8

Sources of Motivation to Teach Selected Science Grade Level Expectations (n = 141)

Purpose of Agricultural Education	*Gender*		*Experience*				
	Female	*Male*	*Novice*	*Experienced*	*Seasoned*	*f*	%
To prepare students for work in agriculturally related careers	18	59	21	28	28	77	54.61
To promote agricultural literacy	17	35	21	21	10	52	36.87
To provide enrichment experiences for students	1	6	1	5	1	7	4.96
To reinforce academic skills	3	1	3	1	0	4	2.83

Note: Novice = 1 – 5 years teaching experience, Experienced = 6 – 15 years teaching experience, Seasoned = 16 and greater years teaching experience

Table 9 shows instructors' responses when asked about other sources of motivation to teach selected science GLEs. They were asked to mark all sources of motivation that apply. Seventy-two of the instructors indicated that the state staff asked them to incorporate science GLEs into the agriculture curriculum. Fifty-nine of the instructors had been asked to do so by their local school administration. Fifty-nine agriculture teachers indicated that they have worked with one or more science instructors to incorporate science GLEs into their courses, and 56 said they would participate in professional development related to the incorporation of science GLEs into agricultural education curriculum.

Table 9

Motivational Factors to Teach Selected Science Grade Level Expectations (n = 141)

	Yes
Motivational Factors	*f*
State staff asked instructors to incorporate science GLEs	72
Participation in in-service workshop / course addressing integrating science GLEs	59
Administration asked instructors to incorporate science GLEs	59
Have worked with one or more science instructors to incorporate science GLEs	56

Instructors agreed that they enjoy teaching principles related to science with a mean score of 3.87 (*SD* = 0.79). Instructors also indicated that they would attend professional development on integrating science GLEs, with a mean score of 3.65 (*SD* = 0.77). Instructors agreed that efforts should be made to upgrade the scientific content of agriculture courses, with a mean score of 3.67 (*SD* = 0.74). Instructors also agreed that they want to teach more science, with a score of 3.63 (*SD* = 0.94). Instructors were neutral when asked about their undergraduate course work preparing them to teach science (*M* = 3.14, *SD* = 1.11) and whether embedded credit should be available to students enrolled in their classes (*M* = 3.10, *SD* = 1.47). These data are shown in Table 10.

Table 10

Sources of Motivation to Teach Selected Science Grade Level Expectations (n = 141)

Source	Mode	*M*	*SD*
Enjoy teaching principles of science	4	3.87	0.79
Applied science principles should be infused into high school agriculture curriculum	4	3.65	0.77
Efforts should be made to upgrade the scientific content of agriculture courses	4	3.67	0.74
Would attend professional development on integrating science GLEs	4	3.63	0.94
Want to teach more science	4	3.63	0.91
Undergrad coursework adequately prepared instructors to teach science GLEs	3	3.14	1.11

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree;
2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

Table 11 shows the perceptions of agriculture instructors' perceptions regarding embedded science credit in agriculture classes. Forty-eight (34.04%) of the instructors indicated that all agriculture classes should offer embedded science credit to students. Thirty-nine (27.66%) indicated that only some of the upper level agriculture courses should offer embedded science credit and 19 (13.48%) instructors agreed that all upper level agriculture courses should offer embedded science credit. Eighteen (12.77%)

indicated that all of the lower level courses should offer embedded science credit and 17 (12.06%) agreed that only some of the lower level courses should offer embedded science credit.

Table 11

Courses in which Embedded Credit Should be Available as Perceived by Agriculture Instructors (n = 141)

Class Type	*f*	%
All of the agriculture classes I teach	48	34.04
Some upper level (junior and senior)	39	27.66
All upper level (junior and senior)	19	13.48
Some lower level (sophomore and lower)	18	12.77
All lower level (sophomore and lower)	17	12.06

Research Objective Five

Objective five sought to describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the instruction and curriculum of secondary agricultural education programs. Table 12 displays agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon instruction in their secondary agricultural education programs. Instructors agreed that integrating science concepts into the curriculum will add value to their agricultural education classes (M = 3.71, SD = 0.77). Instructors also agreed that integrating science GLEs will enhance problem solving skills of their students (M = 3.50, SD = 0.76).

Table 12

Agriculture Instructors Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Instruction and Curriculum of Secondary Agricultural Education Programs (n = 141)

Characteristic	Mode	*M*	*SD*
Integrating science GLEs will add value to the agricultural education classes.	4	3.71	0.77
Integrating science GLEs will enhance problem solving skills.	4	3.50	0.78

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree; 2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

Instructors acknowledged that incorporating science GLEs into their classes will increase (*M* = 3.93, *SD* = 0.73) the amount of time it takes them to prepare for instruction. They were neutral regarding the notion that incorporating science GLEs will affect the number of students enrolled in their classes (*M* = 3.27, *SD* = 0.64). These data are displayed in Table 13.

Table 13

Agriculture Instructors' Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Instruction and Enrollment of Secondary Agricultural Education Programs (n = 141)

Characteristic	Mode	*M*	*SD*
Incorporation of science GLEs effect on time to prepare for instruction	4	3.93	0.73
Incorporation of science GLEs effect on enrollment	3	3.27	0.64

Note: Scale, 1.00 – 1.49 = Greatly Decrease; 1.50 – 2.49 = Decrease; 2.50 – 3.49 = Neutral; 3.50 – 4.49 = Increase; 4.50 – 5.00 = Greatly Increase

Instructors were asked to identify the courses in which they have already integrated science GLEs from the approved course list from DESE (DESE, 2003). The findings related to this question are summarized in Table 14. Nearly half of the instructors (*n* = 73, 47.70%) have integrated science GLEs into Agriculture Science I and more than 40% (*n* = 67, 43.80%) have integrated science into Agriculture Science II. Of the more specialized classes, Greenhouse Operation and Management was most commonly cited as a course into which teachers had incorporated science GLEs. The course with the fewest instructors (*n* = 6, 3.90%) who have incorporated science GLEs into the curriculum was Fruit and Vegetable Production.

Table 14

Missouri Agricultural Education Courses that Agriculture Instructors' have Integrated Science Grade Level Expectations into Approved Courses (n=141)

Course Name	*f*	%
Agriculture Science I	73	47.70
Agriculture Science II	67	43.80
Greenhouse Operation and Management	39	25.50
Animal Science	36	23.50
Conservation and Natural Resources	30	19.60
Crop Science	21	13.70
Floriculture	20	13.00
Forest Management	15	9.80
Food Science and Technology	15	9.80
Soil and Water Management	14	9.20
Nursery Operation and Management	13	8.50
Turf Management	11	7.20
Other	9	5.80
Fruit and Vegetable Production	6	3.90

Instructors were also asked about what courses into which they plan to integrate science GLEs in the future. Animal Science was identified by 25 (16.30%) and Greenhouse Operation and Management was cited by 21 (13.7%). Agriculture Science I and II were both identified by 20 (13.10%) instructors. Turf Management and Forest Management were each identified by the fewest teachers 5 (3.30%) as being courses in which they plan to integrate science GLEs. These data are displayed in Table 15.

Table 15

Missouri Agricultural Education Courses That Missouri Agriculture Instructors Plan to Integrate Science Grade Level Expectations Into Approved Courses (n=141)

Course Name	*f*	%
Animal Science	25	16.30
Greenhouse Operation and Management	21	13.70
Agriculture Science I	20	13.10
Agriculture Science II	20	13.10
Other	15	9.80
Floriculture	12	7.80
Conservation and Natural Resources	11	7.20
Crop Science	10	6.50
Food Science Technology	10	6.50
Nursery Operation and Management	8	5.20
Soil and Water Management	7	4.60
Fruit and Vegetable Production	6	3.90
Forest Management	5	3.30
Turf Management	5	3.30

Research Objective Six

Objective six sought to describe agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon the student leadership organization of agricultural education. Instructors agreed that FFA members would benefit from the integration of science GLEs (M = 3.59, SD = 0.72). However, instructors were neutral with respect to science GLEs being a good fit with the current FFA events, activities, and award programs (*M* = 3.36, *SD* = 0.83). These data are shown in Table 16.

Table 16

Agriculture Instructors' Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Student Leadership Organization of Agricultural Education (n = 141)

Characteristic	Mode	*M*	*SD*
FFA members will benefit from the integration of science GLEs	4	3.59	0.72
Science GLEs are a good fit with current FFA events, activities and award programs	4	3.36	0.83

Note: Scale, 1.00 – 1.49 = Strongly Disagree; 1.50 – 2.49 = Disagree; 2.50 – 3.49 = Neutral; 3.50 – 4.49 = Agree; 4.50 – 5.00 = Strongly Agree

Table 17 displays the opinions of agriculture instructors regarding the impact of integrating science GLEs upon the student leadership organization, FFA. Instructors' indicated that there would be no change (*M* = 3.27, *SD* = 0.54) in the number of students who are members of the FFA if science GLEs were incorporated into the agricultural education curriculum. Instructors indicated that they believe incorporating science GLEs will slightly decrease (*M* = 3.00, *SD* = 1.07) the amount of time they have to advise and work with FFA events, activities and award programs.

Table 17

Agriculture Instructors' Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Student Leadership Organization of Agricultural Education (n = 141)

Characteristic	Mode	*M*	*SD*
Incorporating science GLEs will impact the number of members in the local FFA chapter	3	3.27	0.54
Incorporating science GLEs impacts the amount of time available to advise and work with FFA events, activities and award programs	3	3.00	1.07

Note: Scale, 1.00 – 1.49 = Greatly Decrease; 1.50 – 2.49 = Slightly Decrease; 2.50 – 3.49 = No Change; 3.50 – 4.49 = Increase; 4.50 – 5.00 = Greatly Increase

Research Objective Seven

Objective seven sought to describe agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon supervised agricultural experiences (SAE) of students. Table 18 shows the proportion of students who have a research SAE and the proportion of those who participate in the Agriscience Fair. Almost three-fourths of the teachers (*f* = 101, 71.63%) indicated that they have no students with a research SAE project. Nearly one-fourth (*f* = 35, 24.82%) of the instructors indicated that less than 10% of their students are engaged in a research SAE. Two instructors (1.41%) indicated that they have more than 30 students engaged in a research SAE. More then three-quarters of the instructors (*f* = 115, 81.56%) indicated that they have no students participating in the Agriscience Fair. These data are displayed in Table 18.

Table 18

Agriculture Instructors' Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Supervised Agriculture Experiences of Student (n = 141)

Characteristic	*f*	%
Percent of students with a research SAE		
0	101	71.63
0 – 10 %	35	24.82
11 - 20%	2	1.42
21 – 30%	1	0.71
More than 30	2	1.42
Percent of students participating in the Agriscience Fair		
0	115	81.56
0 – 10 %	23	16.31
11 - 20%	1	0.71
21 – 30%	1	0.71
More than 30	1	0.71

Table 19 displays the interval level data associated with the agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon students' SAE. Instructors believe that there will be no change in regard to the quality, number, and time to advise SAEs from the integration of science GLEs as represented by means scores ranging from 2.91 – 3.30 (*SD* = 1.00 – 0.69).

Table 19

Agriculture Instructors' Opinions Regarding the Impact of Teaching Selected Grade Level Expectations Related to Science Upon the Supervised Agriculture Experiences of Student. (n = 141)

Characteristic	Mode	*M*	*SD*
How will incorporating science GLEs impact the quality of SAE's	3	3.30	0.69
Incorporating science GLEs will impact the number of SAEs	3	3.25	0.50
How will incorporating science GLEs impact available time to supervise SAEs	3	2.91	1.00

Note: Scale, 1.00 – 1.49 = Greatly Decrease, 1.50 – 2.49 = Slightly Decrease, 2.50 – 3.49 = No Change, 3.50 – 4.49 = Increase, 4.50 – 5.00 = Greatly Increase

Research Objective Eight

Objective eight sought to describe the relationships between and among selected variables. For interpreting the correlations in this section, Davis' (1971) conventions were used to describe the levels of correlations where: 0.01 – 0.09 = negligible, 0.10 – 0.029 = low, 0.30 – 0.49 = moderate, 0.50 – 0.69 = substantial, 0.70 – 0.99 = very high, and 1.00 = perfect. Correlations that were found to be significant were noted with an asterisk.

There was a low positive correlation (r = 0.18) between Strand 3 and years taught. A low negative correlation was found between gender and Strand 7 (r = -0.21) as well as test scores (r = -0.21). Notably, another low negative correlation was found between experience category and test score (r = -0.17). These data are shown in Table 20.

Table 20

Relationships Between Agriculture Instructors' Demographic Characteristics, Perceived Level of Competence to Teach, and Test Scores on the General Science Exam (n = 141)

Variables	Strand 3	Strand 4	Strand 7	Test Score
Age	0.10	0.10	-0.07	-0.14
Gender	0.73	-0.11	-0.21*	-0.21*
Years Taught	0.18*	0.13	-0.04	-0.11
Experience Category	0.10	0.04	0.06	-0.17*

Note. Female = 1, Male = 2

*$p < 0.05$

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to provide a summary and share the conclusions, implications, and recommendations of the findings. These discussions are organized by the objectives investigated.

Summary

Purposes of the Study

The purposes of this study were: 1) to assess the knowledge base and interest levels among agriculture instructors in teaching concepts related to science;
2) To assess how such a change in the curriculum would impact agricultural education programs.

Research Objectives

1. Describe selected personal and professional characteristics of secondary agriculture instructors in Missouri.
2. Describe agriculture instructors' self-perceived competence to teach selected grade level expectations related to science for students in grades 9 - 11.
3. Describe agriculture instructors' knowledge of principles of science associated with selected grade level expectations related to science for students in grades 9 - 11.
4. Describe agriculture instructors' sources of motivation for teaching selected grade level expectations related to science for students in grades 9 - 11.

5. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the instruction and curriculum of secondary agricultural education programs.
6. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon the student leadership organization of agricultural education.
7. Describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to science for students in grades 9 – 11 upon supervised agricultural experiences of students.
8. Describe relationships between and among selected variables (demographic characteristics, confidence to teach selected GLE strands, competence in science.)

Research Design

The design of this research was descriptive correlational as defined by Ary, et al. (2002). That is, descriptive research is "asking questions about the nature, incidence, or distribution of variables" (Ary et al., p. 558), whereas, correlational research seeks to "determine the extent and direction of the relationship between two or more variables" (Ary et al., p. 557). Descriptive correlational research allows the researcher to summarize characteristics and measure attitudes and opinions of the population while comparing different variables of interest. However, the data only represent the population that the sample was drawn from and should not be inferred on another.

Population and Sample

The target population for this study was Missouri secondary agriculture instructors. The 447 instructors of this population were identified from the 2006 – 2007 Agriculture Teacher Directory produced by the Agriculture Division of the Missouri Department of Elementary and Secondary Education (DESE). Since the directory is a complete listing of all instructors in the state of Missouri, it was determined to be the best resource to substantially reduce frame error. Probability sampling was used in which no one person had a zero chance of being selected to participate in the study (Ary et al., 2002). The representative sample size for this population was determined utilizing Krejcie and Morgan's Small-Sample Techniques (1960). This procedure yielded a sample size of 210.

Data Collection

Two instruments were used, in series, to collect data for this study. The first instrument was an Internet based instrument that utilized Simple Survey Builder hosted by the University of Central Missouri (see Appendix B). It was used to collect data associated with all but objective 3. For that objective, a 20 question biology certification practice exam obtained from the American Board for Certification of Teacher Excellence was used (see Appendix C). The intent for utilizing two instruments was to collect data on self perceived competence of Missouri agriculture instructors to teach selected science grade level expectation (GLEs). The second instrument ascertained agriculture instructors' content knowledge in science concepts.

Reliability for the questionnaire used to collect data for objectives 1, 2, 4, 5, 6 and 7 was determined through the use of a pilot study. The pilot study was conducted using

36 instructors who were not included in the sample group. Members of this group were purposefully selected to accurately simulate the population. Data yielded from the pilot group were analyzed the Cronbach's alpha was used to measure the homogeneity of items. That procedure yielded reliability coefficients of: Strand 3 = 0.91, Strand 4 = 0.84, and Strand = 0.89. These coefficients were considered to be acceptable.

Face validity was assessed by a panel of experts (see Appendix E). Minor changes to the appearance of the instrument were made based upon the suggestions of the panel.

Reliability and validity for the instrument used to collect data for objective 3 were determined by the American Board for Certification in Teacher Excellence (ABCTE, 2007). To determine the reliability of the exam, the Kuder-Richardson formula 20 was chosen because of it is appropriate for use on tests with only correct and incorrect responses (Ary et al, 2002). Reliability was determined by ABCTE by working with subject matter experts, classroom instructors, administrators, teacher educators, policymakers and business leaders to ensure that the instrument was valid (ABCTE, 2006).

Members of the sample group were contacted by email to solicit their participation in the study. Data were collected during July of 2007. The instrument used to collect data associated with objectives 1, 2, 4, 5, 6 and 7 was made available to members of the sample group online and following the district meetings during the 2007 Missouri Vocational Agriculture Teachers Association (MVATA) Conference in Springfield, Missouri. The instrument used to collect data associated with objective 3 was also administered following the district meetings at the MVATA conference. After the conference, non-respondents were identified and contacted by email to encourage them to complete the instruments. In all, responses from 175 of the participants were collected. After review, data from141 respondents were deemed to be usable, yielding a response rate of 67.14%.

Summary of Findings

Research Objective One

Objective one sought to identify selected personal and professional characteristics of secondary agriculture instructors in Missouri. The mean age of the instructors was about 35 years old with a range of 22 to 61 years. The average number of years of teaching experience was just less than 11 years old with a range of 0 years to 34 years. The average age of females in the study was nearly 30 years old with nearly 6 years of teaching experience. The average age of males was just less than 38 years old with nearly 13 years of teaching experience.

Research Objective Two

Objective two sought to determine agriculture instructors' self-perceived competence to teach selected grade level expectations (GLEs) related to science for students in grades 9 - 11. Instructors strongly agreed or agreed that they are competent to teach all 13 of the GLE concepts related to Strand 3 – Living Organisms. They agreed that they are confident to teach eight of the nine concepts related to ecology and all five of the concepts related to Strand 7, Scientific Inquiry.

Research Objective Three

Objective three sought to determine sources of agriculture instructors' knowledge of principles of science associated with selected GLEs related to science for students in grades 9 – 11, using a biology practice certification exam from the American Board for Certification in Teacher Excellence.

The mean score for the agriculture instructors was 8.35, which is 41.25% of the maximum score of 20. Scores ranged from 0 – 16. The mean score for female teachers was a 9.44 and the mean score for males was 7.97. Further analysis showed novice instructors scored the highest followed by experienced instructors and then seasoned instructors.

Research Objective Four

Objective four sought to determine sources of motivation for agriculture instructors to teach selected GLEs related to science for students in grades 9 - 11.

More than half 48% of the instructors indicated that they believe the purpose of agricultural education is to prepare students for work in agriculturally related areas. Seventy-two of the instructors indicated that the state staff asked them to incorporate science GLEs into the agriculture curriculum and 52 of the instructors had been asked to do so by their local school administration. Fifty-nine indicated that they have worked with one or more science instructors to incorporate science GLEs into their courses and 56 said they would participate in professional development related to the incorporation of science GLEs into agricultural education curriculum.

Instructors agreed that they enjoy teaching principles related to science. Instructors also indicated that they would attend professional development on integrating science GLEs. Instructors agreed that efforts should be made to upgrade the scientific content of agriculture courses. Instructors also agreed that they want to teach more science. Instructors were neutral when asked about how well their undergraduate course work prepared them to teach science and whether embedded credit for science should be available to students enrolled in their agriculture classes.

Research Objective Five

Instructors agreed that integrating science concepts into the curriculum will add value to their agricultural education classes. Instructors also agreed that integrating science GLEs will enhance problem solving skills of their students.

Instructors acknowledged that incorporating science GLEs into their classes will increase the amount of time it takes them to prepare for instruction. They were neutral regarding the notion that incorporating science GLEs will affect the number of students enrolled in their classes.

Agriculture Science I was the course most frequently cited by the instructors among the courses in which they have already integrated science GLEs. Of the more specialized classes, Greenhouse Operation and Management was most commonly cited. Instructors were also asked about what courses into which they plan to integrate science GLEs in the future. Animal Science was most frequently cited followed by Greenhouse Operation and Management.

Research Objective Six

Objective six sought to describe agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon the student leadership organization of agricultural education. Instructors agreed that FFA members would benefit from the integration of science GLEs; however, they were neutral about science GLEs being a good fit with the current FFA events, activities, and award programs.

Instructors' indicated that there would be no change in the number of students who are members of the FFA if science GLEs were incorporated into the agricultural education curriculum. Instructors indicated that they believe incorporating science GLEs will slightly decrease the amount of time they have to advise and work with FFA events, activities and award programs.

Research Objective Seven

Objective seven sought to describe agriculture instructors' opinions regarding the impact of teaching selected GLEs related to science for students in grades 9 – 11 upon supervised agricultural experiences (SAE) of students. More than 80% of the teachers indicated that they have no students who participate in Agriscience Fair activity and almost three-fourths of the teachers indicated that they have no students with a research SAE project. Instructors believe that the integration of science GLEs will result no change the quality of SAEs, the number of SAEs, or the time they have available to supervise SAEs.

Research Objective Eight

Objective eight sought to describe the relationships between and among variables. There was a low positive correlation between Strand 3 and years taught, a low negative correlation between gender and Strand 7 as well as gender and science knowledge test scores. Notably another low negative correlation was found between experience category and test score.

Conclusions, Implications, and Recommendations

Conclusions, Implications, and Recommendations Related to Objective One.

Objective one sought to describe selected personal and professional characteristics of secondary agriculture instructors in Missouri.

The average agriculture instructor in Missouri is a 36 year old male with 11 years of teaching experience. While this conclusion is similar to the profile for this population ten years ago, one major difference should be noted. According to the *1997-1998 Agricultural Education Directory* (DESE, 1997) females composed less than 10% of all Missouri agricultural education teachers in 1997. In contrast, nearly 25% of the respondents for this study were female. Changes in demographics and other factors such as background and life style issues of these teachers should be considered when designing and delivering pre-service and in-service programs.

Conclusions, Implications, and Recommendations Related to Objective Two

Objective two was to describe agriculture instructors' self perceived competence to teach selected grade level expectations related to science for students in grades 9 – 11.

Instructors are confident they can teach all of the concepts of science GLEs that are related to agricultural education. This conclusion is in agreement with the findings of Thompson and Balschweid (1999) who found that agriculture instructors in Oregon feel they are prepared to teach science concepts. One can only speculate why these teachers have such confidence considering that Harlin and Holroyd (1997) found that confidence in the subject matter is a primary challenge cited by science teachers. Regardless, this confidence to teach science should not be confused with competence to teach science. The confidence that Missouri agriculture instructors have in their ability to teach science concepts should be used as a foundation to create professional development programs to increase their effectiveness in teaching this content.

Conclusions, Implications, and Recommendations Related to Objective Three

Objective three sought to describe agriculture instructors' knowledge of principles of science associated with selected grade level expectations related to science for students in grades 9 -11.

Missouri agriculture teachers do not have an acceptable level of competence in the subject area of science. The average score of this group on the science knowledge examination is considered to be "not proficient" by ABCTE (Boots, 2007). The average score for the teachers in this study was 42.00% compared to the national average of science certification candidates' score of 64.00% (Boots). Only 13 of 141 (9.22%) agriculture instructors scored high enough on the examination to be considered proficient. According to Boots, the average score of agriculture instructors on this assessment would translate 243 points on where 251 points indicates proficiency. The researcher acknowledges that the instrument used in this study could be criticized for a variety of reasons; however, it is a validated tool that provides baseline information for further discussion and research.

If agriculture instructors are going to be expected to teach science concepts, there must be an effective and focused in-service program designed to increase their knowledge about science and to expose them to the methods used to teach this content. Secondly, if science concepts are to be successfully implemented, teacher preparation programs need to examine the amount of science coursework that pre-service agriculture instructors are taking. This recommendation is similar to recommendations from studies of Oregon agriculture instructors by Warnick and Thompson (2002) as well as Warnick, Thompson, and Gummer (2004). Both science instructors and researchers suggest that to be effective in integrating science into their coursework, agriculture instructors need more content knowledge (Warnick, Thompson & Gummer, 2004).

Further, research must be completed to measure competence in science concepts among pre-service and current instructors. Measures must be taken to identify the needs of current instructors so that professional development can be provided to increase the competence of agriculture instructors.

Conclusions, Implications, and Recommendations Related to Objective Four

Objective four sought to describe agriculture instructors' sources of motivation for teaching selected grade level expectations related to science for students in grades 9 -11.

Agriculture instructors believe that the purpose of agricultural education programs is vocational in nature. Only four instructors indicated that the purpose of agricultural education is to reinforce academic skills. Some caution should be used in analyzing this conclusion because instructors were asked to identify the one purpose they consider to be most important. They were not given the opportunity to rank or compare the four alternatives.

If the CASE model (Team AgEd, 2005) and the recommendations of the Strategic Plan for Agricultural Education (The National Council for Agricultural Education, 2000) related to curriculum improvement are to be effectively implemented, then a clearer vision of the purpose of agricultural education needs to be developed. Further research must be conducted to analyze what instructors consider to be the purpose of agricultural education and how it is affected by geographic region, gender, and years of experience.

Instructors perceive that state leaders in agricultural education in Missouri expect them to integrate science GLEs into their curriculum. Interestingly enough, no evidence was found in the review of literature indicating that the state staff has formally directed instructors to integrate science into agricultural education curriculum. Instructors indicated that they have not attended professional development nor have they worked with a science instructor to integrate science GLEs, yet they believe that efforts should be made to increase the scientific content of agriculture courses. Why do teachers hold this belief? Such a change in the emphasis seems to be in conflict with a program focused on career development. Research has found that instructors believe that added support from the science teacher will increase the amount of science integrated into the agriculture curriculum (Thompson, 2001). This matter should be examined more carefully to better understand these seemingly conflicting viewpoints. In addition, because agriculture teachers seem open to the idea of working with science teachers, professional development opportunities should be created to allow agriculture and science instructors to work collaboratively. Such relationships could be of great benefit to teachers and students.

Instructors were neutral about science credit being awarded through agriculture courses. This conclusion is not in direct agreement with the recommendation of the Committee on Agricultural Education in Secondary Schools (NRC, 1988) and other studies that found favorable support for agriculture students earning science credit (Chiasson & Burnett, 2001).

Interestingly, while instructors are confident in their ability to teach science concepts, they do not agree that science credit should be offered to students who successfully complete their courses. With respect to agriculture classes being used in exchange for science credit, research by Chiasson and Burnett, (2001), as well as Conners and Elliot (1995) has shown that agriculture students score higher on standardized tests than do non-agriculture students. Yet one needs to be careful in suggesting that agriculture alone is enough for such crediting. To date, there has been little research investigating the science aptitude of students who take agriculture courses in exchange for science courses. Thompson and Balschweid (1999) as well as Newman and Johnson (1993) cautioned against awarding science credit for agriculture courses and suggested that additional research is needed in the area of science crediting for agriculture.

Further research needs to be conducted into the amount of science taught in the agriculture curriculum. Content analysis of the agriculture curriculum should be done to determine the amount of science, type and level of science concepts found therein.

Instructors enjoy teaching principles of science and are willing to attend professional development to improve their skills in teaching science concepts. Instructors believe that they can teach science concepts, yet their scores on a science knowledge assessment indicate a less than acceptable level of science knowledge. As stated before, professional development opportunities should be provided for agriculture teachers to increase their competence to teach science.

Conclusions, Implications, and Recommendations Related to Objective Five

Objective five was to describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to the science for students in grades 9 – 11 upon the instruction and curriculum of secondary agricultural education programs.

Agriculture teachers believe integrating science concepts into their agriculture classes will have positive effects upon the classes they teach. While there may be benefits to such a change, there are numerous consequences that should be considered. If instructors increase the amount of science they teach, they will certainly have to remove or reduce some of the content they currently teach. What students will be drawn to agriculture classes that count for science credit? Such classes could attract students who are merely looking for an alternative to the regular science classes, rather than students who have a genuine interest in agriculture and natural resources. On the other hand, will students who enroll because they are interested in agriculture receive the content they desire from these courses?

Instructors recognize that integrating science will require additional time to prepare for instruction. If teachers spend more time preparing for class, will they have the necessary time to advise the student organization and supervise SAE?

Further research must be conducted to understand the true nature of the benefits and negative effects of integrating science into the agricultural education courses. Impacts of such changes upon students' science knowledge and knowledge about agriculture should be evaluated. Additionally, analysis of instructors' job satisfaction and efficacy should be conducted in cases where a more science-based curriculum has been adopted.

Conclusions, Implications, Recommendations Related to Objective Six

Objective six sought to describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to the science for students in grades 9 – 11 upon the student leadership organization of secondary agricultural education programs.

Instructors believe that the incorporation of science GLEs will benefit FFA members; however, they are unsure if science GLEs are a good fit with current FFA activities and programs. If teachers are unsure about the match between increasing science concepts in the curriculum and FFA programs are they considering all of the effects such a change might have upon FFA? It seems that a change in curriculum would require changes to current FFA competitions and awards programs as well. How well would such changes be received by agriculture teachers and students? The FFA Agriscience Fair activity has existed for a number of years yet, as this study found, participation in this event remains low. Would new events, programs and activities designed to fit a more science based curriculum fare any better?

Missouri teachers are unsure about how integrating more science concepts into the curriculum might impact the number of students who join FFA or the time teachers will have to advise FFA programs and activities. As was reported earlier, teachers acknowledge that they will need to spend more time prepare for classes where science concepts are incorporated. This change in time allocation could take away from the time they devote to the student organization. If such a change in emphasis were to take place, it is questionable if they would be able to prepare CDE teams, work on student and chapter award applications and other activities as they do now. Research must be conducted to examine both the positive and negative impacts upon the FFA organization, its student members and advisors resulting from the integration of science concepts in to the curriculum.

On a related note, researchers have found a correlation between FFA membership and success in college (Ball & Garton, 2001). How will an increased emphasis upon science in the curriculum impact this advantage for FFA members?

Conclusions, Implications, and Recommendation Related to Objective Seven

Objective seven sought to describe agriculture instructors' opinions regarding the impact of teaching selected grade level expectations related to the science for students in grades 9 – 11 upon the supervised agriculture experiences of students.

Teachers believe that the integration of science GLEs will have no impact upon the number or quality of students' SAEs. It can also be concluded that agriculture instructors have not embraced existing opportunities for students to engage in SAE activities that are related to science in agriculture. The vast majority of teachers stated that they have no students conducting research SAEs. This seems odd considering research SAEs provide opportunities for students to apply scientific concepts and are also a good match for agriculture students from diverse backgrounds. Is this low involvement in research SAE activities a result of teachers' unfamiliarity with these opportunities, their limited of knowledge about scientific methods and procedures, or other factors? Research should be conducted to examine perceived barriers and limitations that explain the lack of participation in science related SAEs.

Teachers believe that the integration of science GLEs will have no impact upon their time to supervise students' SAEs. Could this belief be an indication of how little time it takes to supervise SAEs? Could it be an indication of a lack of emphasis upon the SAE component? Researchers need to examine teachers' perceptions about the role of SAE as it relates to current agriculture programs as well as programs where science is emphasized in the curriculum.

Conclusions, Implications, and Recommendations Related to Objective Eight

Objective eight sought to describe relationships between and among selected variables (demographic characteristics, confidence to teach selected GLE strands, competence in science).

Female agriculture teachers have more competence in biological science than do their male counterparts. Further research should be conducted verify this conclusion. In addition, as the females become more numerous in the profession, their impact upon various aspects of agricultural education should be examined.

Less experienced teachers have more competence in biological science than do their more experienced colleagues. Further research should be conducted to assess the reason for this difference.

APPENDICIES

APPENDIX A

Institutional Agricultural Education Degree Requirements
In Missouri Institutions

College of the Ozarks

Department of Agriculture

Youngman Agriculture Center, Phone: (417) 334-6411, Fax: (417) 336-0764
Email: russell@cofo.edu
Web Site: www.cofo.edu/ozarks.htm
Department Head: Associate Professor Dan Swearengen, Ph.D.

Agriculture Education Emphasis/Secondary Education

Required major courses: 45 hours

- AGR core courses 19
- AGR 353 Farm Machinery (F-O) 3
- AGH 133 Introduction to Horticulture (S) 3
- AGH 153 Introduction to Forestry (F) 3
- AGT 153 Welding (F) 3
- AGT 343 Construction Technology (S-O) 3
- AGE 433 Organization and Management of Agriculture/Technology Education (S-O) 3
- AGE 443 Methods of Teaching Agriculture Education (S) 3
- AGE 453 Agriculture Education Program Construction (F) 3
- Additional Agriculture courses in area of concentration 2

Agriculture majors with an Education emphasis must also major in Secondary Education (see Secondary Education section under Education). Agriculture Education majors must earn a C- grade or higher in all required agricultural classes, Education classes and the required collateral classes of Chemistry and Biology

Missouri State University

Department of Agriculture

201 Karls Hall, Phone: (417) 836-5638, Fax: (417) 836-6979
Email: Agriculture@missouristate.edu
Web Site: http://ag.missouristate.edu
Department Head: Professor W. Anson Elliott, Ph.D.

Agriculture Education Bachelor of Science in Education
(Certifiable grades 9-12)

A. General Education (see General Education section of catalog)
   Specific General Education Requirements: BIO 102(4); CHM 105(5) or 160(4); MTH 135(3) or 138(5); PSY 121(3)
B. Major Requirements
   1. AGS 101(4); AGA 105(3), 215(3); AGB 144(4), 334 (3); AGH 303(3); AGE 337(3); AGW 143(3)
   2. AGE 318(2), 568(3), 578(2), 588(2)
   3. Area of Specialization: Students must select a minimum of 20 hours of Agriculture courses to complete 45 hours of Technical Agriculture required by the State Department of Education.
C. Professional Education courses: AGE 558(3), 493(5-6), 494(5-6); and the Professional Education Required Core and Competencies (see "Teacher Certification, Teacher Education Program and Secondary Education Requirements" section of catalog).
D. General Baccalaureate Degree Requirements (see "Academic Programs and Requirements" section of catalog)
E. In order to meet Missouri state teacher certification requirements, candidates for the Bachelor of Science in Education degree are required to meet the following grade point average requirements: at least a 2.50 GPA on all course work attempted at all colleges attended; at least a 2.50 GPA in the certificate subject area (major field of study) which includes all courses listed under C; at least a 2.50 GPA in any additional certificate subject area; at least a 2.50 GPA in the professional education courses; and no grade lower than a "C" in all professional education courses. All GPA requirements include both Missouri State and transfer grades.

Northwest Missouri State University

Department of Agriculture

800 University Drive: (660) 562-1161, Fax: (660) 562-1621
Email: admiral@nwmissouri.edu
Web Site: http://nwmissouri.edu
Chairperson: Arley Larson

Comprehensive Major in Agricultural Education, 59 hours: B.S.Ed., Secondary Program—No Minor Required (Certifies Grades 9-12)

The Major in Agricultural Education is designed to prepare teachers of agriculture for the secondary and adult levels in compliance with state certification requirements.

Required Courses	Semester Hours
Ag 03-150 Animal Science	4
Ag 03-334 Soils	4
**Ag 03-130 Plant Science	4
**Ag 03-102 Introductory Agricultural Economics	3
Ag 03-496 Seminar	1
Ag 03-112 Agricultural Mechanics	4
Ag 03-304 Farm Management and Record Analysis	3
Ag 03-232 Crop Production	3
Horticulture elective	3
Advisor-approved electives in agriculture	16
	Total 45

Required Courses in Agricultural Education	
Ag 03-320 Foundations of Agricultural Education	3
Ag 03-420 Program Planning in Agricultural Education	3
Ag 03-421 Conducting Supervised Agricultural Experience Programs	2
Ag 03-422 Adult Education in Agriculture	2
Ag 03-524 Teaching Agricultural Laboratories	2
Ag 03-580 Methods in Teaching Agriculture	2
	Total 14

Directed General Education Requirement
Chem 24-112/113 General Chemistry and Laboratory OR
Chem 24-114/115 General Chemistry I and Laboratory 4
**Can be used to fulfill General Education requirement.

University of Central Missouri

Department of Agriculture

126 Grinstead: (660) 543-4240, Fax: (660) 543-8753
Email: agriculture@ucmo.edu
Web Site: http://ucmo.edu/agriculture
Department Head: Professor Stephen Wilson, Ph.D.

VOCATIONAL AGRICULTURE EDUCATION
Functional Major, B.S. in Ed. Degree

Sem. Hours

FUNCTIONAL MAJOR REQUIREMENTS 53

Agri 2010 Comp. Applications for Agri	3	Agri 3420 Animal Nutrition	3
Agri 1100 Introduction to Agriculture	1	Agri 1600 Intro. Horticulture Science	3
Agri 3110 Agri-Business Management	3	Agri 4820 Agricultural Safety	3
Agri 3120 Dist. & Mkt. Agri. Products	3	Agri 4900 Plan & Conduct. Prog Ag Ed	3
Agri 1200 Agri. Mechanics	3	Agri 4910 Agri. Occup. Exper. Programs	2
Agri 3200 Farm Power & Machinery	3	Agri 4920 Agri. Mechanics in Agri. Ed.	
Agri 1300 Introductory Plant Science	1	Econ 1011 Principles of Economics	3
Agri 1310 Agronomy I: Row Crops	2	Biol 1004 Intro. to the Sciences:	4
Agri 2315 Agronomy II: Forages	2	Agri 4430 Animal Science: Beef Or Agri 4435 Animal Science: Pork	3
Agri 2330 Introduction to Soil Science	3		
Agri 1420 Animal Husbandry	3		

MINOR NOT REQUIRED

UNIVERSITY STUDIES REQUIREMENTS- 48 s.h. (In the functional major, Biol 1004 fulfills 3 s.h. of Div. II A) 45

Math 1111	Div. I C (required)	3	PolS 1510	Div. II B (required)	3
Chem 1104	Div. II A (required)	4	Agri 2130	Div. II E (required)	3
Hist 1350 Or Hist 1351	Div. II B (required)	3	Psy 4230	Psy. Of Adolescen	3
			ICap 4101	Div. III B (required)	3

Secondary Education students will be allowed to substitute Psy. 4230 to fulfill 3 s.h. in Div. II B

PROFESSIONAL EDUCATION REQUIREMENTS 28

Agri 4930	Methods of Teaching Voc. Agriculture	2
Agri 4940	Secondary Field Experience II	1

MINIMUM TOTAL. 126

University of Missouri-Columbia

Department of Agricultural Education

121 Gentry (573) 882-7451, Fax: (573) 884-4444
Email: aged@missouri.edu
Web Site: http://aged.missouri.edu
Department Head: Professor Robert H.Terry, Jr., Ph.D.

General Education Requirements (41 Hours)

- Communications (9)
  - English 1000 (Composition II)
  - Communication 1200 (Public Speaking)*
  - Elective
- Mathematics (3)
  - Math 1100 (College Algebra) or higher
- Physical and Biological Science (11)
  - Biology 1010 and 1020, 1200 or 1500
  - Chemistry 1100, 1310 or 1320
  - Biochemistry 2110, 2112 or Chem 1330
- Social and Behavioral Sciences (9)
  - Agricultural Economics 1041 or Economics 1014 (microeconomics)
  - Agricultural Economics 1042 or Economics 1015 (macroeconomics)
  - History 1100 or 1200 (American History) or Political Science 1100 or 2100 (American/State Government)
- Humanistic Studies and Fine Arts (9)
  - Electives from specified areas

**3 of 9 credits of Humanistic Studies requirement met with Communication 1200*

Professional (Certification) (42 Hours)

Phase I

- Ag Ed 1000: Orientation to Ag Ed (1)
- TDP 2000: Inquiry into Learning I (3)
- TDP 2xxx: Integrated Field Experience I (1)
- TDP 2040: Inquiring/School, Community and Society I (3)
- TDP 2044: Integrated Field Experience I (1)
- Ag Ed 4310: Rationale and Structure of Ag Ed Programs (3)
- Ag Ed 4311: Integrated Field Experience I (1)

Phase II

- Ag Ed 3310: Teaching Financial Mgt and Economics (2)
- Ag Ed 4320: Designing Curriculum and Instruction in Agriculture (3)
- Ag Ed 4321: Integrated Field Experience II (1)

- TDP 4020: Inquiring into Learning II (3)
- Ag Ed 4330: Teaching Agriculture Subjects (3)
- C&I 4560: Teaching Reading in the Content Areas (2)

Phase III (Internship Semester)

- Ag Ed 4087: Internship Seminar (3)
- Ag Ed 4995: Student Teaching Internship in Agriculture (12)*
  **Capstone course for emphasis area*

Agricultural, Food and Natural Resources
(45 Hours)

- Agricultural Business (3)
  - Ag Econ 2183: Agric Marketing System **or**
  - Ag Econ 2224: New Products Marketing
- Agricultural Systems Management (6)
  - Ag SM 1020: Intro to Ag Systems Mgt
  - Ag Ed 3320: Metal Fabrication and Lab Mgt.
- Animal Science (6)
  - An Sci 2165: Ruminant Livestock Production
  - An Sci 2175: Monogastric Production
- Food Science (3)
  - FS 1030: Food Science and Nutrition **or**
  - FS 2114: Meat Classification, Grading and Judging
- Natural Resources (3)
  - Soils 2100 - Introduction to Soils
- Horticulture (3)
  - Plt Sci 2074 - Home Horticulture **or**
  - Plt Sci 3230 - Plant Propagation
- Plant Science (3)
  - Plt Sci 2110 - Plant Growth and Culture
- Leadership (3)
  - Ag Ed 2250 - Professional Leadership Development **or**
  - Ag Ed 2260 - Team and Organizational Leadership
- CAFNR Minor and/or Elective (15 minimum)

Additional General Education Requirements

- Two Writing Intensive Courses (WI)
- Math Reasoning Proficiency (MP)

APPENDIX B

Data Collection Instrument

Integration of Science **Code ______________**

1. Thank you for taking the time to participate in this study. The purpose of this study is to assess the competence and interest of agriculture instructors to teach concepts related to science. The survey should take between 15-20 minutes to complete. Understand that your participation in this study is voluntary and that all responses are confidential with no materials being recorded or traced to any particular respondent. This research is non-life threatening and that you have the right to withdraw from the research at any time. While responding to the survey you realize that you can stop at anytime without any repercussions from The University of Central Missouri or the University of Missouri-Columbia or the researcher. If you agree to these terms, please select yes and proceed with the survey. In the case that you should have questions please feel free to contact Jason Scales at 660-543-4519 by phone or email jscales@ucmo.edu, or Dr. Rob Terry, Jr. at 573-884-7375 by phone or email robterry@missouri.edu. If you have questions about your rights as a research participant please contact the Campus Institutional Review Board at 1-573-882-9585 or the Office of Research 573-882-9500.

□ No □ Yes

The following statements are concepts within the Scope and Sequence of the Science Grade Level Expectations. Please rate them on your perceived level of competence to teach each.

Please mark your responses the by placing an X in the appropriate box.

3. I feel competent to teach about how organisms progress through life cycles unique to different types of organisms.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

4. I feel competent to teach about how cells are the fundamental units of structure and function of all living things.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

5. I feel competent to teach about how biological classifications are based on how organisms are related.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

6. I feel competent to teach about how the cell contains a set of structures called organelles that interact to carryout life processes through physical and chemical means.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

The following statements are concepts within the Scope and Sequence of the Science Grade Level Expectations. Please rate them on your perceived level of competence to teach each.

Please mark your responses the by placing an X in the appropriate box.

7. I feel competent to teach about how photosynthesis and cellular respirations are complementary processes necessary to the survival of most organisms on Earth.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

8. I feel competent to teach about how cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

9. I feel competent to teach about how protein structure and function are coded by the DNA (Deoxyribonucleic acid) molecule.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

10. I feel competent to teach about how cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis).

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

11. I feel competent to teach about how reproduction can occur asexually or sexually.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

12. I feel competent to teach about how all living organisms have genetic material (DNA) that carries hereditary information.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

13. I feel competent to teach about how chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

14. I feel competent to teach about how there is heritable variation within every species of organism.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

The following statements are concepts within the Scope and Sequence of the Science Grade Level Expectations. Please rate them on your perceived level of competence to teach each.

Please mark your responses the by placing an **X** in the appropriate box**.**

15. I feel competent to teach about how the pattern of inheritance for many traits can be predicted by using the principle of Mendelian genetics.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

16. I feel competent to teach about how all populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

17. I feel competent to teach about how living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

18. I feel competent to teach about how all organisms, including humans, and their activities cause changes in their environment that affect the ecosystem.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

19. I feel competent to teach about how the diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

20. I feel competent to teach about how as energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form that they can use.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

21. I feel competent to teach about how matter is recycled through an ecosystem.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

The following statements are concepts within the Scope and Sequence of the Science Grade Level Expectations. Please rate them on your perceived level of competence to teach each.

Please mark your responses the by placing an **X** in the appropriate box.

22. I feel competent to teach about how evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

23. I feel competent to teach about how reproduction is essential to the continuation of every species.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

24. I feel competent to teach about how natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

25. I feel competent to teach about how scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

26. I feel competent to teach about how scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

27. I feel competent to teach about how evidence is used to formulate explanations.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

28. I feel competent to teach about how scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings).

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

29. I feel competent to teach about how the nature of science relies upon communication of results and justification of explanations.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

Please answer the questions below by filling in the space with the appropriate information.

30. How many years have you taught agricultural education? ______

31. What is your age? ________

Please answer the questions below by selecting the correct response.

Mark your responses the by placing an **X** in the appropriate box(s).

32. Which of the following best describes the primary purpose of your agricultural education program?

- □ To prepare students to work in agriculturally related careers (production agriculture, agriculture)
- □ To promote agricultural literacy (teach about where food comes from, impact of agriculture upon the economy, environment, etc.)
- □ To reinforce academic skills and prepare students for higher education (in science, math, etc.)
- □ To provide enrichment experiences for students (similar to music, art, athletics, etc.)

33. My administration has asked me to benchmark science grade level expectations (GLEs) within the agricultural education curriculum.

□ No □ Yes

34. The Missouri Agricultural Education State Staff (Terry Heiman and/or district supervisors) has encouraged me to integrate the science GLEs into my classes.

□ No □ Yes

35. I have worked with one or more science instructors to incorporate science GLEs into the agriculture curriculum.

□ No □ Yes

36. My undergraduate coursework adequately prepared me to teach science GLEs in the agriculture curriculum.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

37. I have participated in one or more in-service workshop/course addressing how to integrate science principles into secondary agriculture classes (e.g. biotechnology).

□ No □ Yes

Mark your responses the by placing an X in the appropriate box(s).

38. I would attend professional development sessions on integrating science GLEs into the agriculture curriculum.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

39. I enjoy teaching principles of science.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

40. I want to teach more science in the agriculture curriculum.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

41. Based upon the way my classes are currently taught, embedded science credit should be available to students in my classes.

- □ All of the upper level (junior and senior) agriculture classes I teach.
- □ Some of the upper level (junior and senior) agriculture classes I teach.
- □ All of the lower (sophomore and lower) agriculture classes I teach.
- □ Some of the lower level (sophomore and lower) agriculture classes I teach.
- □ All of the agriculture classes that I teach.

42. I believe applied science principles and concepts, represented by the science GLEs, should be infused into the high school agriculture curriculum.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

43. I believe efforts should be expanded to upgrade the scientific content of agriculture classes.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

44. I believe that integrating the science GLEs into my agriculture curriculum does/would add value to the classes that I teach.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

45. I believe integrating science GLEs does/will enhance my students' problem solving skills.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

Mark your responses the by placing an X in the appropriate box(s).

46. I believe science GLEs are a good fit with current FFA events, activities and award programs.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

47. I believe FFA members will benefit from the integration of science GLEs into the agriculture curriculum.

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

48. I have integrated science GLEs into the following courses. Check all that apply.

- □ Agriculture science I
- □ Agriculture science II
- □ Animal science
- □ Crop science
- □ Soil and water management
- □ Floriculture
- □ Greenhouse operation and management
- □ Nursery operation and management
- □ Turf management
- □ Fruit and vegetable production
- □ Conservation and natural resources
- □ Forest management
- □ Food science and technology
- □ Other

49. I plan to integrate science GLEs into the following courses. Check all that apply.

- □ Agriculture science I
- □ Agriculture science II
- □ Animal science
- □ Crop science
- □ Soil and water management
- □ Floriculture
- □ Greenhouse operation and management
- □ Nursery operation and management
- □ Turf management
- □ Fruit and vegetable production
- □ Conservation and natural resources
- □ Forest management
- □ Food science and technology
- □ Other

Mark your responses the by placing an X in the appropriate box(s).

50. During the previous school year, what percentage of your students had a research SAE?

□ 0 □ 1-10 □ 11-20 □ 21-30 □ More than 30

51. During the previous school year, what percentage of your students participated in the Agriscience Fair?

□ 0 □ 1-10 □ 11-20 □ 21-30 □ More than 30

52. How will incorporating science GLEs impact enrollment in your agricultural education program?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

53. How will incorporating science GLEs impact the number of members in your local FFA chapter?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

54. How will incorporating science GLEs impact the number of students with SAEs in your agricultural education program?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

55. How will incorporating science GLEs impact the amount of time you need to prepare for class?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

56. How will incorporating science GLEs impact the amount of time you have available to advise and work with FFA events, activities and award programs?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

57. How will incorporating science GLEs impact the amount of time you have available to supervise SAEs?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

58. How will incorporating science GLEs impact the quality of SAEs conducted by students in your agricultural education program?

□ Greatly Increase □ Increase □ No Change □ Slightly Decrease □ Greatly Decrease

APPENDIX C

Biological Science Exam

Please mark all answers on the Scantron that is provided. DO NOT mark on the instrument.

1. Which part of the human brain is involved in controlling body temperature?
    a. Cerebrum
    b. Cerebellum
    c. Thalamus
    d. Hypothalamus***

2. From an evolutionary standpoint, what is a disadvantage of asexual reproduction (compared to sexual reproduction)?
    a. Asexual reproduction requires less specialization.
    b. There is less variability between generations. ***
    c. Asexual reproduction is not possible for large organisms.
    d. Asexual reproduction is possible for large organisms.

3. Which of the following pairs of animals is most likely to occupy the same trophic level within their own food webs?
    a. Hawk and zooplankton
    b. Rabbit and blue jay***
    c. Algae and beetle grub
    d. Grasshopper and spider

4. In humans, which compartment of the heart does deoxygenated blood enter first?
    a. Right ventricle
    b. Right atrium***
    c. Left ventricle
    d. Left atrium

5. Which of the following structures reduces friction caused by the movement of skin and muscle over bone?
    a. Synovial membrane
    b. Articular cartilage
    c. Bursae***
    d. Symphyses

6. How do electrons orbit the nucleus of an atom?
    a. Each electron follows a fixed path, like a planet.
    b. All electrons of an atom revolve at the same distance from the nucleus.
    c. Electrons orbit in a cloud-like region all around the nucleus of an atom.***

d. Electrons exist in a state of equilibrium, both in and around the nucleus.

Please mark all answers on the Scantron that is provided. DO NOT mark on the instrument.

7. Which organelle provides energy for movement, division, and contraction?
   a. Cytoskeleton
   b. Chloroplast
   c. Cell membrane
   d. Mitochondrion***

8. An abrupt decrease in fossil diversity in rock horizons, followed by fossils of different species, is an indication of
   a. succession
   b. microevolution
   c. mass extinction***
   d. natural selection

9. Which of the following organelles are in plant cells, but not animal cells?
   a. Cell walls and chloroplasts****
   b. Lysosomes and centrioles
   c. Chloroplasts and mitochondria
   d. Cell walls and nuclei

10. What is the major difference between prokaryotic cells and eukaryotic?
    a. Prokaryotic cells do not have cell walls
    b. Eukaryotic cells do not have a nucleus
    c. Prokaryotic cells only have one chromosome***
    d. Eukaryotic cells do not have cytoplasm

11. What are the levels of organization, in order of complexity, within an animal?
    a. Tissues → Cells → Organs → Organ Systems
    b. Cells →Tissues → Organs → Organ Systems ***
    c. Organ Systems → Organs →Tissues → Cells
    d. Organs → Organ Systems → Tissues→ Cells

12. ABO blood typing is genetically determined, with the genes from antigens, A or B, dominant, and the gene for no antigen, O, being recessive, If the genotype for a person's ABO blood type is AO, what is the phenotype?
    a. Type A***
    b. Typo AO
    c. Type O

d. Type AA

Please mark all answers on the Scantron that is provided. DO NOT mark on the instrument.

13. According to competitive exclusion two organisms can not occupy the same niche in the same place at the same time. What is the best explanation of a niche?
    a. An organism's microhabitat, abiotic characteristics, and food requirements.***
    b. The biotic environment where an organism lives, reproduces, and dies.
    c. The organism's relationship with other living organisms and their surroundings.
    d. The biome in which an organism lives.

14. Which hormones are responsible for regulating the menstrual cycle?
    a. Progesterone and estrogen***
    b. Progesterone and testosterone
    c. Estrogen and testosterone
    d. Estrogen and gonadotropin

15. What is the function of cellulose in a plant cell?
    a. It stores sugar.
    b. It provides rigid support.***
    c. It is a reserve source for glucose.
    d. It enables reproduction.

16. When a barnacle attaches itself to a whale, the barnacle benefits, but the whale does not. What type of symbiosis does this indicate?
    a. Mutualism
    b. Commensalism***
    c. Parasitism
    d. Natural selection

17. What are the main forces of evolution?
    a. Heritable variation, natural selection, and stochastic events
    b. Differential migration, Hardy-Weinberg equilibrium, and genetic drift
    c. Over-production, natural selection, and heritability
    d. Mutation, migration, selection, and drift***

18. Which of the following statements applies to all nucleic acids?
    a. They are polymers made of nucleotides.***

b. They have no functions in cells, only organs and organ systems.
c. They contain four organic bases.
d. They have a double helix structure.

Please mark all answers on the Scantron that is provided. DO NOT mark on the instrument.

19. What is the function of fermentation in the cells of vertebrates?
    a. Provide oxygen to the muscle.
    b. Provide a quick burst of energy to the muscle.***
    c. Regulate breathing by producing carbon dioxide.
    d. Store energy for later use.

20. Which reproductive strategy is used by conifers?
    a. Windblown homospores that disperse in water.
    b. Heterospores assisted in pollination by animals with fruit over seeds.
    c. Heterospores pollinated by wind with naked seeds.***
    d. Heterospores pollinated by wind and fruit over seeds.

APPENDIX D

Initial Email to Study Participants

I hope that your summer is going well. If you are like me, the season is going by too fast.

The purpose of this email is to ask you to participate in a study I am conducting for my dissertation. The study is related to the integration of science Grade Level Expectations (GLEs) within Ag Ed. I need you to be a part of the study by completing two questionnaires. First, there is an online instrument. It should only take between 15 and 20 minutes to complete. I would greatly appreciate having your input by the end of this week. Second, during the MoACTE/MVATA conference next week, I would also ask that you stay after the district teachers meeting on Tuesday afternoon to complete another instrument. It, too, should only take a few minutes to complete. As an incentive to participate, there will be a $50 bill card drawn for one participant in each district. The name will be drawn when all instructors in the district have finished the instrument.

To proceed, just go to the link listed below, read the instructions and respond to each item.

For the code, please insert the following number: 235

The link to the study is: http://www.ucmo.edu/surveys/?formID=1611

If you have any questions or comments after completing the instrument, please send those to me by email as soon as possible.

Thanks, in advance, for your help and I will see you at the conference.
Jason A. Scales
Assistant Professor Agriculture Education & Mechanization
University of Central Missouri
Grinstead 126
Warrensburg, MO 64093
660-543-4519
jscales@ucmo.edu

APPENDIX E

Panel of Experts

Panel of Experts

Dr. Rob Terry, Jr.
Agricultural Education
University of Missouri – Columbia
127 Gentry Hall
Columbia, Missouri 65211
robterry@missouri.edu

Dr. Brian Garton
Agricultural Education
University of Missouri – Columbia
2 - 64 Agriculture Building
Columbia, Missouri 65211
gartonb@missouri.edu

Dr. Robert Torres
Agricultural Education
University of Missouri – Columbia
126 Gentry Hall
Columbia, Missouri 65211
torresr@missouri.edu

Dr. James Spain
Dairy Nutrition
University of Missouri – Columbia
116 Animal Science Research Center
Columbia, Missouri 65211
spainj@missouri.edu

Dr. Paul Vaughn
Associate Dean & Director Academic Programs
University of Missouri – Columbia
2 – 64 Agriculture Building
Columbia, Missouri 65211
vaughnpr@missouri.edu

APPENDIX F

Follow-up Email to Study Participants

A few weeks ago I sent you an email in regard to a study that I am completing for my dissertation. I would really like to have your input into the incorporation of science Grade Level Expectations within Ag Ed.

This is a very simple and interactive instrument that should only take about 15-20 minutes to complete. When the first instrument has been competed I have a second one that will take no longer then 10 minutes to complete.

To proceed, just go to the link listed below, read the instructions and respond to each item.

For the code, please insert the following number: 303

The link to the study is: http://www.ucmo.edu/surveys/?formID=1611

If you have any questions or comments after completing the instrument, please send those to me by email as soon as possible.

Thanks
Jason A. Scales
Assistant Professor Agriculture Education & Mechanization
University of Central Missouri
Grinstead 126
Warrensburg, MO 64093
660-543-4519
jscales@ucmo.edu

APPENDIX G

Instructional Letter for State Supervisors at the 2007 Summer
Missouri Vocational Agriculture Teachers Association

Thanks for your willingness to help with my dissertation study. The purpose of this message is to provide you with directions for collecting the data at the end of the district instructors meeting Tuesday afternoon.
Directions:

- Pass out the instrument and Scantron to all instructors. Each instrument is labeled with a name and codes for each participant.
- Read the following:
    - Please do not talk while the instrument is being completed.
    - You need only fill in answers to questions on the Scantron. Do not bubble in your name or any other information..
    - PLEASE do not write on the instrument. All answers go on the Scantron form.
    - When you complete the instrument, tear off the name tag and place it in the box. I will take the Scantron form.
    - Please remain in the room for the drawing of the $50 gift card.
- When all instruments are collected, draw a name from the container and award the $50 to that person.

List of participants within your district:

APPENDIX H

Frequency Distribution for Instructors' Perceived
Level of Competence to
Teach Science GLEs

Table 25

Agriculture Instructors Perceived Level of Competence to Teach Science Grade Level Expectations Related to Strand 3 Living Organisms (n = 141)

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Science Grade Level Expectation 3 Living Organisms	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
Reproduction can occur asexually or sexually.					6	2.8	65	30.5	84	39.4
Photosynthesis and cellular respirations are complementary processes necessary to the survival of most organisms on Earth.			1	.5	11	5.2	76	35.7	67	31.5
All living organisms have genetic material (DNA) that carries hereditary information.			5	2.3	6	2.8	77	36.2	67	31.5
Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction.			7	3.3	17	8.0	77	36.2	54	25.4
There is heritable variation within every species of organism.	1	.5	6	2.8	23	10.8	85	39.9	40	18.8
Cells are the fundamental units of structure and function of all living things.	1	.5	7	3.3	21	9.9	89	41.8	38	17.8
The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means.	1	.5	12	5.6	42	19.7	75	35.2	26	12.2

Table 25 Cont.

Agriculture Instructors Perceived Level of Competence to Teach Science Grade Level Expectations Related to Strand 3 Living Organisms (n = 141)

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds.	1	.5	13	6.1	30	14.1	83	39	28	13.1
Biological classifications are based on how organisms are related.	1	.5	11	5.2	35	16.4	82	38.5	27	12.7
Organisms progress through life cycles unique to different types of organisms.	1	.5	14	6.6	28	13.1	90	42.3	23	10.8
The pattern of inheritance for many traits can be predicted by using the principle of Mendelian genetics.	5	2.3	15	7.0	32	15	68	31.9	36	16.9
Protein structure and function are coded by the DNA (Deoxyribonucleic acid) molecule.	3	1.4	15	7.0	41	19.2	74	34.7	22	10.3
Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis).	2	.9	22	10.3	49	23	64	30	18	8.5

Table 26

Agriculture Instructors Perceived Level of Competence to Teach Science Grade Level Expectations Related Strand 4 (n = 141)

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Science Grade Level Expectations Strand 4 Ecology	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
Reproduction is essential to the continuation of every species.			1	.5	18	8.5	76	35.7	60	28.2
Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem.			2	.9	24	11.3	85	39.9	43	20.2
All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.			8	3.8	25	11.7	74	34.7	49	23
All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem.			8	3.8	27	12.7	71	33.3	50	23.5
The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.			10	4.7	27	12.7	69	32.4	50	23.5
Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.			15	7.0	27	12.7	66	31	47	22.1
Matter is recycled through an ecosystem.	1	.5	17	8.0	32	15	72	33.8	34	16

Table 26 Cont.

Agriculture Instructors Perceived Level of Competence to Teach Science Grade Level Expectations Related Strand 4 Ecology (n = 141)

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form that they can use.	1	.5	14	6.6	42	19.7	64	30	35	16.4
Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record.	6	2.8	40	18.8	61	28.6	37	17.4	11	5.2

Table 27

Agriculture Instructors Perceived Level of Competence to Teach Science Grade Level Expectations Related to Strand 7 Scientific Inquiry (n = 141)

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Science Grade Level Expectations Strand 7 Scientific Inquiry	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings).	1	.5	16	7.5	42	19.7	82	38.5	14	6.6
Evidence is used to formulate explanations	1	.5	13	6.1	41	19.2	77	36.2	23	10.8
Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.			10	4.7	60	28.2	67	31.5	18	8.5
Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.			13	6.1	56	26.3	67	31.5	19	8.9
The nature of science relies upon communication of results and justification of explanations.	1	.5	15	7	53	24.9	67	31.5	19.	8.9

APPENDIX J

Selected Science Grade Level Expectations

SCOPE AND SEQUENCE

This is one model of a curriculum scope and sequence. Grade level expectations are clustered into suggested units and arranged to support development of conceptual understanding. School district personnel are encouraged to adapt this model as necessary in order to better meet the needs of their students. The Expectations described in Strand 7: Inquiry and Strand 8: Science/Technology/Human Activity should be made a priority and integrated throughout every teaching unit in each of the other strands. Grade-span assessments will be administered in science at grades 5, 8, and 11 no later than the 2007-2008 school year.

	9, 10, 11
Strand 1 **Matter & Energy**	Atomic Theory and Changes in Matter Energy Forms and Transfer
Strand 2 **Force & Motion**	Interactions between Energy, Force, and Motion
Strand 3 **Living Organisms**	Diversity and Unity Among Organisms Cellular Processes Genetics and Heredity
Strand 4 **Ecology**	Interdependence of Organisms and their Environment Matter and Energy in the Ecosystem Biological Evolution
Strand 5 **Earth Systems**	Components and Structure of Earth's Systems Interactions among Earth's Systems and Processes of Change Effect of Human Activity on Earth's Resources
Strand 6 **Universe**	Objects in the Universe and Their Motion
Strand 7 **Scientific Inquiry**	Inquiry
Strand 8 **Science, Technology, &** **Human Activity**	Science, Technology, and Human Activity

Strand 3: Characteristic and Interactions of Living Organisms

1. There is a fundamental unity underlying the diversity of all living organisms	
Concept	Grades 9, 10, 11
A. Organisms have basic needs for survival	Not assessed at this level
B. Organisms progress through life cycles unique to different types of organisms	*Scope and Sequence – Diversity and Unity Among Organisms* a. Recognize cells both increase in number and differentiate, becoming specialized in structure and function, during and after embryonic development b. Identify factors (e.g., biochemical, temperature) that may affect the differentiation of cells and the development of an organism
C. Cells are the fundamental units of structure and function of all living things	*Scope and Sequence – Diversity and Unity Among Organisms* a. Recognize all organisms are composed of cells, the fundamental units of structure and function b. Describe the structure of cell parts (e.g., cell wall, cell membrane, cytoplasm, nucleus, chloroplast, mitochondrion, ribosomes, vacuole) found in different types of cells (e.g., bacterial, plant, skin, nerve, blood, muscle) and the functions they perform (e.g., structural support, transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal) that are necessary to the survival of the cell and organism
D. Plants and animals have different structures that serve similar functions necessary for the survival of the organism	Not assessed at this level
E. Biological classifications are based on how organisms are related	*Scope and Sequence – Diversity and Unity Among Organisms* a. Explain how similarities used to group taxa might reflect evolutionary relationships (e.g., similarities in DNA and protein structures, internal anatomical features, patterns of development) b. Explain how and why the classification of any taxon might change as more is learned about the organisms assigned to that taxon

Strand 3: Characteristic and Interactions of Living Organisms

2. Living organisms carry out life processes in order to survive	
Concept	Grades 9, 10, 11
A. The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means	*Scope and Sequence – Cellular Processes* a. Compare and contrast the structure and function of mitochondria and chloroplasts b. Compare and contrast the structure and function of cell wall and cell membranes c. Explain physical and chemical interactions that occur between organelles as they carry out life processes
B. Photosynthesis and cellular respiration are complementary processes necessary to the survival of most organisms on Earth	*Scope and Sequence – Cellular Processes* a. Compare and contrast photosynthesis and cellular respiration reactions (Do NOT assess intermediate reactions) b. Explain the interrelationship between the processes of photosynthesis and cellular respiration c. Determine what factors affect the processes of photosynthesis and cellular respiration (i.e., light intensity, availability of reactants, temperature)
C. Complex multicellular organisms have systems that interact to carry out life processes through physical and chemical means	Not assessed at this level
D. Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds	*Scope and Sequence – Cellular Processes* a. Summarize how energy transfer occurs during photosynthesis and cellular respiration (i.e., the storage and release of energy in the bonds of chemical compounds) b. Distinguish among organic compounds (e.g., proteins, nucleic acids, lipids, carbohydrates) in relation to their role in living systems c. Recognize energy is absorbed or released in the breakdown and/or synthesis of organic compounds d. Explain how protein enzymes affect chemical reactions (e.g., the breakdown of food molecules) e. Interpret a data table showing the effects of an enzyme on a biochemical reaction
E. Protein structure and function are coded by the DNA (Deoxyribonucleic acid) molecule	*Scope and Sequence – Cellular Processes* a. Explain how the DNA code determines the sequence of amino acids necessary for protein synthesis b. Recognize the function of protein in cell structure and function (i.e., enzyme action, growth and repair of body parts, regulation of cell division and differentiation)

Strand 3: Characteristic and Interactions of Living Organisms

2. Living organisms carry out life processes in order to survive.

Concept	Grades 9, 10, 11
F. Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis)	*Scope and Sequence – Cellular Processes* a. Explain the significance of semi-permeability to the transport of molecules across cellular membranes b. Predict the movement of molecules needed for a cell to maintain homeostasis, given concentration gradients of different sizes of molecules c. Relate the role of diffusion, osmosis, and active transport to the movement of molecules across semi-permeable membranes d. Explain how water is important to cells (e.g., is a buffer for body temperature, provides soluble environment for chemical reactions, serves as a reactant in chemical reactions, provides hydration that maintains cell turgidity, maintains protein shape)
G. Life processes can be disrupted by disease (intrinsic failures of the organ systems or by infection due to other organisms)	Not assessed at this level

Strand 3: Characteristic and Interactions of Living Organisms

3. There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes	
Concept	Grades 9, 10, 11
A. Reproduction can occur asexually or sexually	*Scope and Sequence – Genetics and Heredity* a. Distinguish between asexual (i.e., binary fission, budding, cloning) and sexual reproduction
B. All living organisms have genetic material (DNA) that carries hereditary information	*Scope and Sequence – Genetics and Heredity* a. Describe the chemical and structural properties of DNA (e.g., DNA is a large polymer formed from linked subunits of four kinds of nitrogen bases; genetic information is encoded in genes based on the sequence of subunits; each DNA molecule in a cell forms a single chromosome) (Assess the concepts – NOT memorization of nitrogen base pairs) b. Recognize that DNA codes for proteins, which are expressed as the heritable characteristics of an organism c. Recognize that degree of relatedness can be determined by comparing DNA sequences d. Explain how an error in the DNA molecule (mutation) can be transferred during replication e. Identify possible external causes (e.g., heat, radiation, certain chemicals) and effects of DNA mutations (e.g., protein defects which affect chemical reactions, structural deformities)
C. Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction	*Scope and Sequence – Genetics and Heredity* a. Recognize the chromosomes of daughter cells, formed through the processes of asexual reproduction and mitosis, the formation of somatic (body) cells in multicellular organisms, are identical to the chromosomes of the parent cell b. Recognize that during meiosis, the formation of sex cells, chromosomes are reduced to half the number present in the parent cell c. Explain how fertilization restores the diploid number of chromosomes d. Identify the implications of human sex chromosomes for sex determination
D. There is heritable variation within every species of organism	*Scope and Sequence – Diversity and Unity Among Organisms* a. Describe the advantages and disadvantages of asexual and sexual reproduction with regard to variation within a population b. Describe how genes can be altered and combined to create genetic variation within a species (e.g., mutation, recombination of genes) c. Recognize that new heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells
E. The pattern of inheritance for many traits can be predicted by using the principles of Mendelian genetics	*Scope and Sequence – Genetics and Heredity* a. Explain how genotypes (heterozygous and homozygous) contribute to phenotypic variation within a species b. Predict the probability of the occurrence of specific traits, including sex-linked traits, in an offspring by using a monohybrid cross c. Explain how sex-linked traits may or may not result in the expression of a genetic disorder (e.g., hemophilia, muscular dystrophy, color blindness) depending on gender

Strand 4: Changes in Ecosystems and Interactions of Organisms with their Environments

1. Organisms are interdependent with one another and their environment	
Concept	Grades 9, 10, 11
A. All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem	*Scope and Sequence – Interdependence of Organisms and their Environment* a. Explain the nature of interactions between organisms in different symbiotic relationships (i.e., mutualism, commensalism, parasitism) b. Explain how cooperative (e.g., symbiosis) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem c. Explain why no two species can occupy the same niche in a community
B. Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite	*Scope and Sequence – Interdependence of Organisms and their Environment* a. Identify and explain the limiting factors that may affect the carrying capacity of a population within an ecosystem b. Predict how populations within an ecosystem change in number and/or structure in response to hypothesized changes in biotic and/or abiotic factors
C. All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem	*Scope and Sequence – Interdependence of Organisms and their Environment* a. Devise a multi-step plan to restore the stability and/or biodiversity of an ecosystem when given a scenario describing the possible adverse effects of human interactions with that ecosystem (e.g., destruction caused by direct harvesting, pollution, atmospheric changes) b. Predict and explain how natural or human caused changes (biological, chemical and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., global wind patterns, water cycle, ocean currents)
D. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes	*Scope and Sequence – Interdependence of Organisms and their Environment* a. Predict the impact (beneficial or harmful) a natural environmental event (e.g., forest fire, flood, volcanic eruption, avalanche) may have on the diversity of different species in an ecosystem b. Describe possible causes of extinction of a population

2. Matter and energy flow through the ecosystem

Concept	Grades 9, 10, 11
A. As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form they can use	*Scope and Sequence – Matter and Energy in the Ecosystem* a. Illustrate and describe the flow of energy within a food web b. Explain why there are generally more producers than consumers in an energy pyramid c. Predict how energy distribution and energy use will be altered due to changes in a food web
B. Matter is recycled through an ecosystem	*Scope and Sequence – Matter and Energy in the Ecosystem* a. Explain the processes involved in the recycling of nitrogen, oxygen, and carbon through an ecosystem b. Explain the importance of the recycling of nitrogen, oxygen, and carbon within an ecosystem

Strand 4: Changes in Ecosystems and Interactions of Organisms with their Environments

3. Genetic variation sorted by the natural selection process explains evidence of biological evolution	
Concept	Grade 9, 10, 11
A. Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record	*Scope and Sequence – Biological Evolution* a. Interpret fossil evidence to explain the relatedness of organisms using the principles of superposition and fossil correlation b. Evaluate the evidence that supports the theory of biological evolution (e.g., fossil records, similarities between DNA and protein structures, similarities between developmental stages of organisms, homologous and vestigial structures)
B. Reproduction is essential to the continuation of every species	*Scope and Sequence – Biological Evolution* a. Define a species in terms of the ability to breed and produce fertile offspring b. Explain the importance of reproduction to the survival of a species (i.e., the failure of a species to reproduce will lead to extinction of that species)
C. Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem	*Scope and Sequence – Biological Evolution* a. Describe how variation in characteristics provides populations an advantage for survival b. Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., long-necked giraffes, long-eared jack rabbits) c. Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance) d. Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection e. Given a scenario describing an environmental change, hypothesize why a given species was unable to survive

Strand 7: Scientific Inquiry

1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking	
Concept	Grades 9, 10, 11
A. Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation	*Scope and Sequence - All Units* a. Formulate testable questions and hypotheses b. Analyzing an experiment, identify the components (i.e., independent variable, dependent variables, control of constants, multiple trials) and explain their importance to the design of a valid experiment c. Design and conduct a valid experiment d. Recognize it is not always possible, for practical or ethical reasons, to control some conditions (e.g., when sampling or testing humans, when observing animal behaviors in nature) e. Acknowledge some scientific explanations (e.g., explanations of astronomical or meteorological phenomena) cannot be tested using the standard experimental "scientific method" due to the limits of the laboratory environment, resources, and/or technologies f. Acknowledge there is no fixed procedure called "the scientific method", but that some investigations involve systematic observations, carefully collected and relevant evidence, logical reasoning, and some imagination in developing hypotheses and other explanations g. Evaluate the design of an experiment and make suggestions for reasonable improvements
B. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations	*Scope and Sequence - All Units* a. Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes, thermometers, analog and digital meters, computers, spring scales, balances, metric rulers, graduated cylinders) b. Measure length to the nearest millimeter, mass to the nearest gram, volume to the nearest milliliter, force (weight) to the nearest Newton, temperature to the nearest degree Celsius, time to the nearest second c. Determine the appropriate tools and techniques to collect, analyze, and interpret data d. Judge whether measurements and computation of quantities are reasonable e. Calculate the range, average/mean, percent, and ratios for sets of data f. Recognize observation is biased by the experiences and knowledge of the observer (e.g., strong beliefs about what should happen in particular circumstances can prevent the detection of other results)
C. Evidence is used to formulate explanations	*Scope and Sequence - All Units* a. Use quantitative and qualitative data as support for reasonable explanations (conclusions) b. Analyze experimental data to determine patterns, relationship, perspectives, and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variable) c. Identify the possible effects of errors in observations, measurements, and calculations, on the validity and reliability of data and resultant explanations (conclusions)
D. Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings)	*Scope and Sequence - All Units* a. Analyze whether evidence (data) and scientific principles support proposed explanations (hypotheses, laws, theories) b. Evaluate the reasonableness of an explanation (conclusion)

Strand 7: Scientific Inquiry

1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking	
Concept	Grades 9, 10, 11
E. The nature of science relies upon communication of results and justification of explanations	*Scope and Sequence - All Units* a. Communicate the procedures and results of investigations and explanations through: ⇛ oral presentations ⇛ drawings and maps ⇛ data tables (allowing for the recording and analysis of data relevant to the experiment such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities) ⇛ graphs (bar, single, and multiple line) ⇛ equations and writings b. Communicate and defend a scientific argument c. Explain the importance of the public presentation of scientific work and supporting evidence to the scientific community (e.g., work and evidence must be critiqued, reviewed, and validated by peers; needed for subsequent investigations by peers; results can influence the decisions regarding future scientific work)

Refer to Missouri Department of Elementary and Secondary Education for materials that articulate standards for data recording and template for experimental design

REFERENCES

American Board for Teacher Certification in Excellence, A Higher Standard (2007). Retrieved August, 6, 2007, from http://www.abcte.org/research.

American Association for Agricultural Education (2001), *National standards for teacher education in agriculture.* Retrieved September 14, 2007, from www.aaaeonline.com.

Ary, D., Jacobs, L. C., & Razavieh, A. (2002). *Introduction to research in education (6th ed.).* Belmont: Wadsworth Group.

Bailey, L. H. (1908). On the training of what it once was, an academic based content persons to teach agriculture in the public schools. U. S. Bureau of Education Bulletin No. 1, Washington, DC: Government Printing Office.

Balschweid, M. A. (2002). Teaching biology using agriculture as the context: Perceptions of high school students. *Journal of Agricultural Education, 43*(2), 56-67.

Balschweid, M. A. & Thompson, (2002). Integrating science in agricultural education: Attitudes of Indiana agricultural science and business teachers. *Journal of Agricultural Education, 43*(2), 1-10.

Belcher, G., McCaslin, N. L., & Headley, W. S. (1996). Implications of performance measures and standards for evaluation and assessment in agricultural education. *Journal of Agricultural Education, 37*(4), 1-7.

Bellah, K. A., Dyer, J. E. & Casey, G. R. (2004) Agricultural education = agricultural literacy. *The Agricultural Education Magazine*, *77(1).*

Brister, M. H., & Swortzel, K. A. (2007) Science integration in secondary agriculture: A review of research. *Proceedings of the 2007AAAE Research Conference, USA, 34,* 229-238.

Boone, H. N. (2002) The current status of preservice agricultural education programs in the United States. *Proceedings of the 2002 AAAE Research Conference, USA, 29.*

Boots, J. (personal communication, November 29, 2007)

Broudy, H. S. (1972). *The Real World of the Public School.* New York: Harcourt Brace Jovanovich..

Carl D. Perkins Act (1998). P. L 109-270, 109th Congress.

Chaisson, T. C. & Burnett, M. F. (2001). The influence of enrollment in agriscience courses on the science achievement of high school students. *Journal of Agricultural Education, 42*(1), 61-71.

Cruickshank, D. R. (1996). *Preparing America's teachers.* Bloomington, IN: Phi Delta Kappa Educational Foundation.

Davis, J. A. (1971). *Elementary survey analysis.* Englewood, NJ: Prentice-Hall.

Dillman, D. A. (2000), *Mail & Internet surveys: The tailored design method* (2nd ed.). John Wiley & Sons, Inc.

Dyer, J. E. & Osborne, E. W. (1999). The influence of science applications in agriculture courses on attitudes of Illinois guidance counselors at model student-teaching centers. *Journal of Agricultural Education, 40*(4), 57-66.

Dormandy, T. J. (1993). Science credentialing and science credit in secondary school agricultural education. *Journal of Agricultural Education, 34*(2), 63-70.

Goecker, A. D. (1992). Priorities for college and university agricultural education faculty. *Journal of Agricultural Education, 33*(3), 2-7.

Harlen, W. & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International Journal of Science Education, 19* (1), 93-105

Hillison, J. (1996). The origins of agriscience: Or where did all that scientific agriculture come from? *Journal of Agricultural Education, 37*(4), 8-13.

Johnson, D. & Newman, M. E. (1993). Perceptions of administrators, guidance counselors, and science teachers concerning pilot agriscience courses. *Journal of Agricultural Education, 34*(2), 46-54.

Missouri Department of Elementary and Secondary Education (1998): *Reinventing agricultural education for the year 2020.* Jefferson City: Missouri Department of Elementary and Secondary Education.

Moore, G. E. (2004). The blind man, the elephant, and agricultural education. *The Agricultural Education Magazine,* 77(1), 4-5.

Moore, G. E. (1987): The status of agriculture prior to the Smith-Hughes Act. *The Agricultural Education Magazine*, *59(8)*

National Council for Agricultural Education. (2000). *The national strategic plan and action agenda for agricultural education: Reinventing agricultural education for the year 2020.* Alexandria, VA.

National FFA Organization. (2005). *2006 – 2010 Agriscience Handbook.* Indianapolis, IN, National FFA Organization

National Research Council. (1988). *Understanding agriculture new directions for education.* Washington DC: National Academy Press.

Newman, M. E. & Johnson, D. (1993). Perceptions of Mississippi secondary agriculture teachers concerning pilot agriscience courses. *Journal of Agricultural Education, 34*(3), 49-58.

Norris, R. J. & Briers, G. E. (1989). Perceptions of secondary agriculture science teachers towards proposed changes in agriculture curricula for Texas. *Journal of Agricultural Education, 39*(2), 8-16.

Osborne, E. W. & Dyer, J. E. (1998). Attitudes of Illinois high school science teachers toward educational programs in agriculture. *Journal of Agricultural Education, 39*(1), 8-16.

Osborne, E. W. & Dyer, J. E. (2000). Attitudes of Illinois students and their parents toward agriculture and agricultural education programs. *Journal of Agricultural Education, 41*(3), 50-59

Phipps, L. J., Osborn, E. W., Dyer, J. E., & Ball, A. (2008). Handbook on agricultural education in public schools (6th ed.). Clifton Park, NY: Thomson Delmar Learning

Rickets, J. C., Duncan, D. W., & Peake, J. B. (2006). Science achievement of high school students in complete programs of agriscience education. *Journal of Agriculture Education, 47*(2), 48-55.

Roberts, T. G. & Dyer, J. E. (2004). Characteristics of effective agriculture teachers. *Journal of Agricultural Education, 45*(4), 82-95.

Small Sample Techniques. *The NEA Research Bulletin*, Vol. 38 (December, 1960), p. 99.

Smith-Hughes Act (1917). P. L. 347, 64th Congress, Section 18, 39 Stat. 936.

Stephenson, L. G., Wrnick, B. K., & Tarpley, R. S. (2007). Collaboration between science and agriculture teachers. *Proceedings of the 34th Annual National Agricultural Education Research Meeting.* Minneapolis, MN. 247-263.

Team AgEd. (2007). Unmistakable potential: 2005 - 2006 Annual report on agricultural education. Retrieved November 15, 2006 from the World Wide Web: http://www.teamaged.org/webAR.pdf.

Terry,Jr., R. (2004). Questioning our purpose. *The Agricultural Education Magazine*, *77(1).*

Thompson, G. W. (2001). Perceptions of Oregon secondary principals regarding integrating science into agricultural science and technology programs. *Journal of Agricultural Education, 42*(1), 49-59.

Thompson, G. W. & Balschweid, M. A. (1999). Attitudes of Oregon agricultural science and technology teachers towards integrating science. *Journal of Agricultural Education, 40*(3), 21-29.

Torres, R. M. (2004). *Agricultural education 410 handouts: Data collection and analysis*: Columbia, MO: University of Missouri.

True, A. C., (1969). *American education its men, ideas, and institutions.* New York, NY: Arno Press & New York Times.

Warrick, B. & Straquadine, G. S. (1998). Measuring the impact of agricultural applications in the teaching of biology on student achievement as measured by a state biological science competency test. *Proceedings of the 25th Annual National Agricultural Education Research Meeting.* New Orleans, LA. 208-220.

Warnick, B. K., Thompson, G. W. (2002). Perceptions of Oregon science teachers regarding the integration of science into the agricultural education curriculum. *Proceedings of the 29th Annual National Agricultural Education Research Meeting.* Las Vegas, NV.

Warnick, B. K., Thompson, G. W. & Gummer, E. S. (2004). Perceptions of science teachers regarding the integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 45*(1), 62-72

Whent, L. S., & Leising, J. (1998). *A descriptive study of the basic core curriculum for agriculture students in California.* Paper presented at the 66th Annual Western Region Agriculture Education Research Seminar, Fort Collins, CO.

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