THE LEVEL PRE-SERVICE TEACHERS PLAN TO INTEGRATE STEM INTO THEIR AGRICULTURAL EDUCATION LESSONS

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"A dream doesn't become reality through magic; it takes sweat, determination and hard work."

Colin Powell

These words have never been truer than when pursuing a doctoral degree. My path to receiving my doctoral degree has been long and filled with hard work from more than just myself. However, "I can do all things through Him who strengthens me" (Philippians 4:13). Ultimately, I thank God for His ability to ensure relationships were present to assist me in completion of my degree. He provided all the individuals for which I am thankful.

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I respectfully bow to all who have assisted me in my pursuit of a doctoral degree and humbly exit this stage in my life to pursue further goals.

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Abstract: Science, technology, engineering, and mathematics (STEM) education has become increasingly important. Ill-prepared secondary graduates, along with increased demand for qualified STEM employees, sparked a plethora of STEM integration research. This study's purpose was to determine the extent pre-service teachers in agricultural education at Oklahoma State University (OSU) plan to integrate STEM during their 12-week student-teaching internship. Further, this study sought to determine if correlations existed between pre-service teachers' science and mathematics aptitudes, creativity, STEM interest and value, and perceived STEM ability. Pre-service teachers' Oklahoma General Education Test (OGET) science and mathematics scores were used to determine their science and mathematics aptitudes. Mahoney's (2009) Student Attitude Toward STEM (SATSTEM) instrument was used to measure STEM interest and value along with their perceived STEM ability. Aschenbrener's (2008) Creative and Effective Teaching Assessment (CETA) was used to determine self-perceived creativity. Although the study was predominantly descriptive in nature, the final research question employed multiple correlational using Pearson R^2. Experienced educators in the respective STEM areas were used to evaluate three randomly selected lesson plans from each participant for their STEM content. Another group of experienced educators evaluated lesson plan quality. The study's findings revealed that pre-service teachers had slightly favorable attitudes, interests, value, and perceived ability regarding STEM. Of the four content areas, science and mathematics were integrated into lesson plans most frequently. Lesson plan quality hindered STEM content identification due to a mean score of 13.22 out of a possible 20. In addition, there was a statistically significant relationship between variables such as science and mathematics aptitudes; STEM value and interest; STEM attitude with interest, value, and perceived ability; and creativity with STEM interest and attitude. It was recommended that the agricultural education teacher preparation unit at Oklahoma State University continue to emphasize the integration of STEM into school-based agricultural education courses. Further, research is needed to fully understand the relationships between pre-service teachers' STEM abilities, attitudes, and creativity.

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CHAPTER I

INTRODUCTION

Concern has increased steadily regarding the preparation of students, teachers, and practitioners in science, technology, engineering, and mathematics (STEM) in the United States (Kuenzi, Matthews, & Mangan, 2006). The concern is due to an escalating number of students who are failing to reach basic levels of proficiency in mathematics and science (Adelman, 1996; American College Testing [ACT], 2005; Cavanagh, 2004; Wilmer, 2008).

Per the 2017 ACT report on the condition of college and career readiness, 48 percent of graduates in 2017 had an interest in pursuing a STEM major or occupation; however, only 21 percent met the STEM benchmark (The Condition of College & Career Readiness 2017, 2017). What is more, only 42 percent of high school graduates command the academic skills necessary to begin college (Hornstein, 2004; Wilmer, 2008). “Fewer than three in 10 ACT-tested 2017 graduates were likely, based on their ACT Composite score, to attain an ACT WorkKeys® National Career Readiness Certificate® (NCRC®) at the Gold level (ACT Composite Score of 25 or higher) or higher” (The Condition of College & Career Readiness 2017, 2017, p. 3). ACT Research has identified grade point average (GPA) and ACT scores as substantial forecasters of success in STEM majors (Hayes, 2017).

While most, if not all, K-12 STEM programs give at least some attention to quality of

> instruction, current student achievement levels show students are still not adequately prepared by current programs, and more needs to be done to ensure high school students in the STEM pipeline are ready for the postsecondary courses necessary to join the STEM workforce. (Hayes, 2017, p. 2)

The reasons for students' poor performance in these areas are numerous. However, part of the problem points to the fact that educators who teach these students lack the neceassary STEM subject matter knowledge themselves (Hayes, 2017; Kuenzi et al., 2006). Based on this concern, the 109th Congress introduced several legislative acts, such as the National Aeronautics and Space Administration Authorization Act of 2005, the National Defense Authorization Act of 2006, the No Child Left Behind Act of 2001, the Carl D. Perkins Vocational and Technical Education Act of 2006, the Defense Act of 2005, the Deficit Reduction Act of 2005, and Protecting America's Competitive Edge Through Energy Act of 2006 to address teacher quality of American school systems by improving their STEM competencies (Apple, 2006; Baker, 2013; Haynes, 2011; Martin, Fritzsche, & Ball, 2006; & Kuenzi et al., 2006). Various science and business communities provided valuable input to each of these legislative acts to increase capacity in the STEM educational pipeline (Kuenzi et al., 2006).

Investing in improving teachers' abilities to teach STEM is a better alternative than remediating students in those subject areas. Locating resources necessary to retain, reteach, and retool students for post-secondary education and the workforce costs in excess of $1 billion annually (Bettinger & Long, 2004, 2005; Breneman & Haarlow, 1998; Merisotis & Phipps, 2000). In their 1996 study, the National Center for Educational Statistics (NCES) reported 100 percent of public two-year postsecondary institutions offered remedial coursework. The percentage decreased to 81 percent when two- and four-year postsecondary institutions with freshmen were combined. Other statistics revealed 41 percent of freshmen at two-year colleges and 22 percent at four-year institutions were enrolled in remedial courses as of 1995 (NCES, 1997; Stephens, 2001). Aside from the enormous financial burden of remediating students, other factors such as lowering standards, are just as costly (Stephens, 2001). Students substantially increase their potential of failing to meet academic goals when remediation of more than writing or intermediate algebra is needed (Wilmer, 2008).

The mission of America's educational system is to meet the demand for a knowledge-based economy (Interstate New Teacher Assessment and Support Consortium [INTASC], 1992; Ricketts, Duncan, & Peake, 2006; & Young, 2006) by improving students' college and work preparedness (ACT, 2005). Rather than merely providing educational opportunities, schools and their educators "are expected to ensure that all students learn and perform at high levels" (INTASC, 1992, p. 5). To do so, educators should learn the knowledge and skills necessary for providing student-centered instruction effectively (INTASC, 1992, Kress, McClanahan, & Zaniewski, 2008).

Agricultural education is not exempt from this expectation. In fact, agricultural education aims to simultaneously prepare students for post-secondary education and the workforce (Roberts & Ball, 2009; U.S. Congress, 1998; U.S. Department of Education, 2001). This focus is based on a renewed vision of the purpose of agricultural education. In 1996, the National Council for Agricultural Education (NCAE) (2000) published the *Reinventing Agricultural Education for the Year 2020* (RAE 2020). This new vision for agricultural education outlined a variety of goals and objectives, which included educator collaboration, cross-curricular course development, and relevant and integrated instructional approaches, among others (NCAE, 2000). Agricultural literacy, teacher supply, lifelong learning, and partnerships were recognized later as resulting areas of emphasis from RAE 2020 in the agricultural education profession (Conroy & Kelsey, 2000). Stubbs and Myers (2015) called for agricultural education to create a 21st century workforce but recognized difficulty in increasing the integration of STEM into agricultural curricula due to a research gap. Identifying and equipping pre-service teachers to implement the teaching methods necessary for integrating STEM into agricultural education (i.e., AG-STEM) curricula is of paramount interest (Myers & Dyer, 2004).

Stubbs and Myers (2015) encouraged preservice teachers to "practice developing and delivering highly integrated AG-STEM lessons using a diversity of teaching methods" (p. 200). Incorporating AG-STEM curricula to solve real-world problems allows contextual connections for students, specifically, and improves their perceptions of STEM, generally (Reyes, Brackett, Rivers, White, & Salovey, 2012; Stubbs & Myers, 2015). Agricultural learning environments which highlight STEM may be created due to the alignment of contextual and experiential agricultural methods with research-based STEM education methods (Ejiwal, 2012; National Research Council, 2009; Stubbs & Myers, 2015).

The integration of STEM principles, particularly science, into agricultural curriculum is not new (Balschweid, 2002; National Academy of Sciences, Committee on Agricultural Education in the Secondary Schools, 1988; National Commission on Excellence in Education, 1983; Secretary's Commission on Achieving Necessary Skills, 1991). Research has confirmed that students taught by merging scientific and agricultural principles demonstrate a higher level of achievement than those who are taught with traditional methods (Balschweid, 2002; Enderlin & Osborne, 1992; Enderlin, Petrea, & Osborne, 1993; Roegge & Russel, 1990; Parr, Edwards, & Leising, 2006; Stripling & Roberts, 2012; Whent & Leising, 1988; Young, Edwards, & Leising, 2009).

Agricultural education has long embraced Dewey's (1938) philosophy regarding learning by doing (Phipps & Osborne, 1988; Roberts, 2006; Stimson, 1919). Dewey's philosophy of contextualized learning is reflected in agricultural education across both secondary and post-secondary classrooms (McLean & Camp, 2000; Morgan, King, Rudd, & Kaufman, 2013; Roberts, 2006; Simon, Haygood, Akers, Doerfert, & Davis, 2004). However, "the future of agricultural education in the schools may rest on the need for empirical evidence to verify how agricultural education assists in student development in science and other academic subject areas" (Myers, Washburn, & Dyer, 2004, p. 75). For years, agricultural education teachers across the nation have addressed science integration by offering science credit for agricultural education coursework

(Conners & Elliot, 1995; Dormody, 1993; Enderlin & Osborne, 1992; Myers, Washburn, & Dyer, 2004). Myers et al. (2004) recognized that despite the need for science integration, "the ability of current agricultural educators to meet this challenge has not yet been fully examined" (p. 75).

Agricultural education has progressed to include vocational, technical, and applied science with mathematics education, which relates to both vocational and core education (Conroy, 1999). Further, a key component of STEM education philosophy is connecting content knowledge, STEM knowledge, real-world problems with problem-solving skills to align with agricultural education (Ejiwal, 2012). Ejiwal (2012) promoted hands-on (i.e., inquiry-based) experiences required for solving problems regarding environmental issues. Combining science inquiry and mathematics research within agricultural education has been well documented (Miller & Gliem, 1996; Parr et al., 2006; Stripling & Roberts, 2012; Young et al., 2009). Yet, research is lacking regarding the content areas of technology and engineering (Coppala & Malyn-Smith, 2006). Chronicling and expanding the STEM content that exists within agricultural courses might increase the public's opinion of agriculture (Stubbs & Myers, 2015). Further, teaching STEM in the context of agriculture has the potential to prepare youth for both employment and higher education (Roberts & Ball, 2009), both of which require various cognitive skills (Conroy & Kelsey, 2000).

Numerous research studies have investigated scientific integration training received by agricultural education teachers (Balschweid & Thompson, 1999; Chiasson & Burnett, 2001; Connors & Elliot, 1995; Dyer & Osborne, 1999; Johnson, 1996; Layfield, Minor, & Waldvogel, 2001; Myers, Washburn, & Dyer, 2004; Newman & Johnson, 1993; Peasley & Henderson, 1992; Thompson, 1998; Thompson & Balschweid, 1999; Thompson & Balschweid, 2000; Thompson & Schumacher, 1998; Welton, Harbstreit, & Borchers, 1994). However, the majority of that work has included teachers' attitudes and perceptions toward integrating science. What is needed most are investigations into the ability of agricultural education teachers to integrate and teach science in the agricultural education curriculum effectively (Myers et al., 2004). One way to determine how pre-service teachers in agricultural education integrate science into their teaching is through the investigation of their lesson plans (Wang & Knobloch, 2018).

Preparation through instructional planning forms the basis for effective teaching and student learning (Reiser & Dick, 1996). Sung (1982) supported this assertion by finding that students taught by teachers who used highly structured lesson plans had better academic achievement than those who were taught by teachers who used less structured lesson plans. Lesson planning is a proactive strategy used by teachers to anticipate how topics will be delivered in the learning environment (Bond & Peterson, 2004). The lesson plans allow the instructor additional control of classroom experiences and outcomes instead of merely reacting to what happens (Duke & Madsen, 1991). Thus, it is critical for teacher preparation programs to facilitate pre-service teachers' development in an efficient means for instructional planning (Baylor & Kitsantas, 2005; Kitsantas & Baylor, 2001; Kress, McClanahan, & Zaniewski, 2008).

Spanning the last two decades, research has recognized teacher quality as the most critical variable regarding student success (American Council of Education, 1999; Feistritzer & Haar, 2008; Good, McCaslin, Tsang, Zhang, Wiley, Bozack, & Hester, 2006). Research has revealed educators often teach as they were taught (Murphrey, Miller, & Roberts, 2009; Shulman, 1987). Regarding effective teaching, the American Council of Education (1999) stressed the importance of pedagogical (i.e., teaching) knowledge. Teachers develop their teaching knowledge from four sources which include: content knowledge, knowledge of the materials and settings of the institution, knowledge of the school and nature and purposes of schooling, and the wisdom or knowledge of practice itself (Ball, Knobloch, & Hoop, 2007). Content knowledge is the "understanding, skill, and disposition that are to be learned by school children" (Shulman, 1987, p. 9). Materials and settings of the institution are required to further the goals of organized schooling (Shulman, 1987). Knowledge of the school and nature and purposes of schooling grants educators understanding of teaching, learning, and human development, or in simple terms, educational psychology and pedagogy (Shulman, 1987).

Wisdom or knowledge of practice itself is perhaps the most important, as it is the reflective rationalization for the *what, why*, and *how* questions necessary for educating students (Shulman, 1987). "Therefore, the practice of teaching could be transformed from a craft to a science by examining the pedagogical reasoning of both experienced and inexperienced teachers to codify the wisdom of practice into a scientific knowledge base in teacher education" (Ball et al., 2007, p. 56).

Content knowledge for agricultural education requires knowledge of STEM areas because agriculture has been referred to as the oldest science in the world (Ricketts, Duncan, & Peake, 2006). In regard to its longevity, the term, *agricultural science*, has been present since the emergence of the Hatch Act (Hillison, 1998a). Connors and Elliot (1995) placed agricultural science parallel to core sciences as an essential component in secondary science education programs. Agricultural education programs facilitate science goals through teaching soils, plants, livestock, genetics, natural resources, and nutrition, to name a few (Chiasson & Burnett, 2001; Moss, 1986). Numerous researchers have determined that students who participate in agricultural education courses score higher in both science (Balschweid, 2002; Chiasson & Burnett, 2001; Connors & Elliot, 1995; Conroy & Walker, 1998; Enderlin & Osborne, 1991; Haynes, Robinson, Edwards, & Key, 2012; Mabie & Baker, 1996; Ricketts et al., 2006) and mathematics (Balschweid, 2002; Enderlin & Osborne, 1992; Enderlin, Petrea, & Osborne, 1993; Parr et al., 2006; Roegge & Russel, 1990; Stripling & Roberts, 2012; Whent & Leising, 1988; Young et al., 2009) assessments when compared to those who do not.

At a minimum, agricultural education as a content area is viewed as an applied science by science teachers, administrators, guidance counselors, and agricultural education teachers when STEM is emphasized (Balschweid & Thompson, 2002; Dyer & Osborne, 1999; Johnson & Newman, 1993; Warnick, Thompson, & Gummer, 2004; Scales, Terry, & Torres, 2009; Shelley-Tolbert, Conroy, & Dailey, 2000). However, not all agricultural educators can integrate STEM components effectively despite their perceived ability to do so (Scales et al., 2009).

The teacher preparation program in agricultural education at Oklahoma State University (OSU) strives to demonstrate STEM and pedagogy throughout its teacher preparation courses. Students in the program are required to plan and facilitate lessons incorporating STEM with appropriate pedagogical methods, as evidenced by the course syllabi in the pre-service courses. Specifically, an objective of AGED 3103 – *Foundations and Philosophies of Teaching Agricultural Education* is: "The integration of STEM components into the lesson planning and delivery process through enriched learning activities" (OSU, 2011a, p. 2). In AGED 4103 – *Methods and Skills of Teaching and Management in Agricultural Education*, students learn about using teaching methods such as inquiry-based teaching and contextualized teaching and learning (OSU, 2012a) as a means for introducing STEM concepts. Further, AGED 4200/5900 – *Student Teaching in Agricultural Education* is a 12-week internship at a site off campus. During this experience, pre-service teachers are required to use a minimum of ten different teaching methods (OSU, 2011b) to highlight their agricultural and STEM content to secondary students.

Unfortunately, teachers in the United States have a weaker grasp of teaching basic concepts, such as STEM, when compared to other educators across the world (Akiba, LeTendre, & Scribner, 2007). Regarding agricultural education, those with formal educational preparation have the most difficult time integrating STEM in their lessons when compared to students from informal or nonformal preparation programs (Wang & Knobloch, 2018). Therefore, if the teacher preparation program in agricultural education at OSU is to produce effective STEM integrating teachers, students must either enter the program with an appreciation for STEM content knowledge or express a willingness to develop those areas of expertise (Roberts & Dyer, 2004).

Robinson, Kelsey, and Terry (2013) studied the philosophy of pre-service agricultural teachers in a junior-level teacher preparation course at OSU. Pre-service teachers were asked to draw an effective agricultural education teacher at work in the 21st century. Students provided drawings at three points throughout the semester – at the beginning (week one), middle (week eight), and end (week 16) of the 16-week semester. It was concluded pre-service teachers entered the program with a minimal comprehension and appreciation of effective agricultural education teacher roles for the 21st Century, especially in regard to teaching STEM (Robinson et al., 2013). Drawings in week one consisted largely of images that included teacher-centered learning environments and demonstrations involving livestock exhibitions. However, drawings during the middle of the semester gave hope to students' acceptance of STEM principles, as they included images such as Bunsen burners, mathematical symbols, and gears and pulleys. Unfortunately, the images did not persist. At the end of the semester (week 16), students digressed in their perceptions, as their drawings were more similar to week one than week eight (Robinson et al., 2013). The setback is potentially attributed to differing views from guest speakers and lack of STEM and pedagogical instruction in the second one-half of the course (Robinson et al., 2013). However, perhaps the problem is larger and more substantial, similar to the problem identified by Kotrlik, Redmann, and Douglass (2003) regarding teachers' integration of technology. In their study, they suggested teachers perceived various barriers to integrating technology (Kotrlik et al., 2003), one of which involved their ability to plan for the use of technology. Murphrey et al. (2009) also highlighted the need for teachers to be able to plan for the integration of technology in their lessons and course delivery. Integrating technology into the educational process is required for quality education (Kotrlik et al., 2003) just as it is with all the STEM areas.

After completing the methods and instructional course requirements, pre-service teachers typically culminate their learning experience through the student teaching internship, which vitally links the university experience and the secondary classroom (Edgar, Roberts, & Murphy, 2009; Edwards & Briers, 2001; Harlin, Edwards, & Briers, 2002; Nekolny & Buttles, 2007; Robinson, Krysher, Haynes, & Edwards, 2010; Torres & Ulmer, 2007). Pre-service teachers at OSU are no different. The valuable real-life experience of the student teaching internship provides a safe space to implement pedagogical knowledge and skills under a cooperating (mentor) teacher's direct guidance

(Roberts & Ball, 2009; Robinson et al., 2010; Swanson, 1971; Talbert, Vaughn, & Croom, 2005; Torres & Ulmer, 2007). Although pre-service teachers spend most of their time planning, they do so at an inconsistent rate (Torres & Ulmer, 2007; Torres, Ulmer, & Aschenbrener, 2008), which may be a result of them becoming more efficient planners (Torres & Ulmer, 2007; Torres, Ulmer, & Aschenbrener, 2008). Regardless, a teacher's knowledge and experience with the content can have a direct impact on his or her planning, which ultimately affects what is taught in the classroom (Ball et al., 2007; Torres & Ulmer, 2007). Therefore, what impact does the pre-service teachers' preparation program in agricultural education at OSU have on their interest in, attitude for, and ability to include STEM competencies into their lesson plans during their 12-week student teaching internship?

Problem Statement

Through the ages of American society, patrons have been able to reach success by climbing the ladder of education. America's education system has been the reason for success in a global economy. The President's Council of Advisors on Science and Technology (PCAST) (2010) contended that in the 21st century, the United States will continue to depend on ideas and skills of its population to remain a successful, competitive, and viable country. As technology advances, importance grows in maintaining an educational system that is effective in facilitating learning in STEM (Lynch, 2000; PCAST, 2010; Prensky, 2001a; 2001b).

In 2007, the U.S. Bureau of Labor Statistics (BLS) projected a 22% growth of STEM occupations by 2014. Terrell (2007) defined technical occupations as being related to STEM and using science and mathematics to solve problems. Unfortunately, research from the NCES (2000; 2009) reported issues of twelfth graders performing poorly in mathematics and science, which are basic components of STEM. In 2000, only seventeen percent of twelfth graders performed at a level of proficient or above in mathematics with a five percent decrease in students performing at a basic level between 1996 and 2000 (NCES, 2000). The percentage of students taking higher-level mathematics courses has increased almost fifteen percent in the last two decades, but no statistically significant differences have been detected in student performance (NCES, 2009). To address the issue, PCAST (2010) called for the following five overarching priorities:

> (1) Improve Federal coordination and leadership on STEM education; (2) support the state-led movement to ensure that the Nation adopts a common baseline for what students learn in STEM; (3) cultivate, recruit, and reward STEM teachers that prepare and inspire students; (4) create STEM-related experiences that excite and interest students of all backgrounds; and (5) support states and school districts in their efforts to transform schools into vibrant STEM learning environments. (p. iii)

Other reports such as the National Academies' Rising Above the Gathering Storm outlines several obstacles in preserving the United States' role in global innovation (Kress et al., 2008; Locklear, 2013; The National Academies, 2005). Among these obstacles included, "needed improvements in science education, teacher training, and curriculum" (Kress et al., 2008, p. 3). To assist in accomplishing this task, The National Academies (2005) recommended, "recruitment of 10,000 new science and math teachers each year" (p. 9) with a five-year teaching commitment and funded training for current teachers and increased funding for STEM research.

Agricultural education has been identified as a context in which STEM components can be taught (Balschweid, 2002; Conners & Elliot, 1995; Dormody, 1993; Enderlin & Osborne, 1992; Enderlin, Petrea, & Osborne, 1993; Haynes et al., 2012; Parr et al., 2006; Roberts & Ball, 2009; Roegge & Russel, 1990; Stripling & Roberts, 2012; Whent & Leising, 1988; Young et al., 2009; Myers et al., 2004). However, there is little evidence for how teachers in agricultural education plan to incorporate STEM content purposefully into agricultural education lessons. Thus, there is uncertainty surrounding the ability and willingness of pre-service teachers in agricultural education to integrate STEM into their classrooms during their 12-week student teaching internship.

Purpose of the Study

The purpose of this study was to determine the extent to which pre-service teachers in agricultural education at OSU planned to incorporate STEM content into their agricultural education lessons during the 12-week student teaching internship. This study also sought to determine the correlation between pre-service teachers' science and mathematics aptitudes, self-perceived instructional creativity, and STEM attitude (including STEM interest, value, and self-perceived STEM ability).

Research Questions

The following research questions guided this study.

1. What are the personal and professional characteristics of pre-service agricultural teachers in agricultural education during the Fall 2011 and Spring 2012 semesters?
2. What are pre-service agricultural teachers' self-perceived instructional creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability) and science and mathematics aptitudes?
3. What percentage of pre-service agricultural teachers' lesson plans contained STEM concepts during the 12-week student teaching internship?
4. What quality level are pre-service agricultural teachers' lesson plans per the departmental lesson plan rubric?
5. What aspects of STEM do pre-service agricultural teachers plan to teach most frequently?
6. What grade level of STEM standards do pre-service agricultural teachers plan to integrate into their lesson plans?

7. What is the relationship between pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., STEM interest, value, and self-perceived STEM ability)?

Assumptions

The following assumptions were made pertaining to this study:

1. Pre-service teachers involved in the study intended to create detailed lesson plans per their course requirements as pre-service teachers.
2. Pre-service teachers reported their STEM attitude accurately and to the best of their ability.
3. Pre-service teachers' intentions to integrate STEM were assumed per the instruction received throughout the pre-service education program.
4. Pre-service teachers taught the STEM competencies that they included in their lesson plans.

Limitations of the Study

The following limitations guided the study:

1. The participants were selected purposively as those enrolled in AGED 4200 – *Student Teaching in Agricultural Education* during the Fall 2010 and Spring 2011 semesters in Oklahoma State University (OSU). This population of interest is a purposive group and limits the generalizability of the findings.
2. The details in the lesson plans received from pre-service teachers are limited to the amount of detail each participant elected to place in the lesson plan. Thus, consistency of the lesson plan detail is a limitation. Limited detail in lessons

prevented accurate determination of all potentially intended STEM concepts planned for integration.

3. The number of lesson plans submitted by participants was a limitation of the study. Each cooperating center contained a different experience, such as bell schedules, number of agricultural courses offered, and number of course taught by the pre-service teacher. No triangulation was conducted to determine the total number of lesson plans created by the participant. Thus, the number of Lesson plans submitted by each participant is a limitation of the study.
4. Pre-service teachers' intentions to integrate STEM were assumed from the instruction they received throughout their pre-service education program.

Relevant Definitions

The following are definitions relevant to this study:

1. **Ability**: Competence in mastery, understand, or knowledge toward completing a task (Nicholls, 1984).
2. **Agricultural Education**: Standardized secondary instruction regarding agriculture, food, and natural resource content intended to increase agricultural literacy while preparing students for employment and postsecondary education (Blackburn, 2013; Phipps, Osborne, Dyer, & Ball, 2008; Shinn, 1997).
3. **Agricultural Educator (agriculture teacher/agricultural education teacher)**: an individual actively engaged in planned instruction, appropriate experiences, and proper assessment toward advancing secondary agricultural education program student knowledge and skills in the agricultural fields (Franklin & Molina, 2012; McLean & Camp, 2000; Myers & Dyer, 2004; Retallick & Miller, 2007, 2010; Shinn, 1997).

4. **Attitude**: “[A] learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object” (Fishbein & Ajzen, 1975, p. 6).
5. A**wareness**: Consciousness of knowledge or an innovation (Mahoney, 2009).
6. **Behavioral belief (hypothesis of distribution of reinforcement)**: “[A] person’s subjective probability that performing a certain behavior will produce a particular outcome, and the subjective value of the reinforcer is designated the person’s evaluation of that outcome” (Ajzen, 2012, p. 440).
7. C**ommitment**: An acceptance of an innovation past mere exposure and a desire to gain more from said innovation (Mahoney, 2009).
8. **Cooperating Teacher**: An agriculture teacher which supervises the pre-service teacher during the student teaching internship in partnership with the teacher educator program (Franklin & Molina, 2012; Harlin, Edwards, & Briers, 2002; McLean & Camp, 2000; Myers & Dyer, 2004; Retallick & Miller, 2007, 2010).
9. C**reativity**: “[T]he process of sensing gaps and discerning missing elements; forming new hypotheses and communicating the results; and possibly modifying and retesting the hypothesis” (Torrance, 1962, p. 141).
10. **Intelligence**: The ability to adapt to one’s environment (“Intelligence and Its Measurement,” 1921; Sternberg & Detterman, 1986; Sternberg, 1985, 2001; Sternberg, Conway, Ketron & Berstein, 1981).
11. N**ormative belief (behavioral hypothesis)**: “[A] person’s subjective probability that a particular normative referent … wants the person to perform a given behavior” (Ajzen, 2012, p. 441).
12. **Pre-service teacher (student teacher)**: “[A] college student who is working under the guidance of a certified teacher in an approved setting. A student teacher, while serving a non-salaried internship under the supervision of a certified teacher, shall be according the same protection under the law as that accorded the certified teacher.

The student teacher should not be assigned in any situation where he/she is to be a replacement for a qualified teacher" (Oklahoma State University, 2012b, p. 1).

13. **Self-efficacy**: "[A] teacher's expectation that he or she will be able to bring about student learning" (Ross & Bruce, 2007, p. 50).
14. S**TEM**: "[A]n initiative for securing America's leadership in science, technology, engineering and mathematics fields and identifying promising strategies for strengthening the educational pipeline that leads to STEM careers" (Alliance for Education, 2011, paragraph 1) (as cited by Mahoney, 2009).
15. **Student Teaching Internship (student teaching)**: "[A] period of guided teaching during which the student, under the direction of a cooperating teacher, takes increasing responsibility for leading the school experiences of a given group of learners over an extended prior of time and engages directly in many of the activities which constitute the wide range of a teacher's responsibilities" (Oklahoma State University, 2012b, p. 1).
16. V**alue**: The relative worth or importance of an innovation to an individual (Mahoney, 2009).

CHAPTER II

REVIE OF LITERATURE

Introduction

This chapter presents a detailed review of literature related to this study. The purpose of this review is to highlight the current literature that has impacted STEM education in the United States. An examination of the history of STEM in the U.S. will provide the launching point for the literature review. Then, legislation addressing STEM integration will lead us to STEM in the context of Agricultural Education. Following Agricultural Education STEM will be agricultural teacher preparation programs and teacher creativity. Lastly, the lens (the Theory of Planned Behavior) of this study will be addressed in the theoretical framework.

The History of STEM in the United States

K-12 STEM education has had a precarious history containing its share of both failure and success (Chedid, 2005) in regard to STEM education. STEM content areas did not gain much momentum until October 4, 1957, the year Sputnick I was launched by the Soviet Union (Scott, 2009). During 1963 to 1972, the space race consumed 27% of federal expenditures (Guston & Keniston, 1994). Sputnick I's and II's launch represented failure and humiliation regarding the United States' advancement in technological endeavors (Hackler, 2011; Murray & Bly Cox, 1989). In retaliation, the United States summoned the brightest minds to lead the way in space exploration, along with new political, military, and scientific ideas (National Aerospace Science Administration, 2007).

Legislation emphasizing STEM areas started with the passing of the *National Defense Education Act* (NDEA) on September 2, 1958 and targeted increasing the number of undergraduates in STEM fields in the United States (Flattau, Bracken, Van Atta, Bandeh-Ahmadi, De La Cruz, & Sullivan, 2005; Klein, 2003). This legislation pursued opportunities for teacher and researcher collaboration to compete with the Soviet Union (Jolly, 2009) and provided supplemental funding for programs promoted by the National Science Foundation (NSF) and National Institutes of Health (NIH) (Flattau et al., 2005). The NDEA contained ten overarching titles. Title I addressed general provisions. Title II provided for loans to students in institutions of higher education. Title III financed assistance for strengthening science, mathematics, and modern foreign language instruction. Title IV implemented national defense fellowships. Title V allocated guidance, counseling, testing, identification and encouragement of able students. Title VI outlined language development. Title VII devised research and experimentation in more effective utilization of television, radio, motion pictures, and related media for educational purposes. Title VIII emphasized area vocational education programs. Title IX organized science information services. Title X addressed miscellaneous provisions. Titles III and VIII were the most important for secondary education. Title III was directed toward improving science and mathematics education in secondary education, and Title VIII functioned to distribute funding for science and technology technical training (Hackler, 2011).

Science, Technology, Engineering, and Mathematics (STEM) Defined

The acronym STEM represents specific academic subject headings as follows: science, technology, engineering, and mathematics. The term STEM serves primarily as a tool to lessen the time and space designated to speaking and writing those individual subjects represented due to their increased importance over the past twenty years. Increasing popularity within educational organizations and industries has permitted the creation of logical definitions from a simple acronym to more definitive ones. The National High School Alliance (NHSA) (2008) defined STEM as an “integrative approach to teaching and learning that draws on the foundations of each individual field to form a cohesive course of instruction” (STEM/Index) (as cited by Mahoney, 2009, p. 17). The Alliance for Education (2011), as cited by Mahoney (2009) offered their own definition: “STEM is an Initiative for securing America’s leadership in science, technology, engineering and mathematics fields and identifying promising strategies for strengthening the educational pipeline that leads to STEM careers” (para.1). STEM is a meta-discipline, that is transdisciplinary with greater complexities and new spheres of understanding that ensure the integration of disciplines (Kaufman, Moss, & Osborn, 2003; Morrison, 2006).

Through all the numerous definitions, Scott (2009) recognized four categories in the literature describing STEM education. The first category emphasized the importance of “integrating science and mathematics content while implementing technology into the curricula” (p. 15), which mirrors definitions in the previous paragraph. The second category included “blending academic coursework with career-technical education (CTE)” (p. 15). The third category focused on “applying concepts and ideas from STEM courses into other disciplines such as Language Arts and Social Studies” (p. 15), and the fourth category outlined STEM education as a “well-rounded education with outstanding science and mathematics instruction with technology integrated across the curriculum” (p. 15).

Categories one and two involve the integration of STEM concepts into general and CTE curriculum. However, this initiative is not without reservation. Czernik, Weber, Sandmann, and Ahern (1999) indicated, “few empirical studies exist to support the notion that an integrated curriculum is any better than a well-designed traditional curriculum” (p. 1). These categories were directed toward improving students’ opportunities for college. Stern and Stearns (2006) recognized students in a blended STEM and CTE program perform better in high school but protested there was no evidence showing improvement in college enrollment or completion resulting from a blended curriculum.

Scott (2009) formulated category three from the Ohio Department of Education (ODE) and category four from the Texas initiative, which is called T-STEM. The ODE defined STEM as a movement intended to foster problem solving, innovation, logical thinking and strong communication skills of K-16 students by applying STEM, Language Arts, and Social Studies concepts (Ohio STEM Learning Network, 2007). Texas's initiative defined STEM education as building rigorous well-rounded educational programs and schools, cultivating a personalized and work-ready culture and procuring teacher and leadership development (Texas Education Agency, 2007).

Despite the various STEM definitions, teachers generally have positive perceptions and agreement about the need to integrate STEM concepts into their curricula (Lehman, 1994). However, teachers are limited in the time needed to adequately incorporate STEM concepts into an already overcrowded curriculum (Lehman, 1994). Postsecondary institutions are challenged to prepare pre-service teachers and provide in-service on STEM education, and they should blend STEM knowledge, pedagogical methods, and effective practices into pre-service and in-service programs (Scott, 2009). Unfortunately, content knowledgeable STEM professors lack the pedagogical preparation necessary for modeling STEM teaching to future K-12 educators in a usable format (Chedid, 2005).

The National Science Foundation (NSF) has been a leader in STEM education for numerous years. Some of their successful programs include Mathematics and Science Partnership (MSP), which improved student proficiency in K-12 mathematics and science over a three-year period (NSF, 2007). Another program, the Computational Math, Science and

Technology Institute (CMST), built partnerships between K-12 education and post-secondary education (Yasar, Little, Tuzan, Rajasethupathy, Maliekal, & Tahar, 2006). CMST trained in excess of 265 teachers through summer workshops and bimonthly meetings along with providing them with technologies such as laptops and Interactive White Boards (IWBs). A positive correlation existed between the educators with CMST training and their students' achievement (Yasar et al., 2006).

The Bayer Corporation (2006) evaluated successful informal summer and after-school programs for K-12 STEM education under its Making Science Make Sense® (MSMS) program. All MSMS programs were evaluated on the following criteria: challenging content/curriculum, an inquiry learning environment, defined outcomes/assessment, and sustained commitment with community support (The Bayer Corporation, 2006). MSMS identified in excess of 30 different successful programs in its 2010 report. Some of the programs included in the MSMS report were American Chemical Society's Project Seed, EQUALS, Kinetic City, Science in Motion, and Techbridge, to name a few. Several of the programs, depending on their specific goals, resulted in increased STEM content knowledge and interest, pursuit of STEM degrees, and student achievement in K-12 STEM content (The Bayer Corporation, 2010).

Educational Legislation

A Nation at Risk

In 1983, the National Commission on Excellence in Education (NCEE) presented a report known as *A Nation at Risk*. This report inaugurated a rebirth for the STEM movement in education. A slow but steady change in economic stability was manifesting through shifting power from domestic industries to foreign markets. Despite the history of this trend being present for several decades, it was the NCEE that shed light on this matter bringing it to the publics' attention in the report, *A Nation at Risk*. *A Nation at Risk* recommended more rigorous and measurable performance standards, additional time to learn "New Basics," improved teacher preparation, and greater fiscal and leadership support for school systems to increase high school graduation rates (Gardner, 1983).

> The time is long past when America…'s destiny was assured simply by an abundance of natural resources and inexhaustible human enthusiasm, and by our relative isolation from the malignant problems of older civilizations. The world is indeed one global village. We live among determined, well-educated, and strongly motivated competitors. We compete with them for international standing and markets, not only with products but also with the ideas of our laboratories and neighborhood workshops. America's position in the world may once have been reasonably secure with only a few exceptionally well-trained men and women. It is no longer. (NCEE, 1983, p. 10)

The National Research Council

After the 1983 publication focusing on science, the NRC published recommendations focusing on vocational education, and more specifically, agricultural education. In this NRC (1988) report known as *Understanding Agriculture: New Directions for Education*, a committee; the Committee on Agricultural Education in Secondary Schools (CAESS); was requested to suggest recommendations regarding instructional goals in agriculture, subject matter and skills important in curricula for various student groups and "policy changes needed at the local, state, and national levels to facilitate the new and revised agricultural education programs in secondary schools" (p. vi). Once the committee began its work, Congress broadened the study's scope to include the potential for modern communications and computer-based technology in the instruction of secondary agricultural programs (NRC, 1988). The committee conveyed the importance of extending agricultural education beyond the vocational programs and felt agriculture was "too important a topic to be taught only to the relatively small percentage of students considering careers in agriculture and pursuing vocational agriculture studies" (NRC, 1988, p. 1). Thus, the committee created the concept of agricultural literacy.

Under this new concept of agricultural literacy, the NRC reported numerous principle findings, conclusions, and recommendations. Potentially, one of the most substantial findings was the committee's view that vocational agriculture/agricultural education should provide students with the appropriate skills needed to enter and advance in careers ranging from production agriculture to agribusiness and even on to banking, education, agricultural research, and engineering as well as numerous others (NRC, 1988). A key conclusion and recommendation from the committee was developing and broadening the curriculum to include greater awareness and exposure to STEM and careers in STEM (NRC, 1988). The committee iterated the importance of preparing students effectively for post-secondary schools and colleges through offering a full range of academic courses in addition to agricultural sciences (NRC, 1988).

Carl D. Perkins Acts

Following the decade of the 1980's, concern grew over the NCEE report and the NRC report, known to agricultural education as the *Green Book*. Later Carl D. Perkins Acts reflected these reports in advocating for additional curriculum integration and college preparation in CTE courses. Reports and legislation continued to emphasize curriculum integration and the importance of STEM on into the 21st century.

Fellow advocates for STEM integration from a more vocational outlook included John Wirt and Larry Rosenstock. Both Rosenstock (1991) and Wirt (1991) restated that one of the main purposes of the Carl D. Perkins Vocational and Applied Technology Education Act of 1990 was to utilize the context of job skills to integrate academic and vocational training along with motivating students to succeed in academic and vocational courses. Wirt (1991) reported the average high school student took 4.2 credit hours of vocational education, which exceeded the required four credit hours of English. Further, Wirt (1991) recommended an average of 3.2 credits of vocational education for all sophomores who expected to earn a four-year college degree, which reflected over one-half of the six credits taken by those planning to work full-time after high school. Analysis of the data showed all high school students at that time spent a substantial amount of time in vocational education and thus the purpose of vocational education became part of the ongoing nationwide debate about improving education for all students (Wirt, 1991). Rosenstock (1991) identified the first step of integration to be for teachers to work together and see their mission as one, not divided between those who focused primarily on preparing students for work and those who focused primarily on preparing students for college. Rosenstock (1991) envisioned "students learning about the homeless can learn residential construction, and students learning construction can also study homelessness" (p. 435).

The Carl D. Perkins Vocational and Applied Technology Education Amendments of 1998 included a purpose to promote "the development of services and activities that integrate academic, vocational, and technical instruction, and that link secondary and post-secondary education for participating vocational and technical education students" (U.S. Congress, p. 112 STAT. 3077). Each state was required to identify means of evaluating students' accomplishment of rigorous state established academic, and vocational and technical skill proficiencies (U.S. Congress, 1998). To acquire funding from the Carl D. Perkins Act, local plans had to describe the entities' steps to improving:

> the academic and technical skills of students participating in vocational and technical education programs by strengthening the academic, and vocational and technical components of such programs through the integration of academics with vocational and technical education programs through a coherent sequence of courses to ensure learning

in the core academic, and vocational and technical subjects. (U.S. Congress, 1998, p. 112 STAT. 3114)

No Child Left Behind

The No Child Left Behind Act (NCLB) introduced on January 23, 2001 (U.S. Department of Education, 2001) reflected educational reform early in the 21st century. NCLB functions on the theories of standards-based education and requires states to assess students' basic skills during certain grades to receive federal funding (U.S. Department of Education, 2001). Yamamoto (2008) outlined accountability, flexibility, validated education results, and school choices for parents as the four main ideas of NCLB. Although STEM is not addressed specifically in NCLB through its current acronym, it is addressed regarding core areas of mathematics and science, along with the integration of educational technologies into classrooms. Further, this legislation has greatly impacted all educators regarding accountability through educational results. Yamamoto (2008) stated, "ninety-five percent of students enrolled in a school must be assessed for academic performance and schools need to ensure that all students achieve or exceed the proficiency level designated by the state" (p. 634).

NCLB resulted in multiple groups researching its intended outcomes. Three different groups compiled three consecutive reports spanning from 2005 to 2007 to improve science and mathematics in schools. The Education Commission of the States (ECS) released the first report in July 2004 recommending five strategies to improve mathematics and science education (Sanders, 2004). The strategies consisted of increasing the difficulty of mathematics and science assessments, increasing additional knowledgeable and skilled educators, assigning the lowest level students to the best educators, and relying on universities holistically for teacher education improvement and public engagement (Coble & Allen, 2005). The second group, the Council of Chief State School Officers, President Valerie Woodruff and the Board of Directors, formed a task force to assess the following. They assessed U.S. students' performance on International examinations, determined secondary education graduates' readiness for college, identified the reason(s) for the decreasing number of advanced degrees awarded in mathematics and science, and determined the number of international students pursuing mathematics and science degrees (Jeffrey & Wright, 2006). The third group, the National Governors Association (NGA), reported in 2007 that they were charged to align state K-12 STEM standards and assessments with postsecondary and workforce expectations in their respective states. Through this charge, states sought to audit and increase internal dexterity to improve teaching and learning, as well as identify and highlight best practices in teaching STEM (NGA, 2007).

STEM in Formal and Informal Agricultural Education

Educator Perceptions of STEM

As legislation called for more academic linkage in vocational education, studies emerged at the turn of the century that collected data on pre-service teachers' attitudes/perceptions about curriculum integration. Further, these studies identified perceived barriers, potential support, effects on student enrollment, and recommendations for teacher education programs. Findings from these studies indicated that perceptions held by agricultural and science educators toward integrating science into the agricultural education curriculum were positive (Balschweid & Thompson, 2002; Balschweid & Thompson, 2000; Myers & Washburn, 2008; Myers, Thoron, &Thompson, 2009; Thompson & Balschweid, 1999; Thoron & Myers, 2010; Thompson & Warnick, 2007; Warnick, Thompson, & Gummer, 2004; Washburn & Myers, 2010).

In several studies, participants consisted of science educators. Warnick et al. (2004) found the highest level of agreement among science educators with a statement recognizing agriculture as an applied science, and slightly more than one-half (54.69%) responded neutrally toward integrating science into agricultural classes' ability to teach problem solving. In another study, Thompson and Warnick (2007) found the highest agreement again with agriculture being an applied science. Thompson and Warnick (2007) also found approximately 54% neutral response toward increasing the ability to teach problem solving by incorporating science into agricultural education courses.

Agricultural educators' perceptions differed from those of science educators in several areas. The predominant area of difference was considering science concepts being easier to comprehend when science is integrated into agricultural education programs (Myers & Washburn, 2008; Myers, Thoron, & Thompson, 2009). Studies also revealed agricultural educators perceived students gained improved agricultural concept knowledge after the integration of science (Balschweid & Thompson, 2002; Myers & Washburn, 2008; Myers et al., 2009). However, unlike the science teachers, 100% of agricultural educators perceived the ability to teach problem solving is greatly increased with the integration of science (Myers et al., 2009). Other studies found strong agreement with having improved ability to teach problem solving through a science enhanced agricultural program (Balschweid & Thompson, 2002; Myers & Washburn, 2008; Thompson & Balschweid, 1999). Agricultural educators perceive additional time for preparation is needed for the integration of science into agricultural programs (Myers & Washburn, 2008; Myers et al., 2009). Washburn and Myers (2010) advocated for developing more intrinsic motivation for educators to integrate science into their curricula rather than forcing them to react to external pressures.

Even with several studies on teacher perceptions, there is limited research on pre-service teachers' perceptions of STEM integration. Balschweid and Thompson (2000) found pre-service teachers believed they would integrate science at a level of 74% before student teaching. After three months of student teaching, pre-service teachers reduced the level of integration to 54% (Balschweid & Thompson, 2000). The reason for the decrease was due to the perceived time necessary to incorporate science adequately and the uncertainty to accurately teach the scientific principles once incorporated (Balschweid & Thompson, 2000). Further, pre-service teachers felt confident they would integrate science into their programs, but it would take about three years before they would be willing to do so (Balschweid & Thompson, 2000). Thoron and Myers (2010) found pre-service teachers perceive students are better prepared in and understand science after participating in a science enhanced agricultural course. Pre-service teachers (58%) had the same thoughts as agricultural educators that students can understand agricultural concepts better after science is integrated into the agricultural program (Thoron & Myers, 2010).

While many were trying to determine how to integrate STEM into the classroom, 4-H developed a science, engineering and technology mission mandate in "response to the national concerns for improving human capacity and workforce ability in the areas of science, engineering, and technology education" (Kress et al., 2008, p. 9). The extension service was formed and charged with disseminating university knowledge and research to local community and youth (Kress et al., 2008; Locklear, 2013). Programs span the following content areas: "communications and technology (83%), food and nutritional science (78%), animal sciences (69%), health sciences (69%), environmental sciences (65%), energy (64%), and geospatial technology (64%)" (Kress et al., 2008, p. 10).

During the time STEM was gaining traction in the literature, 4-H made the decision to focus on its historical strengths (i.e., science, engineering, and technology) and use the term 4-H SET instead of STEM (Locklear, 2013) to indicate Science, Engineering, and Technology. Later in 2003, 4-H and land-grant universities decided to eliminate the perceived restriction of 4-H SET by changing to the name 4-H Science for its 4-H STEM work (Locklear, 2013). Multiple 4-H groups (National 4-H Headquarters, National 4-H Council, Extension Committee on Organization and Policy, and 4-H Task Force) helped create the 4-H Science, Engineering and Technology Work Group in 2003. 4-H created a partnership with the Noyce Foundation in 2006 and solicited donors to support its initiative of expanding SET among 4-H youth (Locklear, 2013; Mielke &

Butler, 2013). The new partnership resulted in the goal to "engage one million new youth in a dynamic process of discovery and exploration in science, engineering and technology to prepare them to meet the challenges of the 21st century" (Locklear, 2013, p. 10). A new team was also developed in 2006 consisting of national, state, and county 4-H faculty and staff called the 4-H SET Leadership Team, which has expanded over the years and was renamed the 4-H Science Management Team (Locklear, 2013).

CASE Curriculum

Efforts to address the agricultural education classroom got serious with the Curriculum for Agriculture Science Education (CASE). The Curriculum for Agriculture Science Education (CASE) was created in 2007 by the National Council for Agricultural Education (NCAE) intended as a national curriculum (Chaplin, 2013; Velez, Lambert, & Elliott, 2015; Witt, 2012). CASE was first used by a teacher in 2009 (Lambert, Velez, & Elliott, 2014). CASE (2012b) reported the curriculum was created in response to the pressure from Perkin's reform, which called for Career and Technology Education (CTE) curriculum integration with science and mathematics through structured course sequences. During its creation, the NCAE outlined eight initiatives based on the long-range goal to increase Agricultural Education growth and program quality (CASE, 2012b), the third of which called "for the creation of a curriculum model to establish a sequence of agricultural education courses that enhances the delivery of agricultural education" (CASE, 2012b, p. 1). The CASE project was intended to furnish an organized progression of courses as well as increase the rigor and relevance envisioned for a new future in agricultural education (CASE, 2012b; Chaplin, 2013).

CASE (2012a) reported the curriculum utilizes "elements from pedagogical approaches that are recognized in educational literature as proven and effective modes of teaching and learning (p. 1)" to ensure validity and effectiveness of the CASE model. The CASE model seeks to equip and train teachers in the areas of curriculum instruction, professional development, assessment and certification, along with accurately accounting for student learning (CASE, 2012b) to improve students' math and science ability through an agricultural context (Chaplin, 2013; Witt, 2012). The CASE curriculum was bolstered by collaboration with Project Lead the Way (PLW) during its creation (CASE, 2012b; Lambert, Velez & Elliott, 2014; Witt, 2012). The national recognition and problem-based investigation PLW brought to the table positioned CASE to be a leader in curriculum development (Lambert, Velez & Elliott, 2014; Witt, 2012). The CASE curriculum aligned the agricultural food and natural resources (AFNR) content standards with those of science, mathematics, and English (CASE, 2012a; Witt, 2012). The NCAE released National AFNR Career Cluster Content Standards, which define proficiency indicators linked to knowledge and skills students should obtain as a result of taking CASE courses (CASE, 2012b; The National Council for Agricultural Education, 2009).

CASE (2012a) outlined two primary works, *How People Learn* (Bransford, Brown, & Cocking, 2000) and *Understanding by Design* (Wiggins & McTighe, 2005), as foundations of the CASE Model. Bransford's, Brown's, and Cocking's (2000) *How People Learn* describes the learning audience as well as epistemological considerations (CASE, 2012a). Wiggins' and McTighe's (2005) *Understanding by Design* contributes the road map utilized in designing instructional lessons (CASE, 2012a). Bransford et al. (2000) explore human thought complexities and forms the learning environment designing standard with specific goals related to the topic of study. These goals were adopted originally by PLW and converted into inquiry-based learning opportunities through activities, projects and problem-based (APPB) modalities (Witt, 2012). Further, these goals represent the concepts/deeper understanding learners need to know about the topic (CASE, 2012a). CASE gathered expert teachers and industry representatives in this first phase to develop and organize the concepts into a logical instructional sequence (CASE, 2012a, 2012b). The second phase of CASE Model development involved the recommended evidence collection for student assessment (CASE, 2012a). CASE then determined the exercise scopes needed for the conceptual demands in the third and final phase (CASE, 2012a), which was utilized to identify appropriate activities, projects, or problems to reach learning goals and adjust content and instructional strategy rigor (CASE, 2012a).

Contextualized Learning

John Dewey stated, “I believe that education which does not occur through forms of life, or that are worth living for their own sake, is always a poor substitute for the genuine reality and tends to cramp and deaden” (1959, p. 23), thus, advocating for the importance of learning content in a familiar context. Shinn et al. (2003) added, “Contextual relationships have the potential to strengthen linkages among the learning environments of school, home and community and add meaning to mathematics for students” (p. 1). Budke (1991) surmised, “agriculture provides a marvelous vehicle for teaching genetics, photosynthesis, nutrition, pollution control, water quality, reproduction, and food processing where real-life examples can become part of the classroom experimentation and observation” (p. 4). Warnick, Thompson, and Gummer (2004) advocated that both academic and vocational groups have requested the integration of agriculture and science.

The CTL teaching method consists of seven elements. The first element is preparing the students to learn (Parr et al., 2006; Young et al., 2009). The second element consists of the teacher presenting the content of the lesson. The third element allows the instructor to teach the agricultural content while highlighting the academic content (i.e., mathematics). An example might be teaching engine rotations per minute (rpm) while highlighting ratios. The fourth element allows the instructor to provide the same content in a similar context (i.e., teach student ratios such as cattle per acre). The fifth element mandates the teacher take students out of their context completely (i.e., teach students ratios in a nonagricultural context, such as people per square foot in a football stadium). The sixth element allows for the instructor to return to the original agricultural content taught (i.e., the rpm of an engine). The seventh and final element includes a lesson closure just as any other lesson requires (Parr et al., 2006; Young et al., 2009).

Other studies also supported the importance of teaching mathematics in the context of agriculture based on both practical and statistically significant findings (Miller & Vogelzang, 1983; Young et al., 2006). Burris, Bednarz, and Fraze (2008) reported a new course in Texas called Agricultural Algebraic Extensive Exploration (A2E2) "is as effective as other forms of math remediation in increasing student achievement in mathematics (p. 138)." Stone, Alfeld, Pearson, Lewis, and Jensen (2007) found enhancing mathematics instruction in CTE classes can improve students' mathematics understanding without any loss of technical or occupational knowledge.

Marzano, Kendall, and Cicchinelli (1999) found mathematics was deemed to be one of the top five necessary subject areas in the school curriculum. However, a study by Robinson (2003) revealed mathematics was rated as America's most valuable subject (Robinson, 2003). Fortunately, mathematics is present in all sectors of the agricultural curriculum and industry. Slusher's, Robinson's, and Edwards's (2010) study revealed that the number one technical skill that animal science industry experts deem most important for high school graduates before entering the animal agricultural industry is basic mathematics. As such, the authors recommended that secondary agricultural education instructors identify ways to highlight and teach mathematics in existing animal science lessons per the animal systems pathway.

Teacher Preparation in Agricultural Education

Colleges and universities have many roles (Franklin & Molina, 2012). Those colleges and universities with agricultural education programs work to prepare agricultural pre-service teachers (Franklin & Molina, 2012, Myers & Dyer, 2004). Despite all these programs typically working toward the same goal of pre-service teacher preparation, each program typically strives to reach said goal in their own unique way (Myers & Dyer, 2004). Thus, each institution requires different admission parameters, courses, and experiences in their teacher education programs in some regards (Franklin & Molina, 2012; Graham & Garton, 2003; Myers & Dyer, 2004; Shinn, 1997; Swortzel, 1999). However, almost all agricultural education programs meet teacher licensure along with state and national teacher education accreditation standards (Myers & Dyer, 2004; Swortzel, 1999; Retallick & Miller, 2007, 2010). Further, the student teaching internship has been incorporated into the accreditation standards (CAEP, 2019; CCSSO, 2013; Retallick & Miller, 2007, 2010).

Council for the Accreditation of Educator Preparation (CAEP)

The Council for the Accreditation of Educator Preparation (CAEP) is the sole accreditation body for teacher certification programs at colleges and universities in the U.S. (CAEP, n.d., *History of CAEP*). CAEP was the result of the National Council for Accreditation of Teacher Education (NCATE) combining with the Teacher Education Accreditation Council (TEAC) in 2010 (CAEP, n.d., *History of CAEP*). CAEP created revised standards for teacher preparation programs featuring two principles:

- Solid evidence that the provider's graduates are competent and caring educators, and
- There must be solid evidence that the provider's educator staff have the capacity to create a culture of evidence and use it to maintain and enhance the quality of the professional programs they offer. (CAEP, n.d., Introduction, para. 1)

There are five standards required by CAEP. These five standards encompass content and pedagogical knowledge; clinical partnerships and practice; candidate quality, recruitment and selectivity; program impact; and provide quality, continuous improvement and capacity. Under standard one, pre-service teacher candidates must "demonstrate an understanding of the 10 InTASC standards" (CAEP, 2019, para. 1). Under standard one, agricultural education programs should ensure pre-service teachers properly use research; apply content and pedagogical knowledge; afford students college and career-ready access; and model and apply technology standards during instruction (CAEP, 2019). Standard two requires shared responsibility between partners during the student teaching internship with emphasis on technology-based collaboration, clear expectation, and theory and practice linkage (CAEP, 2019). Student teaching internships must be with highly qualified educators to ensure enough opportunities for pre-service teachers to demonstrate positive and effective student learning (CAEP, 2019).

CAEP (2019) standard three requires agricultural education programs maintain quality pre-service teachers from admission to certification ranging in background and diverse populations. Quality pre-service teachers include minimum grade point average (GPA) and group average on state- or national-normed mathematic, reading and writing achievement assessment (CAEP, 2019). No pre-service teacher may be recommended for licensure or certification without proper documentation of their ability and understanding of professional expectations, code of ethics, standards of practice, and relevant laws and policies (CAEP, 2019). Standard four progresses the data collection past pre-service teachers' time in the agricultural program to their entrance into the profession. Lastly, standard five requires agricultural education programs maintain quality of data collection, continually evaluate and improve their program (CAEP, 2019).

Interstate Teacher Assessment and Support Consortium (InTASC)

Interstate Teacher Assessment and Support Consortium standards were created by the Council of Chief State School Officers (CCSSO) for the support of ongoing teacher effectiveness regarding student college and career readiness (CCSSO, 2013).

> More importantly, these Model Core Teaching Standards articulate what effective teaching and learning looks like in a transformed public education system – one that empowers every learner to take ownership of their learning, that emphasizes the learning of content and application of knowledge and skill to real world problems, that values the differences each learner brings to the learning experience, and that leverages rapidly changing learning environments by recognizing the possibilities they bring to maximize learning and engage learners. (CCSSO, 2013, p. 3)

InTASC standards are referenced in CAEP accreditation standards and are grouped into four categories for assisting users' reflection upon the standards. These four categories are the learner and learning, content, instructional practice and professional responsibility. Learner and learning include standards one, two and three. Content includes standards four and five, instructional practice includes standards six, seven and eight. Professional responsibility includes standards nine and ten.

The content category maintains the importance of content knowledge and being able to utilize that knowledge to assure student mastery (Cantue, 2015; CCSSO, 2013). Teachers need to be able to utilize multiple means of communication and media, digital or otherwise, to convey content knowledge (Cantue, 2015; CCSSO, 2013). Content knowledge must be relevant and include "cross-disciplinary skills (e.g., critical thinking, problem solving, creativity, communication) (CCSSO, 2013, p. 8)." Standard four assures mastery of content by presenting content knowledge through meaningful experiences (Cantue, 2015; CCSSO, 2013). Standard five engages learners' critical thinking and problem solving by connecting content to local and global issues (Cantue, 2015; CCSSO, 2013). Standard six addresses utilizing multiple assessment methods to engage, monitor, and guide teachers' and learners' decision making (Cantue, 2015; CCSSO, 2013).

Interstate Teacher Assessment and Support Consortium (InTASC) standards align with STEM (Cantue, 2015; Johnson, 2013; Lantz, 2009; Partnership for 21st Century Skills, n.d.; Roberts, 2013; Sanders, 2009; Strimel, 2014; Tsupros, Kohler, & Hallinen, 2008). The alignment between STEM and InTASC standards starts with standard three: Learning Environment (Cantue, 2015; Johnson, 2013; Roberts, 2013). Standard three requires teachers to develop supportive environments for self-motivation, active engagement as well as individual and collaborative learning (CCSSO, 2013). STEM also calls for a collaborative learning environment to foster self-motivation while solving real-world problems (Cantue, 2015; Johnson, 2013; Roberts, 2013). Next, InTASC standards four: learning environments, five: application of content, and six: assessment corresponds to academic rigor as well as fostering creativity, innovation, and problem-solving skills (Cantue, 2015; Lantz, 2009; Strimel, 2014; Tsupros et al., 2008; Partnership for 21st Century Skills, n.d.). Standard seven, planning for instruction, addresses STEM's call for real-world contextual problem-solving (Cantue, 2015; Lantz, 2009; Sanders, 2009; Strimel, 2014; Tsupros et al., 2008; Partnership for 21st Century Skills, n.d.). Lastly, standard eight, instructional strategies, specifically speaks to the integration of STEM disciplines (Cantue, 2015; Lantz, 2009; Sanders, 2009, Strimel, 2014; Tsupros et al., 2008).

Agricultural Education Teacher Preparation

Traditionally agricultural education programs have a focus of preparing pre-service teachers to teach in middle and high schools across the nation (Myers & Dyer, 2004). Most teacher educators are tenured professors with previous secondary agricultural education experience (Myers & Dyer, 2004; Swortzel, 1998). Agricultural education programs have seen an increase in female and urban students but have not reflected this change in their teacher educator composition (Myers & Dyer, 2004). Further, not all agricultural education programs are actively producing certified agricultural education teachers (McLean & Camp, 2000; Myers & Dyer, 2004). Although most agricultural education programs are housed in the college of agriculture, around one-fifth are housed in the college of education (Myers & Dyer, 2004; Swortzel, 1999). Despite degree requirements varying across programs (Franklin & Molina, 2012; Graham & Garton, 2003; Myers & Dyer, 2004; Shinn, 1997; Swortzel, 1999), courses of commonality include methods of teaching, program planning, and a student teaching internship (McLean & Camp, 2000; Myers & Dyer, 2004; Retallick & Miller, 2007, 2010).

An agricultural teacher educator's traditional role included preparing pre-service teachers to transition into professional educators and providing professional development to current teachers (Franklin & Molina, 2012; Myers & Dyer, 2004). Recently, agricultural teacher educators' roles have expanded to include recruitment, faculty development, and teaching college-wide courses (Hillison, 1998b; Myers & Dyer, 2004). Despite this expansion of responsibility, various secondary agriculture teachers and state staff still consider pre-service teacher preparation an agricultural education program's greatest responsibility (Myers & Dyer, 2004).

The 1990s found teacher educators preparing pre-service teachers in traditional teaching methods such as lecture/discussion while secondary teaching method expectations had changed (Myers & Dyer, 2004; Swortzel, 1996). In the late 1990s to early 2000s, there was a highly supported call for preparing pre-service teachers to integrate science into agriculture curriculum (Balschweid & Thompson, 1999, 2000, 2002; Myers & Dyer, 2004; Myers & Washburn, 2008; Myers, Thoron, &Thompson, 2009; Thompson & Balschweid, 1999; Thoron & Myers, 2010; Thompson & Warnick, 2007; Warnick et al., 2004; Washburn & Myers, 2010). Science integration was further supported by states which provided biological science credit for agricultural education courses (Giustino & Straquadine, 1994; Myers & Dyer, 2004). Even though secondary agricultural education potentially needed the change it was undergoing, Myers & Dyer (2004) called for the "focus of teacher preparation programs … [to remain] on the process of teaching and learning (p. 48)."

The student teaching internship is a highly influential part of preparing pre-service teachers (Franklin & Molina, 2012; Myers & Dyer, 2004; Retallick & Miller, 2007, 2010; Zuch, 2000). Pre-service teacher attitudes often change over the student teaching internship (Myers & Dyer, 2004). Several important elements pre-service teachers identified for the student teaching internship to have included mentorship, communication, clear expectations, and discipline management plans by cooperating teachers (Harlin, Edwards, & Briers, 2002; Myers & Dyer, 2004; Young & Edwards, 2006). Further, cooperating teachers highly influence future instructional practices of pre-service teachers (Garton & Cano, 1996; Harlin et al., 2002; McKee, 1991; Myers & Dyer, 2004; Young & Edwards, 2006). The relationship between the cooperating teacher and the university supervisor also plays and important role in pre-service teachers' development during the student teaching internship (Deeds, Flowers, & Arrington, 1991; Franklin & Molina, 2012; Myers & Dyer, 2004). It is important to realize all these elements are addressed by CAEP accreditation and InTASC standards.

Student Teaching Internship in Oklahoma

After completing all the methods and instructional courses in a teacher preparation program, pre-service teachers typically culminate their learning experience through the student teaching internship, which links the university experience and the secondary classroom (Franklin & Molina, 2012; Torres & Ulmer, 2007; Retallick & Miller, 2007, 2010). The student teaching internship provides pre-service teachers opportunities to demonstrate knowledge and skills regarding pedagogy in a structured real-life classroom under a cooperating teacher (Kelleher, Collins & Williams, 1995; Retallick & Miller, 2007, 2010; Torres & Ulmer, 2007). The Oklahoma Legislature through House Bill 1013 in 1969 established legal standing for student teaching (OSU, 2012b). House Bill 1013 created guidelines for student teaching in Oklahoma public schools (OSU, 2012b).

OSU Department of Agricultural Education, Communications & Leadership (DAECL) highly values the student teaching experience and considers it "the most dynamic and vital phase of the total curriculum for preparing teachers of Agricultural Education" (OSU, 2012b, p. 1). During the student teaching experience in Oklahoma, pre-service teachers should gain competence in fifteen areas. Some of these areas include teaching high school students, advising the FFA chapter, facilitating supervised agricultural experiences, preparing students for competitions, organizing community events, and counseling students (OSU, 2012b). Pre-service teachers will work through four phases in their student teaching experience. No specific time frame is allocated to the various phases due to the individualistic nature of the student teaching experience (OSU, 2012b). The four phases include: orientation and observation (1 week), Progressive teaching experience (5-7 weeks), extensive teaching experience (3-5 weeks), and culminating experience (1 week). Phase one, orientation and observation, allows the pre-service teacher to familiarize themselves with the classroom and discuss observations with the cooperating teacher (OSU, 2012b). Phase two, progressive teaching experience, allows the pre-service teacher to start teaching one to two courses under close supervision (OSU, 2012b). Pre-service teachers also start routine procedures such as planning, preparing, grading, and tutoring while receiving immediate feedback from the cooperating teacher (OSU, 2012b). Phase three, extensive teaching experience, turns responsibility for the full course load over to the pre-service teacher with regular feedback. Phase four, culminating experience, provides the pre-service teacher the opportunity to observe other teachers in the school (OSU, 2012b).

The OSU DAECL requires pre-service teachers to complete several assignments during their experience. The purpose of these assignments are "1) To ensure the field experience exposes the pre-service teacher to all facets of teaching Agricultural Education in Oklahoma; 2) To provide the pre-service teacher with materials and records that will be useful during the beginning of his/her teaching career" (OSU, 2012b, p. 6). The assignments include teaching portfolio submission three and a student teaching resource file to include the rest of the assignments in an organized location (OSU, 2012b). Items to be included in the resource file are documentation of educational technology use, lesson plans, formal assessments of student learning, cooperating teacher evaluations, teaching methods exploration, evidence of Career Development Event (CDE) preparation, FFA activities, program visitation and peer observation, mock interview, weekly reports and calendar, and formal student evaluation of teaching. Lesson plans were to be developed in addition to those created on campus prior to the student teaching experience (OSU, 2012b). The Student Teaching Handbook, regarding the lesson planning assignment, states the following:

> The unit of instruction you develop during AGED 4103 will only last so long. As you teach your assigned classes, you will develop additional lesson plans and other related teaching materials (i.e., "lesson planning"); note examples provided. Design a system that works for you to keep your teaching materials well organized. Similar to the materials you developed while on campus, new units should include lesson plans, visual aids, related instructional materials, assessment and evaluation instruments, and keys. Your university supervisor will review these and related materials with you during on site observations. (OSU, 2012a, p. 7).

Creativity

Creativity is needed to produce innovative ideas, processes, and ultimately outcomes (Kirton, 2011; Shayo, Woodward, Simpson, & Rudd, 2019). Educators and pre-service teachers not only teach problem-solving but must utilize it as well. During pre-service teachers and educators use of problem-solving creativity and critical thinking is used (Shayo et al., 2019). Shayo et al. (2019, p. 19) stated, "critical thinking and creativity cannot be separated from problem-solving," inferring the ability to integrate STEM through problem-solving/inquiry requires pre-service teachers to think critically and be creative. Further, "creativity and critical thinking does not occur in empty space, but in well-planned and thoughtful instruction" (Shayo et al., 2019, p. 20).

Creativity has been an interest of researchers for decades; however, a firm definition for creativity still does not exist (Baker, Rudd, & Pomeroy, 2001; Friedel & Rudd, 2005; Hocevar, 1981; Marksberry, 1963; Sternberg, 1999; Starko, 2005). Torrance (1962) defined creativity as: "the process of sensing gaps and discerning missing elements; forming new hypotheses and communicating the results; and possibly modifying and retesting the hypothesis" (p. 141). Parnes (1978) defined creativity as a "function of knowledge, imagination and evaluation" (p. 14). Perkins (1988) defined creativity in multiple ways: "(a) A creative result is a result both original and appropriate. (b) A creative person—a person with creativity—is a person who fairly routinely produces creative results" (p.311).

Examining in excess of 90 articles from the leading creativity journals, Plucker, Beghetto, and Dow (2004) found only 38% contained a clear definition of creativity. Of the remaining articles, 41% contained an implied definition while the last 21% offered no definition at all.

Cropley (2001) suggested that creativity contains three primary elements: novelty, effectiveness, and ethicality. Novelty refers to a creative product or idea breaking from the familiar (Cropley, 2001). Effectiveness references the product's or idea's ability to meet an end goal successfully whether the goal is tangible, such as making a profit, or intangible, such as art or spirituality (Cropley, 2001). Ethicality addresses the concept of the goal being ethical in nature and not referring to a selfish or destructive behavior (Cropley, 2001). Amabile, Conti, Coon, Lazenby, and Herron (1996) defined creativity "as the production of novel and useful ideas in any domain" (p. 1155), which is similar to Stein (1974) and Woodman et al. (1993).

Teacher Role in Producing Creativity

Mack (1987) suggested increasing the amount of creative education in both secondary education and teacher educator programs. Teachers need to infuse creativity in their lessons through their instructional methods and assessments (Sternberg, 2006) because when creativity is present, improvements in student motivation, concentration, curiosity, alertness, and achievement has been observed (Torrance, 1981). Teachers can infuse creativity in their students better whenever they model divergent thinking (Karnes, McCoy, Zehrbach, Wollersheim, Clarizio, Costin, & Stanley, 1961). In general, creativity leads to increased interest of the student, resulting in efficient ways to advance youths' personal growth and learning (Cropley, 2001). Creative educators bolster creative students, and creative teaching strengthens learning and development (Cropley, 1995, 2001; Fasko, 2000-2001).

Theory of Planned Behavior

Creativity, attitudes and behavior are influenced by contextual factors (Williams, 2004). Even stable environments, not requiring immediate change, benefit from creative ideas which improve quality, productivity, and safety (Eisenberger, Fasolo, Davis-LaMastro, 1990; Williams, 2004) regarding instruction and classroom environment. Many factors impact creativity such as personality, attitudes, ability, cognition, and motivation (Oldham & Cummings, 1996; Redmond, Mumford, & Teach, 1993; Williams, 2004; Woodman, Sawyer, & Griffin, 1993; Zhou, 1998). Thus, the Theory of Planned Behavior (TPB) best fits this study due to its ability to account for multiple factors discussed in previous sections.

The Theory of Planned Behavior (TPB) emerged from Ajzen and Fishbein's work on attitude and Theory of Reasoned Action (TRA). Ajzen (1991, 2005, 2012) noted the TRA contained a severe limitation in predicting and explaining a magnitude of social behaviors. As a result, the Theory of Planned Behavior (TPB), shown in Figure 2.1, was created. The TPB accounts for degrees of control to accommodate those behaviors which people have little volitional control over (Ajzen, 1985, 1991, 2005, 2012; Madden, Ellen, & Ajzen, 1992; Morris, Marzano, Dandy, & O'Brien, 2012; Sommer, 2011). Behaviors, if under volitional control, will produce desired acts from an individual's intentions (Ajzen, 2005). Additionally, the TPB asserts that perceived control may exist in situations where complete volitional control is not present (Ajzen, 2005; Montano and Kasprzyk, 2002, p. 70).

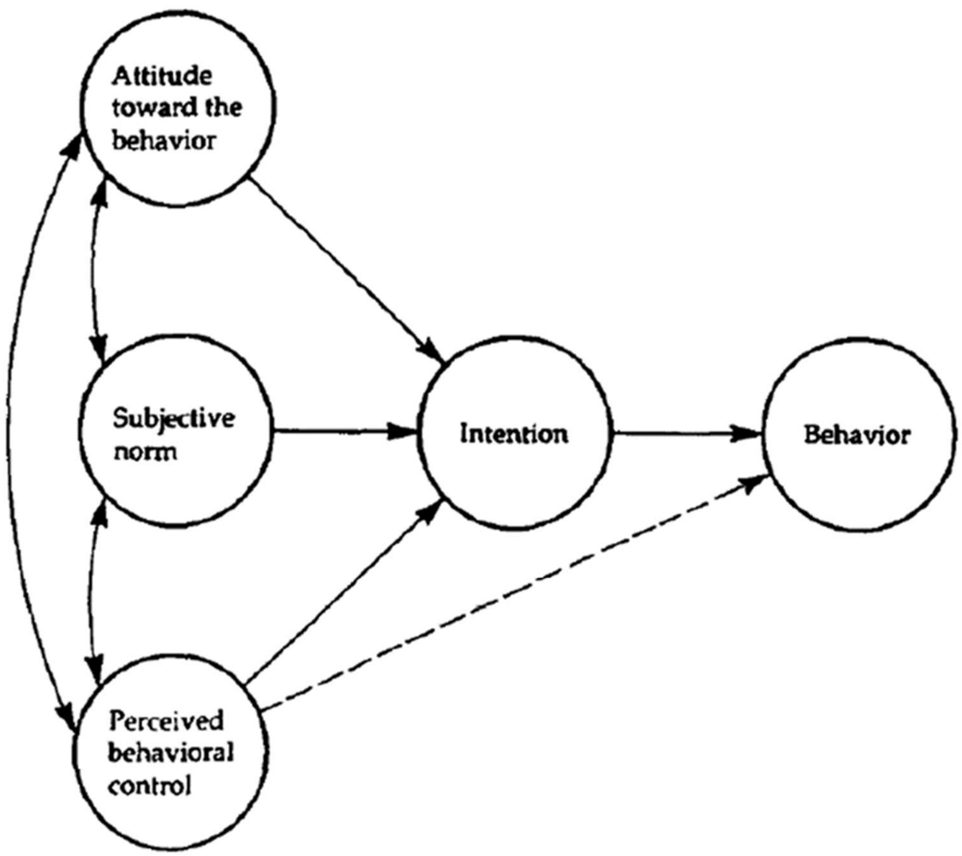

Figure 2.1. The Theory of Planned Behavior (Ajzen, 1991, p. 182).

"People do what they intend to do and do not do what they do not intend" (Sheeran, 2002, p. 1). Intention is a result of the blending of attitudes toward a behavior (Ajzen, 2005, 2012; Morris et al., 2012). Numerous internal/external background factors (see Figure 2.2) may hinder or support performance of a specific behavior (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Sommer, 2011).

> People should be able to act on their intentions to the extent that they have the information, intelligence, skills, abilities, and other internal factors required to perform the behavior and the extent that they can overcome any external obstacles that may interfere with behavioral performance. (Ajzen, 2012, p. 446)

The amount of actual control is determined by the effect of intentions on behavior (Ajzen, 2005, 2012; Conner & Armitage, 1998; Hartmann, 2009). High universal behavioral control with all being able to perform the task makes intentions a sole predictor of behavior (Ajzen, 2005, 2012; Conner & Armitage, 1998; Feldman & Lynch, 1988). However, when individuals' behavioral control varies, both intentions and control interact to impact behavioral performance (Ajzen, 2005, 2012; Conner & Armitage, 1998). Those with intentions to perform a behavior with a large amount of control should be willing to perform the behavior (Ajzen, 2005, 2012; Conner & Armitage, 1998; Hartmann, 2009).

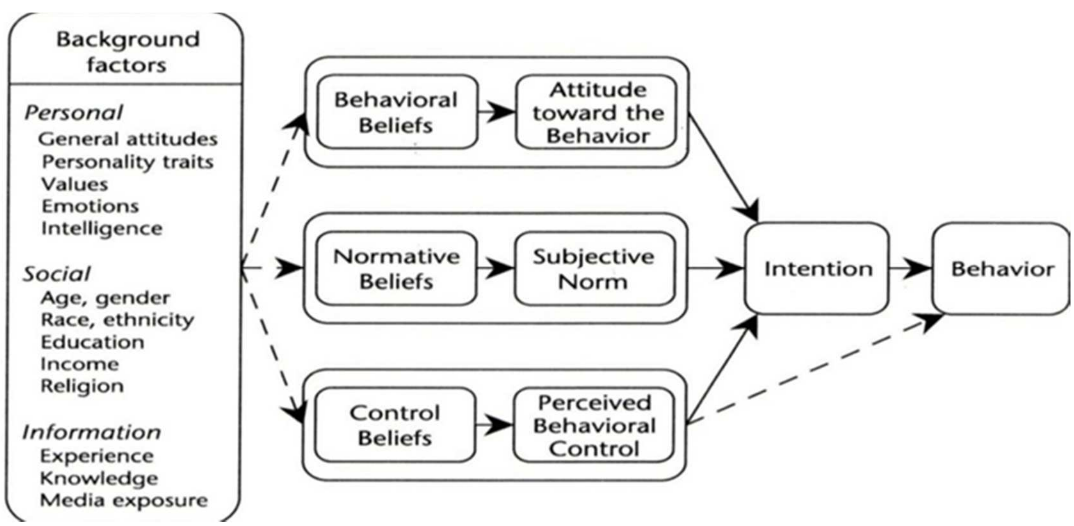

Figure 2.2. "The role of background factors in the Theory of Planned Behavior" (Ajzen, 2005, p. 135).

Perceived behavioral control, “the extent to which people believe that they can perform a given behavior if they are inclined to do so” (Ajzen, 2012, p. 446), may be more important than actual behavioral control (Ajzen, 2005, 2012; Conner & Armitage, 1998). Perceived behavioral control in the TPB is founded on Albert Bandura’s work on self-efficacy regarding proximal determinants of human motivation and action (Ajzen, 2005, 2012, Ajzen & Madden, 1986; Conner & Armitage, 1998; Kraft, Rise, Sutton, & Røysamb, 2005). Substantial amounts of research support self-efficacy theory with the strongest evidence coming from studies manipulating self-efficacy to monitor impact on perseverance toward a particular task (Ajzen, 2005, 2012). Several experiments have demonstrated that self-efficacy influences past perseverance to task performance (Ajzen, 2005, 2012). Thus, self-efficacy/perceived behavioral control may impact performance of difficult behaviors (Ajzen, 2005, 2012; Conner & Armitage, 1998).

Comparatively, the TPB (see Figure 2.1) adds perceived behavioral control to the model as a third determinant of behavioral intentions in the TRA (Ajzen, 2005, 2012, Ajzen & Madden, 1986; Conner & Armitage, 1998). Thus, the more an individual believes he or she can perform the behavior along with favorable attitudes and subjective norms, the results should be in obtaining stronger behavioral intentions (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Ferguson, Robinson, & Cohen, no date; Hartmann, 2009; Kraft et al., 2005). The adverse is also relevant where those not believing they are capable are more unlikely to formulate intentions to do so (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Hartmann, 2009; Kraft et al., 2005). Because perceived behavioral control can influence behavioral performance, perceived behavioral control may serve as a proxy for actual control (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Conner & Armitage, 1998; Kraft et al., 2005; Sommer, 2011). Often, perceived behavioral control is used in research instead of actual behavioral control due to the multitude of internal and external factors which may restrict or encourage behavioral performance (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Conner & Armitage, 1998; Kraft et al., 2005; Sommer, 2011).

All three determinants (i.e., attitude, subjective norms, and perceived behavioral control) are expected to trail steadily from readily available beliefs regarding resources and obstacles which may impede or assist in behavioral performance (Ajzen, 2005, 2012; Ferguson et al., no date). The power to which each control factor contributes to behavioral performance through perceived behavioral control is directly proportional to the individual's subjective likelihood that a control factor exists (Ajzen, 2005, 2012). Evidence exits linking perceived behavioral control and composite control beliefs (Ajzen, 2005, 2012). Perceived behavioral control is measured by asking individuals if they can perform said behavior in a free-response format (Ajzen, 2005, 2012). Studies have steadily measured control belief strength with only a few being able to determine the power of influence control factors have on behavioral performance (Ajzen, 2005, 2012). However, research exists supporting perceived behavioral control being predicted from control beliefs (Ajzen, 2005, 2012, Ajzen & Madden, 1986).

The TPB premises on human action being steered by three deliberations: behavioral beliefs, normative beliefs, and control beliefs as shown in figure 2.3 (Ajzen, 2005, 2012; Ajzen & Madden, 1986). Behavioral beliefs focus on beliefs surrounding likely outcomes and evaluation of a specific behavior (Ajzen, 2005, 2012, Ajzen & Madden, 1986). Normative beliefs focus on expectations from important referents and the motivation to follow these referents (Ajzen, 2005, 2012; Ajzen & Madden, 1986). Control beliefs focus on factors which positively or negatively impact behavioral performance along with the perceived power of such factors (Ajzen, 2005, 2012; Sommer, 2011). Combining attitude toward the behavior, subjective norm, and behavioral perception control creates a path to behavioral intention where the more satisfactory the attitude, subjective norm, and increased perceived control, the greater the intent to perform the behavior (Ajzen, 2005, 2012; Ferguson et al., no date). A percentage of actual control should allow for individual intentions to be carried out facilitating intentions to precede behavior (Ajzen, 2005, 2012).

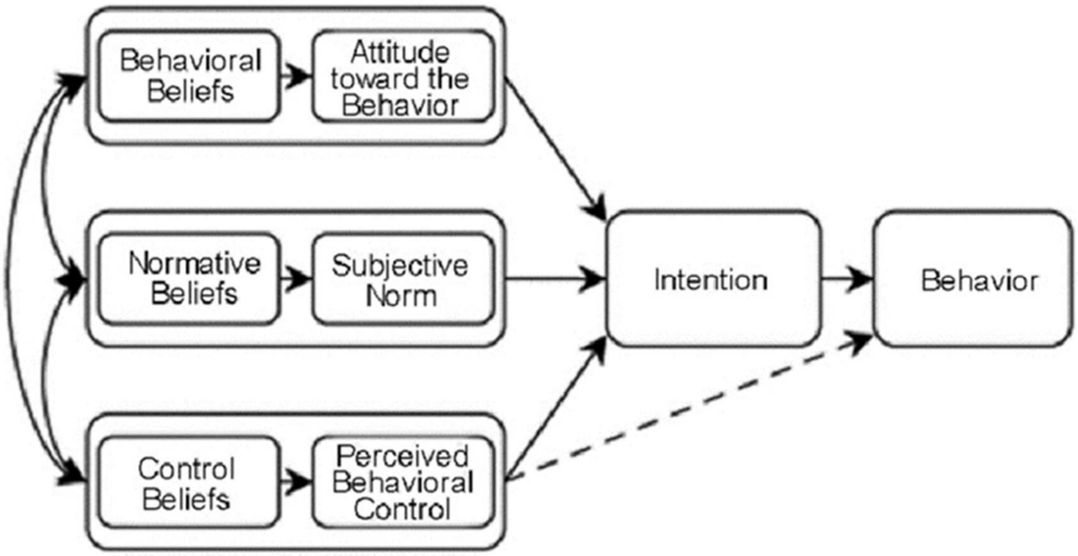

Figure 2.3. “Beliefs as the informational foundation of intentions and behavior” (Ajzen, 2005, p. 126).

Accessible behavioral, normative and control beliefs lay the groundwork for attitudes, subjective norms and perceived control (Ajzen, 2005, 2012; Hartmann, 2009). Identifying an individual’s accessible beliefs provides an understanding of what directs that person’s attitudes, subjective norms and perceptions of control (Ajzen, 2005, 2012; Hartmann, 2009). Accessible beliefs may change over time resulting in potential gaps between intentions and actions (Ajzen, 2005, 2012). Thus, accessible beliefs at any given moment only influence that moment’s intentions, which may change behavior that are performed at later moments (Ajzen, 2005, 2012).

A fundamental concept to the TPB is that behavior is directed through intentions through two implications: first, a strong relation between intentions and behavior exists; and second, intentional changes precede behavioral changes (Ajzen, 2005, 2012). A multitude of studies support behavioral intentions accounting for a substantial amount of variance in behavior (Ajzen, 2005, 2012).

The TPB assumes intentions are causal antecedents of matching behavior (Ajzen, 2002, 2005, 2012; Conner & Armitage, 1998; Feldman & Lynch, 1988; Sommer, 2011). Empirical evidence exists showing that intentions may be used to predict behavior but is not positive proof of contributing an effect (Ajzen, 2005, 2012; Feldman & Lynch, 1988, Ferguson et al., no date). However, causal effects have been found in intervention studies (Ajzen, 2005, 2012; Webb & Sheeran, 2006), resulting in medium to large intentional change with small to medium behavioral change (Ajzen, 2005, 2012; Webb & Sheeran, 2006).

Evidence supports TPB intentions being predicted from attitudes, subjective norms, and perceptions of behavioral control (Ajzen, 2005, 2012; Morris et al., 2012). Meta-analytic studies encompassing diverse behaviors mention mean multiple correlations for the prediction of intentions ranging from 0.59 to 0.66 (Ajzen, 2005, 2012; Armitage & Conner, 2001; Conner & Armitage; 1998; Notani, 1998; Rivis & Sheeran, 2003; Schulze & Wittmann, 2003; Sommer, 2011).

Summary of Literature Review

Education in the United States has transitioned from an instructional approach of behaviorism to one of constructivism. However, knowledge retention remains an issue for students. Students continue to struggle to meet standards in science and mathematics. Research is needed in determining strategies for increasing interest in STEM while improving knowledge retention to help meet the priorities of a growing society. Evidence shows educators' actions influence students' attitudes, creativity, and most importantly ability. Thus, it is important to determine how educators' creativity and attitudes impact their planning for instruction and STEM integration.

CHAPTER III

METHODOLOGY

This chapter describes the design of this study and the methodology used. The participants are described as well as the measures utilized. Finally, the procedures used to collect the data are discussed, and the data analyses are described.

Purpose of the Study

The purpose of this study was to determine the extent to which pre-service teachers in agricultural education at OSU planned to incorporate STEM content into their agricultural education lessons during the 12-week student teaching internship. This study also sought to determine the correlation between pre-service teachers' science and mathematics aptitudes, self-perceived instructional creativity and STEM attitude (i.e., interest, value and self-perceived ability).

Research Questions

The following research questions guided this study.

1. What are the personal and professional characteristics of pre-service agricultural teachers in agricultural education during the Fall 2011 and Spring 2012 semesters?

2. What are pre-service agricultural teachers' self-perceived instructional creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability) and science and mathematics aptitudes?
3. What percentage of pre-service agricultural teachers' lesson plans contained STEM concepts during the 12-week student teaching internship?
4. What quality level are pre-service agricultural teachers' lesson plans per the departmental lesson plan rubric?
5. What aspects of STEM do pre-service agricultural teachers plan to teach most frequently?
6. What grade level of STEM standards do pre-service agricultural teachers plan to integrate into their lesson plans?
7. What is the relationship between pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., STEM interest, value, and self-perceived STEM ability)?

Research Participants

Students enrolled in AGED 4200-*Student Teaching in Agricultural Education* at Oklahoma State University (OSU) were the population of interest and were selected purposively to participate in the study. The rationale for this population was due to the lesson plan development and training they received while on campus. Further, this population was introduced to a uniform lesson plan format. This uniform format should create ease in evaluation of their lesson plans. The students are also required to create lesson plans throughout their 12-week student teaching internship. Although using a purposive sample limits the generalizability of the findings, it is important to understand how pre-service teachers plan to implement STEM into their lessons.

Ary, Jacobs, and Razavieh (1996) stated, purposive sampling is "a nonprobability sampling technique in which subjects judged to be representative of the population [are] included in the sample" (p. 648). Selecting this purposive sample creates potential problems in calculating variance due to potential shrinkage. Shrinkage is "the tendency for the prediction to be less accurate for a group other than the one on which it was originally developed" (Ary et al., 1996, p. 204). Shrinkage results from the zero-order correlations being treated as error-free when calculating coefficients to maximize R (Pedhazur, 1997). Pedhazure (1997) stated this is never the case and there is a degree of "capitalization on chance, and the resulting R is biased upward" (p. 207). Pedhazur (1997) iterated several authors vary in their ratio of subjects per predictor variables. A ratio of 1:15, i.e.15 subjects for everyone predictor, represented the lowest number of subjects per predictor allowed by Pedhazur (1997). Ary et al. (1996) stated a relationship can be found in a moderate size sample (i.e., 50 to 100 participants). However, the authors "do not recommend samples with fewer than 30 subjects" (p. 392) when conducting correlational studies. Due to purposively selecting students enrolled in AGED 4200, this study meets the minimum number of 30 subjects needed to conduct a correlational study but does not reach the moderate size of 50 to 100 subjects (Ary et al., 1996). Culminating from the sample size was the importance to only calculating the variance of one variable at a time. This allowed the ratio of 1:30, i.e. one predictor per thirty subjects.

Environmental Description

Pre-service teachers at Oklahoma State University participated in three courses during their student teaching semester. The semester began with two four-week long courses prior to their student teaching internship, known as the *block*. These two courses were AGED 4103-*Methods and Skills of Teaching and Management in Agricultural Education* and AGED 4113-*Laboratory Instruction in Agricultural Education*. AGED 4103 consisted of a lecture portion (7:30 a.m. to 8:20 a.m.) followed by a laboratory practicum (1:00 p.m. to 5:00 p.m.). AGED

4113 began at 8:30 a.m. and ended at 12:00 p.m. On completion of the block, students transitioned to their cooperating center communities and began their work for AGED 4200-*Student Teaching in Agricultural Education*, a 12-week student teaching internship.

During AGED 4113, students learned teaching methods related to agricultural education in a laboratory setting (Oklahoma State University, 2010a). Students participated in the application of technical agricultural skills in the context of secondary agricultural education (Oklahoma State University, 2010a). Course instruction was designed to "strengthen pre-service teachers' experience in specific areas of technical agriculture" (Oklahoma State University, 2010a, pp. 2) such as welding, animal handling and experiential learning. Further, the course assisted in pre-service teachers' ability to utilize community resources and secure teaching resources through involvement in professional organizations (Oklahoma State University, 2010a).

Students simultaneously acquired facets of the teaching and learning processes in AGED 4103 (Oklahoma State University, 2012a). AGED 4103 course content included teaching methods, basic teaching skills, proper classroom management techniques and motivational techniques and ideas (Oklahoma State University, 2012a). This course was designed to expose students to a variety of teaching methods and techniques, allow them to practice using those methods and techniques and develop their interactive teaching and communication skills (Oklahoma State University, 2012a). AGED 4103 laboratories provided opportunities for students to practice behavioral management techniques, develop a complete unit of instruction, design formative and summative assessments and deliver lessons using multiple methods and media (Oklahoma State University, 2012a).

AGED 4113 and AGED 4103 acted as building blocks which culminated a pre-service teachers' academic preparation with AGED 4200. AGED 4200 was a "twelve-week clinical experience in a selected Agricultural Education program" (Oklahoma State University, 2011b, p.

1). Pre-service teachers applied methods and skills in agricultural education as related to selecting, adjusting, using and assessing curriculum materials (Oklahoma State University, 2011b). Experiences included meeting educational goals, facilitating learning for individual students, working with various school stake holders and carrying out the roles and responsibilities of an educator (Oklahoma State University, 2011b).

Prior to entering the student teaching experience, pre-service teachers must pass the Oklahoma General Education Test (OGET) which was required for teacher certification (Oklahoma State University, 2018). The OGET measured various areas of knowledge such as reading, communication, mathematics, science, art, literature, social sciences and writing (Oklahoma Commission for Teacher Preparation, 2007). The Oklahoma Commission for Teacher Preparation (OCTP) (2007) identified the competencies of the OGET in its study guide. The OGET consisted of broad competencies which "reflect[ed] the general education knowledge and skills an entry-level educator need[ed] to teach effectively in Oklahoma public schools" (OCTP, 2007, p. 2-1). Section three addressed critical thinking skills regarding mathematics and section five, in part, contained items related to science (OCTP, 2007). Mathematic competencies ranged from problem solving using data interpretation and analysis to problem solving using a combination of mathematical skills (OCTP, 2007). Science competencies revolved around understanding and analyzing major scientific principles, concepts and theories; as well as applying skills, principles, and procedures associated with scientific inquiry (OCTP, 2007).

Design

This study was a descriptive study with the final research question being multiple correlational (Aschenbrener, 2008; Ary et al., 2002; Huberty, 2003). Huberty (2003) conceived multiple correlation analysis (MCA) research questions as the "relationship between a single response variable (Y) on one hand and a collection of response variables (Xs) on the other hand"

(p. 272). The X variables utilized in a MCA study should be founded on relevant essential theory (Huberty, 2003). A substantial portion of this study design was descriptive in nature with a singular correlational component, which is used widely in educational research (Ary et al., 2002; Aschenbrener, 2008; Gay, Mills, & Airasian, 2009; Huberty, 2003). “Correlational research seeks to examine the strength and direction of relationships among two or more variables” (Ary et al., 2002, p. 25).

Multiple correlation analyses were performed using the study’s instruments (see Measures section below) along with participants’ mathematics and science scores, as measured by the Oklahoma General Education Test (OGET), in relationship to participants’ planed STEM integration found in their lesson plans. Only two of any given variables were used in the multiple correlation analyses at one time due to the small population. It was important to maintain the ratio of 1:15 for predictor variables to participants recommended by Pedhazur (1997). This study used the 1:15 ratio despite not attempting to predict and only trying to determine association.

Measures

The study involved three formal instruments and one data collection form. The formal instruments used measured STEM attitude (i.e., interest, value and perceived ability), perceived creativity of pre-service teachers’ instruction and lesson quality. Modifications to the instruments were made only to the demographic sections. The SAT STEM Instrument (see Appendix D) was modified to capture the participants’ name, age, gender, standardized science and mathematical scores from the Oklahoma General Education Test (OGET), academic grade point average (GPA), hours of collegiate course work including STEM and hours of extracurricular programs containing STEM. The CETAI instrument demographics (see Appendix E) were modified to capture participants’ name and courses taught during student teaching experience. The Lesson

Plan Quality Rubric was not modified, and the researcher created the STEM depth collection form.

Student Attitude Toward (SAT) STEM Instrument

Mahoney (2009) designed the Student Attitude Toward (SAT) STEM Instrument at Ohio State University. The SAT STEM instrument tests individuals' interest, perceived ability and value of STEM. Mahoney (2009) used "a variation of the Concerns-Based Adoption Model's (CBAM) Stages of Concern (SoC); Taxonomy of Educational Objectives, Handbook II (TEOII); and varied attitudinal and STEM focused instruments" (p. 115) as developmental inspiration for the SAT STEM Instrument. After compiling an item pool from prior instruments and pertinent information sources, items were chosen and submitted to an expert panel representing STEM and STEM education to assist in establishing the instrument's content and face validity (Mahoney, 2009).

From the expert panel, Mahoney (2009) created an instrument containing 24 statements measuring STEM attitude. Participants were asked to respond to statements on a Likert-type agreement scale. Each statement required a response for science, technology, engineering and mathematics resulting in four responses per statement. Thus, the 24 statements ultimately resulted in 96 statements.

Validity measures were utilized in several specific areas: content, face, construct and concurrent validity. A panel of experts and a student focus group were used for content and face validity (Mahoney, 2009). Concurrent validity was established through "the Pearson product moment correlation procedure and its inferences between student responses on the student attitude toward STEM instrument and student responses on the SEMDIFF attitudinal instrument" (p. 196) with the SEMDIFF representing the Semantic Differential. Mahoney (2009) hoped to gain construct validity for the instrument through "collected analysis provided by the extensive attitudinal research, panel of experts, student focus group, principal components analysis, MANOVA and Pearson product moment correlation" (p. 198). The three identified principal components for each content area explained a high percentage of variance: science = 69%, technology = 64%, engineering = 73% and mathematics = 68% (Mahoney, 2009).

Reliability for the SAT STEM instrument was established through using Cronbach's alpha. The pilot study provided alpha ratings of the content areas: science (.94), technology (.91), engineering (.93), and mathematics (.96) (Mahoney, 2009). Mahoney (2009) concluded there was a strong reliability coefficient of .92 alpha for the revised instrument regarding all content areas from the Cronbach's alpha procedure.

Creative and Effective Teaching Assessment Instructor (CETAI) Instrument

The Creative and Effective Teaching Assessment Instructor (CETAI) instrument was designed at the University of Missouri. Aschenbrener (2008) designed and tested the CETAI instrument as partial completion of dissertation requirements. The CETAI instrument determines instructors' creativity and effective teaching. Aschenbrener (2008) shortened the CETAI instrument for college faculty, which is the version utilized for the current study. The CETAI employs a Likert-type scale measuring instructor creativity through four constructs: fluency, originality, elaboration and flexibility, all of which derived from the Torrance creativity test (Aschenbrener, 2008). Teaching effectiveness comprises the second component of the instrument and consists of sixteen statements based on Rosenshine's and Furst's (1971) five effective teaching characteristics (Ashenbrener, 2008).

Content, construct and face validity were addressed by using a panel of experts composed of two content experts and two instrumentation experts (Ashenbrener, 2008). Reliability was addressed "by conducting a pilot test of the CETAI instrument" (Ashenbrener, 2008, p. 69). In regard to the instructor instrument, a pilot was "conducted by university faculty from colleges of agriculture across the nation" (Ashenbrener, 2008, p. 69). Ashenbrener (2008) also utilized Cronbach's alpha to determine internal reliability, which resulted in a .84 (n = 28) for the four creative constructs in the instructor pilot test (Ashenbrener, 2008). Coefficients for each individual construct were as follows: fluency (.46), flexibility (.74), originality (.77), and elaboration (.68) (Ashenbrener, 2008).

Lesson Plan Quality Rubric

The Lesson Plan Evaluation Rubric (Appendix F) was the same lesson plan grading rubric used by the Oklahoma State University (OSU) Department of Agricultural Education, Communications and Leadership to evaluate students' lesson plans throughout all the department's agricultural education courses (Oklahoma State University, 2010b). Participants of the study were introduced and required throughout their agricultural education courses to use the same lesson plan format for which the grading rubric aligned (Oklahoma State University, 2011a, 2011b, 2012a). The lesson plan template and grading rubric were founded around the Allen (1919) 4-step instructional model and Tyler's four questions.

A panel of three experts who had in excess of 10 years of school-based agricultural education teaching experience and two years of post-secondary teaching experience was organized to conduct the evaluation of lesson plan quality. The panel consisted of OSU agricultural education graduate students familiar with the departmental grading rubric. Each member used the departmental grading rubric to evaluate the lesson plans produced by students in Agricultural Education courses at Oklahoma State University. Inter-rater reliability was established by having each panel member evaluate the same nine lesson plans prior to evaluating a random selection of lesson plans. Panel members were provided the nine lesson plans on July 25th. The panel then met on July 26th to discuss their rationale for scoring the lesson plans as they did. Each lesson plan was discussed in depth until consensus was reached. Panel members were then instructed to re-score the nine lesson plans per the discussion. The new scores were used for determining inter-rater reliability. The inter-rater reliability for this panel began at 48% agreement reliability prior to discussing the initial scores. After discussion consensus, the reliability of the panel increased to 70% agreement reliability with a Fleiss kappa coefficient of 0.67. McHugh (2012) reported that a kappa value of 0.67 is a moderate level of agreement with 35% to 63% data reliability. A 70% agreement reliability threshold is recommended for establishing consensus (Brown, Glasswell, & Harland, 2004; Jonsson & Svingby, 2007; Stemler, 2004). Fleiss kappa was used instead of Cohen's kappa due to the Fleiss kappa being specifically adapted from Cohen's kappa for three or more raters (McHugh, 2012).

STEM Depth Panel and Form

A separate panel of experienced educators, known as the STEM depth panel, was organized to evaluate and determine the depth of STEM content contained in each randomly selected lesson plan. Each of the panelists was compensated for their work. An expert science educator evaluated the science content, an expert media specialist educator evaluated the technology content, an expert Project Lead The Way (PLTW) educator evaluated the engineering content and an expert mathematics educator evaluated the mathematics content.

The expert science educator had 20 years of experience teaching high school science courses and held a master's degree in education. This expert evaluated the lessons using Oklahoma's Science standards. The expert media specialist educator evaluating technology had 28 years of experience as a media specialist and held a bachelor's degree in the discipline. This expert evaluated the lesson plans using Oklahoma Technology Standards. The expert PLTW educator evaluating engineering had 18 years of teaching experience in mathematics and held a master's degree in the discipline. This expert taught PLTW for 10 years and evaluated lesson plans on PLTW standards. Lastly the expert mathematics educator had 5 years of experience teaching Common Core Mathematic Standards. This educator held a bachelor's degree in education and certification in both mathematics and business education and evaluated the lessons using Common Core Mathematic Standards.

Intra-rater reliability was conducted by each panel member. A rater in this context refers to individuals generating data where intra-rater reliability represents the self-consistency in scores (Gwet, 2008). One of the various ways utilized to determine intra-rater reliability include percent agreement (McHugh, 2012). Therefore, each member evaluated five lesson plans once per day for three consecutive days and then compared their scores for consistency over the three-day span. The intra-rater reliability for each panel member was as follows: science panel member = 93% consistency, technology panel member = 100% consistency, engineering panel member = 100% consistency, and mathematics panel member = 100% consistency. These consensus agreements exceed the 70% agreement threshold needed for establishing consistency (Brown et al., 2004; Jonsson & Svingby, 2007; Stemler, 2004).

A STEM depth form (Appendix G) was created to assist the experts in tracking the STEM content identified in the lessons. The STEM depth form was produced in table format with the columns representing lesson content, grade level addressed, and STEM standard met. The grade levels themselves incorporated the depth of STEM contained in the lesson with the highest-level taking precedent. The grade level classifications included 12th, 11th, 10th, 9th, and below 9th. The 9th- through 12th-grade level classification represents the grade level to which they correspond. Any content prior to 9th grade was classified as: below 9th.

Procedure

Pre-service agricultural education teachers enrolled in AGED 4200 were asked to volunteer for the study through an informative letter (Appendix B) describing the study and distributed in person by the researcher. Pre-service teachers were requested to sign the consent document and return it to the researcher within three days. The researcher distributed informative letters during the first two days of the Fall 2011 semester (August 18th and 19th) and again the first two days of the Spring 2012 semesters (January 9th and 10th). After three days, the researcher scheduled time to administer the instruments directly to the pre-service teachers (Ary et al., 1996). The participants were allowed a 24-hour period during the Fall 2011 semester (August 20th and 21st) to complete the instruments. All participants in the Spring 2012 semester completed instruments after a laboratory session on January 17th and 18th.

The first week of each semester was used to solicit and obtain participants while the second week was allotted for taking the STEM Attitudinal Survey. Participants then continued with their requirements for AGED 4200 course responsibilities, which included the student teaching internship. During the student teaching internship, participants created lesson plans per AGED 4200 requirements. On completion of their student teaching internship, participants shared in a capstone seminar as part of AGED 4200 course responsibilities. The Fall 2011 seminar was held December 13th, and the Spring 2012 seminar was held May 5th. During each capstone, participants completed the CETAI instrument. In addition, copies of the participants' lesson plans were obtained during the allotted capstone seminar for data analyses.

Data Analysis

Data analysis began with three randomly selected lesson plans from each participant using www.randomizer.org. The lesson plan quality panel evaluated ten lesson plans to determine inter-rater reliability (Gay et al., 2009; Ary et al., 2010) prior to dividing the randomly selected lesson plans evenly among the three panel members. The STEM depth panel did not undergo inter-rater reliability because each panel member represented a specific STEM component. However, the STEM depth panel did undergo intra-rater reliability (Gay et al., 2009; Ary et al., 2010) prior to evaluating the randomly selected lesson plans by evaluating five lesson plans once per day for three days. Evaluator scores where used in the multiple correlational analyses. Correlations were conducted between pre-service teachers' STEM attitude, interest and value; self-perceived STEM ability; mathematics and science aptitudes; and self-perceived creativity. Microsoft Excel® was used to organize data and determine the frequencies, percent, means, and standard deviations. SPSS was used to determine all correlations and their significance.

Research question one sought to determine the demographic data of pre-service teachers including current age, gender, ethnicity, grade point average (GPA), number of STEM courses taken and involvement in STEM extracurricular programs reported on the STEM Attitudinal instrument. The creativity instrument collected courses taught by the pre-service agricultural education teachers during their 12-week student teaching internship. Basic descriptive statistics (i.e., frequencies and percentages) were used to summarize these data.

Research question two sought to determine the self-perceived creativity (CETAI Instrument/appendix E), science and mathematics aptitude (OGET scores) and STEM attitude (including STEM interest, value, and self-perceived STEM ability) (SAT STEM Instrument/appendix D) of pre-service agricultural education teachers. Interval data from the instruments were described using a grand mean representative of the items for each instrument as used in previous studies (Aschenbrener, 2008; Mahoney, 2009). Standard deviations were used to describe the range and variance of the measures.

Multiple grand means came from the SAT STEM instrument. The SAT STEM instrument was used to measure not only STEM attitude, but STEM interest, STEM value and self-perceived STEM ability. Thus, there was a grand mean for STEM attitude as well as the items which contributed to each of the following: STEM interest, STEM value and self-perceived STEM ability. STEM interest was determined from items one to six and items nineteen to twenty-four, n=12. STEM self-perceived ability was determined from items seven to twelve, n=6. STEM value was determined from items thirteen to eighteen, n=6. All twenty-four items were used to determine STEM attitude. Further, each item required a response for each area of STEM: one for science, one for technology, one for engineering, and one for mathematics. Thus, cumulatively, there were 96 total items for STEM attitude. Also, there were 48 total items for STEM interest; 24 total items for STEM value and 24 total items for self-perceived STEM ability. While most items were positively stated, there were ten items stated negatively. These ten negatively stated items required reverse coding for determining the grand means. These ten items were as follows: items one, four, seven, nine, ten, twelve, fifteen, eighteen, twenty, and twenty-three (see appendix D).

Research question three sought to determine the percentage of lesson plans containing STEM concepts taught by pre-service agricultural education teachers during the 12-week student teaching internship. A random sample of three lesson plans per pre-service teacher were selected as a representation of the lesson plans created over the 12-week period, thus allowing one randomly selected lesson plan to represent 33.3% of each participants total lesson plans. These data were represented by basic descriptive statistics (i.e., frequencies and percentages). The expert panel used the STEM Depth Evaluation Form (see appendix G) to record the STEM content found in each lesson plan.

Research question four sought to determine the quality of the lesson plans created by pre-service agricultural education teachers. The departmental lesson plan rubric (see appendix F), which aligned with the department lesson plan template, was used to score the lesson plans' quality. The rubric allows for a score between zero and twenty. Data were reported as means and standard deviations per each rubric item. This analysis was used to assess the overall quality of the lessons.

Research question five sought to determine the aspects of STEM pre-service agricultural education teachers planned to teach most frequently. The specific concepts teachers planned to teach were identified by the STEM depth expert panel on the STEM Depth Evaluation Form (see appendix G). Data were reported using frequencies and percentages.

Research question six sought to determine the grade level of the STEM concepts pre-service agricultural education teachers planned to teach, as identified by the STEM depth expert panel on the STEM Depth Evaluation Form (see appendix G). Data were reported using frequencies and percentages.

Research question seven sought to determine the relationship between pre-service agricultural education teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., interest, value; and self-perceived STEM ability). Multiple correlation was used to determine the variance of X variables and reported as (Pearson) R2. Further, the Pearson product moment correlations were used to analyze these data due to the data being interval or ratio in nature (Ary et al., 1996).

CHAPTER IV

FINDINGS

This chapter describes the results of the data analyzed to accomplish the study's purpose and addresses its seven research questions. The purpose of this study was to determine the extent to which pre-service teachers in agricultural education at OSU planned to incorporate STEM content into their agricultural education lessons during the 12-week student teaching internship. This study also sought to determine the correlation between pre-service teachers' science and mathematics aptitudes, self-perceived instructional creativity and STEM attitude (i.e., interest, value and self-perceived ability).

Research Questions

The following research questions guided this study.

1. What are the personal and professional characteristics of pre-service agricultural teachers in agricultural education during the Fall 2011 and Spring 2012 semesters?
2. What are pre-service agricultural teachers' self-perceived instructional creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability) and science and mathematics aptitudes?

3. What percentage of pre-service agricultural teachers' lesson plans contained STEM concepts during the 12-week student teaching internship?
4. What quality level are pre-service agricultural teachers' lesson plans per the departmental lesson plan rubric?
5. What aspects of STEM do pre-service agricultural teachers plan to teach most frequently?
6. What grade level of STEM standards do pre-service agricultural teachers plan to integrate into their lesson plans?
7. What is the relationship between pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., STEM interest, value, and self-perceived STEM ability)?

Findings Related to Research Question One

Research question one sought to describe the personal and professional characteristics of pre-service agricultural teachers (n = 30) in agricultural education during the Fall 2011 and Spring 2012 semesters. Specifically, the participants' age, gender, ethnicity, grade point average (GPA), number of STEM courses taken, number of STEM after-school programs participated and courses taught were examined using appropriate statistical measures to determine measures of central tendency and variability (Ary, Jacobs, & Razavieh, 2002).

The personal characteristics of age, gender, ethnicity and GPA are represented in Table 1. The pre-service teachers ranged from 20 to 26 years of age with the most frequent age being 22 years old (f = 11, 36.67%). Regarding gender, 19 (63.33 %) pre-service teachers were female and 11 (36.67%) were male. Twenty-six (86.67 %) pre-service teachers self-identified as white, one (3.33%) self-identified as Hispanic and three (10%) self-identified as Native American (see Table 1).

Due to a minimum GPA requirement for pre-service teachers, necessitated by the Oklahoma Department of Education (2.50), GPAs were collapsed into three ranges. Eleven (36.67%) pre-service teachers had a GPA in the range of 2.50 to 2.99. Eight (26.367%) pre-service teachers had a GPA in the range of 3.00 to 3.49. The final 11 (36.67%) pre-service teachers had a GPA in the range of 3.50 to 4.00 (see Table 1).

Table 1

Personal and Professional Characteristics of Pre-service Teachers in Fall 2011 and Spring 2012

Variable	*f*	%
Current Age		
20 years	1	3.33
21 years	7	23.33
22 years	11	36.67
23 years	6	20.00
24 years	2	6.67
25 years	1	3.33
26 years	1	3.33
Gender		
Male	11	36.67
Female	19	63.33
Ethnicity		
Black	0	0
White	26	86.67
Asian	0	0.00
Hispanic	1	3.33
Native American	3	10.00
Grade Point Average[a]		
2.50 to 2.99	11	36.67

3.00 to 3.49	8	26.67
3.50 to 4.00	11	36.67

Note. [a]A minimum grade point average of 2.50 is required to student teach in Oklahoma (Oklahoma State University, 2018). Therefore, all pre-service teachers had a grade point average of at least 2.50.

Pre-service teachers participated in a minimum of 298 total formal courses and 122 after-school programs in STEM (see Table 2). The minimum total number of science courses taken by participants was 118. Regarding the individual science classes, the greatest number of pre-service teachers (f = 17, 56.67%) reported taking five or more science courses. Four (13.33%) pre-service teachers participated in four science courses. Three (10%) pre-service teachers participated in three science courses.

Pre-service teachers identified taking a minimum total of 59 technology courses. The most frequent number of technology courses taken by pre-service teachers was nine (30%). Eight (26.67%) pre-service teachers participated in two technology courses. Six (2%) pre-service teachers participated in four technology courses. Three (10%) pre-service teachers participated in one technology course. Two (6.67%) pre-service teachers participated in three courses and two (6.67%) pre-service teachers participated in five or more technology courses (see Table 2).

Engineering courses had the lowest number of minimum totals taken among the pre-service teachers (N = 41). Four (13.33%) participants took one engineering course. Three (10%) pre-service teachers participated in two, three and four engineering courses, respectively. Two (6.67%) pre-service teachers participated in five or more engineering courses (see Table 2).

Mathematics courses contained the second highest number of courses taken by pre-service teachers (N = 80). Fourteen (46.67%) pre-service teachers participated in two mathematics courses. Five (16.67%) pre-service teachers participated in three mathematics courses. Four (13.33%) pre-service teachers participated in four courses, and another four (13.33%) participants took five or more mathematics courses. One (3.33%) pre-service teacher participated in one mathematic course (see Table 2).

Pre-service teachers reported participating in a minimum total of 49 after-school science programs. Six (20%) pre-service teachers participated in one or two after-school science programs. Four (13.33%) pre-service teachers participated in three after-school science programs. One (3.33%) pre-service teacher participated in four after-school science programs. Three (10%) pre-service teachers participated in five or more after-school science programs (see Table 2).

Pre-service teachers reported participating in a minimum total of 24 after-school technology programs. Six (20%) pre-service teachers participated in one after-school technology program. Three (10%) pre-service teachers participated in two after-school technology programs, and one (3.33%) each participated in three, four and five or more after-school programs technology programs, respectively (see Table 2).

Pre-service teachers reported participating in a minimum total of 19 after-school engineering programs. Six (20%) pre-service teachers participated in one after-school engineering program. Two (6.67%) pre-service teachers participated in five or more after-school engineering programs and one (3.33%) pre-service teachers participated in three after-school engineering programs (see Table 2).

Pre-service teachers reported participating in a minimum total of 30 after-school mathematics. Eight (26.67%) pre-service teachers participated in one after-school mathematics program. Four (13.33%) pre-service teachers participated in two after-school mathematics programs. Two (6.67%) pre-service teachers participated in five or more after-school programs mathematics. One (3.33%) pre-service teachers participated in four after-school mathematics programs (see Table 2).

Table 2

Number of STEM Courses and After-School Programs Taken by Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Item	0	1	2	3	4	5+	Minimum Total
How many classes/courses have you taken involving the following subjects:							
Science	2	0	4	3	4	17	118+
Technology	9	3	8	2	6	2	59+
Engineering	15	4	3	3	3	2	41+
Mathematics	2	1	14	5	4	4	80+
Combined STEM courses							298 +
How many after-school, weekend, or summer programs have you participated in regarding the following subjects:							
Science	10	6	6	4	1	3	49+
Technology	18	6	3	1	1	1	24+
Engineering	21	6	0	1	0	2	19+
Mathematics	15	8	4	0	1	2	30+
Combined after-school STEM programs							122 +

Pre-service teachers reported teaching 123 total courses during their student teaching experience, as shown in Table 3. Pre-service teachers taught 29 unduplicated courses during the Fall 2011 and Spring 2012 semesters. The most frequently taught course was Agricultural Education I (f = 23, 76.67%) followed by Agricultural Exploration (f = 19, 63.33%), Agricultural Mechanics I (f = 18, 60%) and Animal Science (f = 13, 43.33%). The least frequently taught courses were Agricultural Biology; Agricultural Communication, Leadership and Professional Development; Agricultural Geology; Agricultural Leadership; Agricultural Structures; Botany; College Preparation; Companion Animals; Environmental Science; Food Science; Greenhouse Management; Nursery Landscape; Plant and Soil Science; Plant Science; Principles of Agricultural Food and Natural Resources; Scientific Research Design; and Soil Science ($f = 1$, 3.33%), respectively (see Table 3).

Table 3

Courses Taught by Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Variable	*f*	%
Agricultural Biology	1	3.33
Agricultural Communication, Leadership, and Professional Development	1	3.33
Agricultural Communications	6	20.00
Agricultural Education I	23	76.67
Agricultural Education II	7	23.33
Agricultural Exploration	19	63.33
Agricultural Geology	1	3.33
Agricultural Leadership	1	3.33
Agricultural Mechanics I	18	60.00
Agricultural Mechanics II	3	10.00
Agricultural Structures	1	3.33
Animal Science	13	43.33
Botany	1	3.33
College Preparation	1	3.33
Companion Animals	1	3.33
Environmental Science	1	3.33
Equine Science	2	6.67
Floral Design	2	6.67
Food Science	1	3.33
Greenhouse Management	1	3.33
Introduction to Horticulture	6	20.00
Natural Resources	5	16.67
Nursery & Landscape	1	3.33
Plant & Soil Science	1	3.33
Plant Science	1	3.33
Principles of Agricultural Food and Natural Resources	1	3.33
Scientific Research and Design	1	3.33
Soil Science	1	3.33
Wildlife Management	2	6.67
Total Courses Taught by Student Teachers	123	100.00

Findings Related to Research Question Two

Research question two sought to describe the pre-service agricultural teachers' self-perceived creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability), and science and mathematics aptitudes. Self-perceived creativity was reported on a Likert-type scale ranking as follows: 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = undecided, 5 = slightly agree, 6 = agree, and 7 = strongly agree. Self-perceived STEM ability was ranked on a Likert-type scale as follows: 1 = most, 2 = more, 3 = less, and 4 = least. Pre-service teachers' science and mathematics aptitudes were grouped according to their OGET scores.

Self-perceived creativity during their student teaching internship was determined through Aschenbrener's (2008) Creative and Effective Teaching Assessment (CETA). Each pre-service teacher's creativity was determined for all 16 Likert-type scale items (see Table 4). One pre-service teacher (PS15) strongly disagreed with his/her instructional creativity (*M* = 1.00, *SD* = 0.00). Another participant (PS01) ranged between undecided and slightly agree (*M* = 4.81, *SD* = 0.75) regarding his or her instructional creativity. The remaining pre-service teachers ranged from slightly agree to strongly agree regarding their perceived instructional creativity with the highest average being that of PS07 (*M* = 7.00, *SD* = 0.00), indicating he/she strongly agreed with his/her instructional creativity (see Table 4).

Table 4

The Self-Perceived Instructional Creativity of Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Participant [a]	*M*	*SD*
PF01	6.50	0.63
PF02	6.31	0.60
PF03	6.13	0.72

PF04	5.69	1.25
PF05	6.00	0.63
PF06	6.13	0.72
PF07	5.88	0.81
PF08	6.19	0.75
PF09	6.69	0.48
PF10	6.00	0.63
PF11	6.31	0.70
PS01	4.81	0.75
PS02	5.56	0.73
PS03	5.81	0.40
PS04	6.00	0.37
PS05	6.44	0.63
PS06	6.19	0.75
PS07	7.00	0.00
PS08	6.00	0.73
PS09	6.63	0.50
PS10	6.50	0.73
PS11	6.06	0.93
PS12	5.63	1.41
PS13	6.44	0.81
PS14	5.13	0.89
PS15	1.00	0.00
PS16	5.94	0.25
PS17	6.25	0.68
PS18	6.38	0.62
PS19	5.75	1.24
Participants Average	5.91	1.24

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Slightly Disagree; 4 = Undecided; 5 = Slightly Agree; 6 = Agree; 7 = Strongly Agree.

STEM attitude (including STEM interest, value, and self-perceived STEM ability) for pre-service teachers was measured by Mahoney's (2009) Student Attitude Toward STEM (SATSTEM) survey. The SATSTEM used a Likert scale consisting of 1 = most, 2 = more, 3 = less, and 4 = least to designate the favorable reaction intensity level a participant had to a subject (Mahoney, 2009). Ten items were negatively written and required reverse coding. Those ten items were items one, four, seven, nine, ten, twelve, fifteen, eighteen, twenty, and twenty-three. Thus, the negatively written items were coded as 4 = most, 3 = more, 2 = less, and 1 = least. Still, a lower mean score for pre-service teachers indicated a higher intensity level of perceived STEM attitude, interest, value and self-perceived ability. Inversely, a higher mean score for a pre-service teacher indicated a lower intensity level of perceived STEM attitude, interest, value and self-perceived ability.

Pre-service teachers' STEM interest means scores (see Table 5) fell between three (less reaction intensity) and one (most reaction intensity). Items one through six and nineteen through twenty-four of the SAT STEM survey (appendix D) were used to determine participants STEM interest mean scores. The lowest three scores, indicating most favorable reaction intensity, were PF09 (*M* = 1.38, *SD* = 0.82), PF06 (*M* = 1.54, *SD* = 0.82), and PF10 (*M* = 1.58, *SD* = 0.92). A total of eight participants' mean scores were below 2.00 (more reaction intensity). The majority (17) of the participants' mean scores fell between 2.00 (more reaction intensity) and 2.50 with seven of those scoring 2.50 exactly. The highest three mean scores, indicating less favorable reaction intensity, were PS14 (*M* = 2.73, *SD* = 1.22), PS02 (*M* = 2.71, *SD* = .99), and PS16 (*M* = 2.67, *SD* = 1.15). Twenty-five pre-service teachers had mean scores at 2.5 or below, which indicating more to most favorable intensity for STEM interest. The participants' collective average mean score was 2.20 (*SD* = 1.13), indicating a more favorable reaction intensity for STEM interest (see Table 5).

Table 5

The STEM Interest of Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Participant[a]	*M*	*SD*
PF01	1.83	1.12
PF02	2.50	1.13
PF03	2.50	1.13
PF04	2.06	0.89
PF05	1.77	1.04
PF06	1.54	0.82
PF07	1.81	1.21
PF08	2.50	1.13
PF09	1.38	0.76
PF10	1.58	0.92
PF11	2.50	1.13

PS01	2.15	0.80
PS02	2.71	0.99
PS03	2.48	0.90
PS04	1.75	1.14
PS05	2.50	1.22
PS06	2.50	1.13
PS07	2.50	1.13
PS08	1.71	0.80
PS09	2.54	0.54
PS10	2.38	1.51
PS11	2.17	1.15
PS12	2.02	1.10
PS13	2.58	1.44
PS14	2.73	1.22
PS15	2.13	1.12
PS16	2.67	1.15
PS17	2.15	0.92
PS18	2.40	0.87
PS19	2.06	1.16
Participants Average	2.20	1.13

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Most 2 = More; 3 = less; 4 = least.

STEM value was measured using the SAT STEM survey items thirteen through eighteen. The lowest three scores regarding STEM value (see Table 6), indicating most favorable reaction intensity for pre-service teachers, were PF09 (M = 1.00, SD = 0.00), PS04 (M = 1.08, SD = .28), and PF01 (M = 1.13, SD = 0.61). The highest mean score (M=2.50), indicating less favorable reaction intensity, was held by the following five participants: PF02 (SD = 1.14), PF03 (SD = 1.14), PF08 (SD = 1.14), PS06 (SD = 1.14), PS07 (SD = 1.14), and PS13 (SD = 1.41). All the scores fell below a mean score of 2.50 with majority (16 participants) of the mean scores falling between 1.00 (most favorable reaction intensity) and 2.00 (more favorable reaction intensity). The remaining fourteen pre-service teachers had mean scores between 2.00 and 2.50. The participants' collective mean score was 1.85 (SD = 1.05), indicating a more favorable reaction intensity for STEM value (see Table 6).

Table 6

The STEM Value of Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Participant[a]	*M*	*SD*
PF01	1.13	0.61
PF02	2.50	1.14
PF03	2.50	1.14
PF04	1.67	0.96
PF05	1.88	0.74
PF06	1.08	0.28
PF07	1.17	0.38
PF08	2.50	1.14
PF09	1.00	0.00
PF10	1.17	0.48
PF11	2.46	1.18
PS01	1.92	0.88
PS02	2.00	0.88
PS03	2.42	1.06
PS04	1.08	0.28
PS05	2.04	1.20
PS06	2.50	1.14
PS07	2.50	1.14
PS08	1.33	0.56
PS09	2.04	0.20
PS10	1.88	1.39
PS11	2.08	0.97
PS12	1.29	0.75
PS13	2.50	1.41
PS14	2.46	1.18
PS15	1.58	0.97
PS16	2.29	1.08
PS17	1.92	1.02
PS18	1.38	0.71
PS19	1.21	0.51
Participants Average	1.85	1.05

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Most 2 = More; 3 = less; 4 = least.

Self-perceived STEM ability was measured using the SAT STEM survey items seven through twelve. The lowest three mean scores regarding pre-service teachers' self-perceived STEM ability (see Table 7), indicating most self-perceived STEM ability, were PF10 (*M* = 1.42, *SD* = .78), PS08 (*M* = 1.25, *SD* = .44), and PS19 (*M* = 1.38, *SD* = .88). The highest three mean scores, indicating less self-perceived STEM ability were PS02 (*M* = 2.96, *SD* = 1.00), PS15 (*M* = 2.83, *SD* = 1.01), and PS18 (*M* = 2.92, *SD* =.78). All participants' mean scores fell between a mean score of 1.00 (most favorable reaction intensity) and 3.00 (less favorable reaction intensity) with the majority being between a mean score of 2.00 and 3.00. Seventeen participants had mean scores between 2.50 and 3.00 making majority of the participants have less favorable reaction intensity. The participants' collective average mean score of 2.40 placed the pre-service teachers between more and less favorable reaction intensity regarding their self-perceived STEM ability (see Table 7).

Table 7

The Self-perceived STEM Ability of Pre-service Teachers in the Fall 2011 and Spring 2012 Semesters

Participant[a]	*M*	*SD*
PF01	2.00	1.44
PF02	2.50	1.14
PF03	2.50	1.14
PF04	2.71	1.08
PF05	2.42	0.83
PF06	2.42	1.18
PF07	2.33	1.31
PF08	2.50	1.14
PF09	2.29	1.12
PF10	1.42	0.78
PF11	2.50	1.14
PS01	2.33	0.96
PS02	2.96	1.00
PS03	2.71	0.91
PS04	2.04	1.20
PS05	2.33	1.37
PS06	2.50	1.14
PS07	2.50	1.14
PS08	1.25	0.44
PS09	2.58	0.50
PS10	2.50	1.53
PS11	2.50	1.32
PS12	1.63	1.13
PS13	2.71	1.37
PS14	2.71	1.27
PS15	2.83	1.01
PS16	2.25	1.11
PS17	2.67	0.96

PS18	2.92	0.78
PS19	1.38	0.88
Participants Average	2.40	1.16

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Most 2 = More; 3 = less; 4 = least.

Pre-service teachers' STEM interest, value, and self-perceived ability were combined in Mahoney's (2009) instrument (SAT STEM survey) to form STEM attitude. All pre-service teachers' STEM attitude means scores (see Table 8) fell between 1.00 (i.e., most favorable STEM attitude), and 3.00 (i.e., less favorable STEM attitude). The lowest three scores, indicating slightly more favorable STEM attitude, were PF09 (M = 1.51, SD = .91), PF10 (M = 1.44, SD = .81), and PS08 (M = 1.50, SD = .70). The highest three mean scores, indicating slightly less favorable STEM attitude, were PS03 (M = 2.59, SD = .94), PS13 (M = 2.59, SD = 1.40), and PS14 (M = 2.66, SD = 1.21). All the participants' mean scores were between 1.00 and 2.59. Most of the participants mean scores were between 2.00 and 2.59, more favorable to slightly less favorable attitude toward STEM. The participants' collective mean score was 2.16 (SD = 1.13), indicating the group had a more favorable STEM attitude (see Table 8).

Table 8

The Overall STEM Attitude of Pre-service Teachers in Fall 2011 and Spring 2012 Semesters

Participant[a]	*M*	*SD*
PF01	1.70	1.15
PF02	2.50	1.12
PF03	2.50	1.12
PF04	2.13	1.02
PF05	1.96	0.95
PF06	1.65	0.96
PF07	1.78	1.16
PF08	2.50	1.12
PF09	1.51	0.91
PF10	1.44	0.81
PF11	2.49	1.13
PS01	2.14	0.87

PS02	2.16	1.02
PS03	2.59	0.94
PS04	2.52	1.06
PS05	1.66	1.26
PS06	2.34	1.12
PS07	2.50	1.12
PS08	1.50	0.70
PS09	2.43	0.52
PS10	2.28	1.49
PS11	2.23	1.16
PS12	1.99	1.13
PS13	2.59	1.40
PS14	2.66	1.21
PS15	2.17	1.14
PS16	2.47	1.13
PS17	2.22	0.99
PS18	2.27	0.98
PS19	1.68	1.03
Participants Average	2.16	1.13

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Most 2 = More; 3 = less; 4 = least.

OGET science scores (see Table 9) were recorded in ranges of ten starting with a score of 151 to 160. The range containing the most participants was 261 to 270 (f = 5, 16.67 %). Four (13.33 %) participants each scored in the ranges of 241 to 250, 281 to 290, and 291 to 300, respectively. Three participants (10%) scored in the range of 271 to 280. Ranges of 211 to 220, 221 to 230 and 231 to 240 each contained two participants (6.67%). Ranges of 151 to 160, 201 to 210 and 251 to 260 each had one participant (3.33%). One pre-service teacher did not report his/her OGET science score (see Table 9).

OGET mathematics scores (see Table 9) were recorded in ranges of ten starting with a score of 231. The range containing the most participants was 291 to 300 (f = 13, 43.33%). Six (20%) pre-service teachers scored in the range of 281 to 290. Four (13.33%) pre-service teachers scored in the range of 261 to 270. Three (10%) pre-service teachers scored in the range of 271 to 280. Two (6.67%) pre-service teachers scored in the range of 231 to 240. One (3.33%) pre-service teacher scored in the 251 to 260 range. One (3.33%) pre-service teacher did not report his/her OGET mathematics score (see Table 9).

Table 9

The Science and Mathematics Aptitudes of Pre-service Teachers as Determined by OGET Scores

Scores	*f*	%
OGET Science		
No score reported	1	3.33
151 to 160	1	3.33
161 to 170	0	0.00
171 to 180	0	0.00
181 to 190	0	0.00
191 to 200	0	0.00
201 to 210	1	3.33
211 to 220	2	6.67
221 to 230	2	6.67
231 to 240	2	6.67
241 to 250	4	13.33
251 to 260	1	3.33
261 to 270	5	16.67
271 to 280	3	10.00
281 to 290	4	13.33
291 to 300	4	13.33
OGET Mathematics Scores		
No score reported	1	3.33
231 to 240	2	6.67
241 to 250	0	0.00
251 to 260	1	3.33
261 to 270	4	13.33
271 to 280	3	10.00
281 to 290	6	20.00
291 to 300	13	43.33

Findings Related to Research Question Three

Research question three sought to describe the percentage of STEM concepts exhibited in lesson plans developed by pre-service teachers during the 12-week student teaching internship. Frequencies and percentages were determined for all the lessons per STEM content area as well as per participant. A total of 46 (51.11%) lesson plans contained science standards (see Table

10). Thirty-eight (42.22%) of those lessons, however, contained only one science standard. Four (4.44%) lessons contained two science standards, and another four (4.44%) lessons contained three science standards (see Table 10).

Technology standards (*f* = 5) were only found in one (1.11%) lesson plan. Engineering standards were found in three (3.33 %) lessons. One (1.11%) lesson contained one engineering standard. One (1.11%) lesson contained two engineering standards. Another (1.11%) lesson contained three engineering standards (see Table 10).

Mathematics standards were found in a total of 18 (20%) lessons. Twelve (13.33%) lessons contained one mathematics standard. The remaining six (6.67%) lessons contained two mathematics standards (see Table 10).

Overall, a total of 54 (60%) lessons were found to contain at least one STEM standard. Forty-three (47.78%) lessons contained one STEM standard. Nine (10%) lessons contained two STEM standards. Two (2.22%) lessons contained three STEM standards (see Table 10).

Table 10

Percentage of Pre-service Agricultural Teachers' Lessons Containing STEM Concepts Taught During the 12-week Student Teaching Internship

Standards	*f*	%
Lessons Containing Science Standards		
Lessons with 1 standard	38	42.22
Lessons with 2 standards	4	4.44
Lessons with 3 standards	4	4.44
Lessons with 4 standards	0	0.00
Lessons with 5 standards	0	0.00
Total lessons with standards	46	51.11
Lessons Containing Technology Standards		
Lessons with 1 standard	0	0.00
Lessons with 2 standards	0	0.00
Lessons with 3 standards	0	0.00
Lessons with 4 standards	0	0.00
Lessons with 5 standards	1	1.11
Total lessons with standards	1	1.11
Lessons Containing Engineering Standards		

Lessons with 1 standard	1	1.11
Lessons with 2 standards	1	1.11
Lessons with 3 standards	1	1.11
Lessons with 4 standards	0	0.00
Lessons with 5 standards	0	0.00
Total Lessons with Standards	3	3.33
Lessons Containing Mathematics Standards		
Lessons with 1 standard	12	13.33
Lessons with 2 standards	6	6.67
Lessons with 3 standards	0	0.00
Lessons with 4 standards	0	0.00
Lessons with 5 standards	0	0.00
Total Lessons with Standards	18	20.00
Lessons Containing STEM Overlap		
Lessons with only 1 STEM Standard Type	43	47.78
Lessons with 2 STEM Standard Types	9	10.00
Lessons with 3 STEM Standard Types	2	2.22
Lessons with all STEM Standard Types	0	0.00
Total Lessons with STEM Standards	54	60.00

All but one pre-service teacher in this study planned to teach a percentage of STEM standards in their 3 sampled lessons (see Table 11). Eleven participants had at least one (33.33%) lesson that contained STEM standards. Another eleven participants had two (66.67%) lessons which contained STEM standards. The remaining seven participants had all three (100%) lessons containing STEM standards (see Table 11).

Table 11

The Lesson Plans Containing STEM Concepts Taught by Pre-service Teachers During the 12-week Student Teaching Internship

Participant[a]	*f*	%
PF01	3	100.00
PF02	1	33.33
PF03	1	33.33
PF04	2	66.67
PF05	2	66.67
PF06	1	33.33
PF07	2	66.67
PF08	3	100.00
PF09	3	100.00

PF10	2	66.67
PF11	2	66.67
PS01	1	33.33
PS02	2	66.67
PS03	3	100.00
PS04	1	33.33
PS05	1	33.33
PS06	3	100.00
PS07	2	66.67
PS08	1	33.33
PS09	3	100.00
PS10	2	66.67
PS11	1	33.33
PS12	3	100.00
PS13	1	33.33
PS14	1	33.33
PS15	0	0.00
PS16	1	33.33
PS17	2	66.67
PS18	2	66.67
PS19	2	66.67
Total Lessons	54	60.00

Note. [a] = Participant's student teaching internship according to semester (PF = Participant in the Fall semester; PS = Participant in the Spring semester). Scale: 1 = Most 2 = More; 3 = less; 4 = least.

Findings Related to Research Question Four

Research question four sought to describe the quality of pre-service agricultural teachers' lesson plans during the 12-week student teaching internship, per the departmental lesson plan rubric. Over two-thirds of the lessons' quality scores were more than fifty percent of the possible score, indicating they received a score of at least 10 out of 20 (see Table 12). Three (3.33%) lesson plan quality scores ranged between 0 and 2.50. Six (6.67%) of the lessons had a quality score range of 2.51 to 5.00. Eleven (12.22%) of the lessons had a quality score range of 5.01 to 7.5. Five (5.56%) lessons had a quality score range of 7.51 to 10.00. Seven (7.78%) lessons had a quality score range of 10.10 to 12.50 range. Eighteen (20%) lessons had a quality score range of 12.51 to 15.00 held. Fifteen (16.67%) lessons had a quality score range of 15.10 to 17.50. Twenty-five (27.78%) lessons had a quality score range of 17.51 to 20.00 (see Table 12).

Table 12

Pre-service Teachers' Lesson Plan Quality Scores by Range

Lesson Plan Quality Scores	*f*	%
0 to 2.50	3	3.33
2.51 to 5.00	6	6.67
5.10 to 7.50	11	12.22
7.51 to 10.00	5	5.56
10.10 to 12.50	7	7.78
12.51 to 15.00	18	20.00
15.10 to 17.50	15	16.67
17.51 to 20.00	25	27.78
Total Lessons	90	100.00

Note. Lesson plan quality was assessed on a 0 to 20 scale with 0 indicating nothing and 20 indicating a perfect score.

The overall quality of pre-service teachers' lessons equated to a mean score of 13.22 (*SD* = 5.37) out of 20 total possible points (see Table 13). Each Lesson Plan Quality Rubric category mean score was above 50% of the possible score for that category except for the two application categories.

Pre-service teachers had the highest mean scores regarding the following components of the lesson plan: means to assess and evaluate the learners are listed and described in detail (*M* = 1.31, *SD* = .80); objectives are listed and each includes a behavior, condition and criteria (degree); appropriate OK Pass standard(s) identified (*M* = 1.63, *SD* = .66); and means to assess and evaluate the learners are listed and described in detail (*M* = 1.31, *SD* = .80). Pre-service teachers received the lowest mean scores regarding the following components of the lesson plan: references and resources are identified (*M* = .70, *SD* = .46), plans are described to bring closure to the lesson (*M* = .66, *SD* = .43), and preliminary announcements and routines are listed (*M* = .30, *SD* = .25).

Table 13

Pre-service Teachers' Lesson Plan Quality Rubric Category Means and Standard Deviations

Lesson Plan Components	*M*	*SD*
Category 1: Course, unit, and lesson are identified	0.89	0.26
Category 2: Objectives are listed and each includes a behavior, condition, and criteria (degree); appropriate OK Pass standard(s) identified	1.63	0.66
Category 3: Equipment, materials and other resources needed are listed	0.81	0.38
Category 4: Preliminary announcements and routines are listed	0.30	0.25
Category 5: An interest approach (preparation) is adequately described	1.01	0.48
Category 6: Interest approach includes link to prior learning, motivation ("Why?"), and overview	1.03	0.54
Category 7: New material (presentation) to be taught is outlined and described in sufficient detail	1.27	0.76
Category 8: New material is listed in a logical sequence	0.79	0.39
Category 9: Methods, techniques, and media to be used to teach the new material are described	1.01	0.58
Category 10: Appropriate activities (application) are described to apply the concepts, principles, and/or skills learned	0.94	0.73
Category 11: Methods and materials used in application activities are described	0.88	0.77
Category 12: Plans are described to bring closure to the lesson	0.66	0.43
Category 13: Means to assess and evaluate the learners are listed and described in detail	1.31	0.80
Category 14: References and resources are identified	0.70	0.46
Total Lesson Quality Scores	13.22	5.37

Note. Scores range from zero to a max score. Max scores for categories are as follows: category 1=1, category 2=2, category 3=1, category 4=0.5, category 5=1.5 category 6=1.5, category 7=2, category 8=1, category 9=1.5, category 10=2, category 11=2, category 12=1, category 13=2, and category 14=1 for a total possible max score of 20.

Findings Related to Research Question Five

Research question five sought to describe the aspects of STEM pre-service teachers planned to teach most frequently. Pre-service teachers planned to teach 22 science standards in 45 (50%) lessons spanning biology, environmental science, physical science, physics and chemistry courses (see Table 14). Five technology standards were taught in one (1.11%) lesson.

Three (3.33%) lessons contained five engineering standards. Seven Mathematics standards were taught in 18 (20%) lessons. A total of 54 (60%) lessons contained at least one STEM standard.

Thirteen biology standards were identified across 42 (46.67%) lessons (see Table 14). The biology standards pre-service teachers planned to teach with the greatest frequency were Process Standard B1: Using observable properties, place cells, organism, and/or events into a biological classification system ($f = 9$, 10%); Standard H2: A sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents ($f = 7$, 7.78%); and Standard K2: As matter energy flows through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures, matter and energy are conserved in each change ($f = 6$, 6.67%).

Environmental Science included five standards in seven (7.78%) lessons. The environmental science standards pre-service teachers planned to teach with the greatest frequency were Standard K3B: Individuals and groups have the ability and responsibility to help maintain environmental quality and resolve environmental problems and issues and Standard H2: Ecosystems are composed of biotic and abiotic factors. Matter and energy move between these factors ($f = 2$, 2.22%), respectively (see Table 14).

Physical science standards were represented by two standards in five (5.56%) lessons. The first standard was Standard J2: Moving electric charges produce magnetic forces, and moving magnets produce electric forces; electricity and magnetism are two aspects of a single electromagnetic force (e.g., voltage, current, resistance, induction) was identified in two (2.22%) lessons. The other standard was Standard C5: Recognize potential hazards and practice safety procedures in all physical science activities was identified in three (3.33%) lessons.

One physics standard was found in two (2.22%) lessons. The physics standard was Standard I4: Electricity and magnetism are two aspects of a single electromagnetic force (e.g., series/parallel/complex circuits, electromagnets, induction, Ohm's Law, generators, motors, capacitors). One chemistry standard was present in one (1.11%) lesson. The chemistry standard was Standard C5: Recognize potential hazards and proactive safety procedures in all chemistry laboratory activities (see Table 14).

Table 14

The Frequency of Science Standards Present in Pre-service teachers' Lesson Plans (N = 57)

Science Standards to be taught	*f*	%
Biology I Standards		
Standard J2: Living organisms have the capacity to produce populations of infinite size, but environments and resources limit population size.	2	2.22
Standard H2: A sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.	7	7.78
Standard K2: As matter energy flows through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures, matter and energy are conserved in each change.	6	6.67
Standard K3: matter on earth cycles between the living (biotic) and nonliving (abiotic) components of the biosphere.	1	1.11
Standard J1: Organisms both cooperate and compete in ecosystems (i.e., parasitism and symbiosis) (e.g., symbiotic relationships).	5	5.56
Standard G3: Specialized cells enable organisms to monitor what is going on in the world around them (e.g. detect light, sound, specific chemicals, gravity, plant tropism, sense organs, homeostasis).	4	4.44
Standard I2: Characteristics of populations change through the mechanism of natural selection. These biological adaptations, including changes in structures, behaviors, and/or physiology, may enhance or limit survival and reproductive success within a particular environment.	1	1.11
Standard D: Interpret and communicate. Interpreting is the process of recognizing patterns in collected data by making inferences, predictions, or conclusions. Communicating is the process of describing, recording, and reporting experimental procedures and results to others.	1	1.11
Standard G2: In multicellular organisms, cells have levels of organization (i.e., cells, tissues, organs, organ systems, organisms).	3	3.33
Standard K1: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting,	1	1.11

releasing, and eliminating the matter and energy used to sustain the organism (i.e., photosynthesis and cellular respiration).		
Process standard B1: Using observable properties, place cells, organism, and/or events into a biological classification system.	9	10.00
Process standard C: Experimental design understanding experimental design requires that students recognize the components of a valid experiment.	1	1.11
Standard H1: Cells function according to the information contained in the master code of DNA (i.e., cell cycle, DNA replication & Transcription).	1	1.11
Total Lessons with Biology Standards Taught	42	46.67
Environmental Science		
Standard J1: Natural resources are classified as renewable or nonrenewable.	1	1.11
Standard J1B: Soil conservation methods are important for protection and managing topsoil and reducing erosion.	1	1.11
Standard K3B: Individuals and groups have the ability and responsibility to help maintain environmental quality and resolve environmental problems and issues.	2	2.22
Standard H2: ecosystems are composed of biotic and abiotic factors. Matter and energy move between these factors.	2	2.22
Standard H4: Matter flows through biogeochemical cycles.	1	1.11
Total Lessons with Environmental Science Standards Taught	7	7.78
Physical Science		
Standard J2: Moving electric charges produce magnetic forces, and moving magnets produce electric forces. Electricity and magnetism are two aspects of a single electromagnetic force (e.g., voltage, current, resistance, induction).	2	2.22
Standard C5: Recognize potential hazards and practice safety procedures in all physical science activities.	3	3.33
Total Lessons with Physical Science Standards Taught	5	5.56
Physics		
Standard I4: Electricity and magnetism are two aspects of a single electromagnetic force (e.g., series/parallel/complex circuits, electromagnets, induction, Ohm's Law, generators, motors, capacitors).	2	2.22
Total Lessons with Physics Standards Taught	2	2.22
Chemistry		
Process standard C5: Recognize potential hazards and proactive safety procedures in all chemistry laboratory activities.	1	1.11
Total Lessons with Chemistry Standards Taught	1	1.11
Total Lessons with Science Standards Taught	45	50.00

Technology standards were identified in only one (1.11%) lesson plan (see Table 15). In total, five technology standards were present in the lesson. The five standards are as follows: Standard 12: Apply safe and proper use of tools, machines, materials, process and technical concepts; Standard 13.1: Design and use instruments to collect data for product; Standard 13.2: Use collected data to find trends; Standard 13.3: Synthesize data to draw conclusions regarding the effects of technology was found; and Standard 13.4: Synthesize data to draw conclusions regarding the effects of technology was included (see Table 15).

Table 15

The Frequency of Technology Standards in Pre-service Teachers' Lesson Plans (N = 5)

Technology Standards	*f*	%
Standard 12: Apply safe and proper use of tools, machines, materials, process and technical concepts.	1	1.11
Standard 13.l: Design and use instruments to collect data for product.	1	1.11
Standard 13.2: Use collected data to find trends.	1	1.11
Standard 13.3: Interpret and evaluate accuracy of information to determine usefulness.	1	1.11
Standard 13.4: Synthesize data to draw conclusions regarding the effects of technology.	1	1.11
Total Lessons with Technology Standards Taught	1	1.11

Engineering standards were found in three (3.33%) total lessons (see Table 16). Five total standards were present in the three lessons. Each standard was found in only one (1.11%) lesson. The engineering standards found in the lessons were as follows: IED 1.1: Generate non-technical concept sketches to represent objects or convey design ideas; IED 1.1.3: Create drawings or diagrams as representations of objects, ideas, events, or systems; IED 1.4: Generate and document multiple ideas or solution paths to a problem through brainstorming; DE 1.1.1: Know and practice proper safety while working with electronics; and POE 1.2.5: Calculate circuit resistance, current and voltage using Ohm's Law (see Table 16).

Table 16

The Frequency of Engineering Standards Present in Pre-service Teachers' Lesson Plans (N = 5)

Engineering Standards	*f*	%
IED 1.1: Generate non-technical concept sketches to represent objects or convey design ideas.	1	1.11
IED 1.1.3: Create drawings or diagrams as representations of objects, ideas, events, or systems.	1	1.11
IED 1.4: Generate and document multiple ideas or solution paths to a problem through brainstorming.	1	1.11
DE 1.1.1: Know and practice proper safety while working with electronics.	1	1.11
POE 1.2.5: Calculate circuit resistance, current, and voltage using Ohm's Law.	1	1.11
Total Lessons with Engineering Standards Taught	3	3.33

Mathematics standards were found in 18 (20%) total lessons (see Table 17). There were seven standards depicted in pre-service teachers' lessons. Four different standards were found in one (1.11%) lesson. These four standards were as follows: CCSS Math Content 2.MDA.1: Measure length of objects using appropriate tools; CCSS Math Content ASSE.2: Use the structure of an expression to identify ways to write; CCSS Math Content 6.EEA.2: Write, read and evaluate expressions in which letters stand for numbers; and CCSS Math Practice MP1: Making sense of problems and perceive in solving them (path practice instead of standard). Two of the remaining three standards found were in four (4.44%) lessons each. These two standards were CCSS Math Content 6.RP.3.C: Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity, solve problems involving finding the whole given and the part) and CCSS Math Content 6.RP.3: Use ratio and rate reasoning to solve real world and mathematical problems. The last standard, CCSS Math Content A.SSE.2 use structure of an expression to identify ways to rewrite it, was found in two (2.22%) lessons.

Table 17

The Frequency of Mathematics Standards Present in Pre-service Teachers' Lesson Plans (N = 7)

Mathematics Standards	*f*	%

CCSS Math Content 2.MDA.1: Measure length of objects using appropriate tools.	1	1.11
CCSS Math Content ASSE.2: Use the structure of an expression to identify ways to rewrite it.	1	1.11
CCSS Math Content 6.RP.3.C Find a percent of a quantity as a rate per 100 (e.g. 30% of a quantity means 30/100 times the quantity, solve problems involving finding the whole given and the part.	4	4.44
CCSS Math Content 6.RP.3: Use ratio and rate reasoning to solve real-world and mathematical problems.	4	4.44
CCSS Math Content 6.EEA.2: Write, read, and evaluate expressions in which letters stand for numbers.	1	1.11
CCSS Math Practice MP1: Make sense of problems and persevere in solving them (path practice instead of standard).	1	1.11
CCSS Math Content A.SSE.2: Use structure of an expression to identify ways to rewrite it.	2	2.22
Total Lessons with Mathematics Standards Taught	18	20.00

Findings Related to Research Question Six

Research question six sought to describe the grade level of STEM standards pre-service teachers planned to integrate into their lessons. Frequencies and percentages were used to describe the grade levels of STEM standards addressed. Multiple STEM standards were found to apply across several grade levels, which resulted in a larger number of grade levels being addressed than the number of STEM standards taught or total lessons containing STEM.

Science standards were taught at the seventh-grade level and above (see Table 18). One (1.05%) standard was taught at the seventh-grade level. The most frequent science standards were taught at the 10th grade level (*f* = 35, 36.84%), 11th grade level (*f* = 26, 27.37%) and 9th grade level (*f* = 19, 20%). In all, pre-service teachers planned lessons containing 45 science standards (see Table 18).

Table 18

The Frequency and Percentage of Science Standards Identified in Pre-service Teachers' Lesson Plans by Grade Levels (N = 95)

Grade Level	*f*	%
<7	0	0.00
7	1	1.05
8	7	7.37
9	19	20.00
10	35	36.84
11	26	27.37
12	7	7.37
Total Lessons Containing Science Standards	45	50.00

Note: Percentages per grade level are the percentages for all science standards at that grade level. *Total Lessons Containing Science Standards* is the number (*f*) and percent of lessons containing science standards (%).

Only one (1.11%) lesson plan included the integration of technology standard. The lone technology standard was taught at the 8th grade level (see Table 19).

Table 19

The Frequency and Percentage of Technology Standards Identified in Pre-service Teachers' Lesson Plans by Grade Level (N = 1)

Grade Level	*f*	%
<7	0	0
7	0	0
8	1	100
9	0	0
10	0	0
11	0	0
12	0	0
Total Lessons Containing Technology Standards	1	1.11

Note: Percentages per grade level are the percentages for all technology standards at that grade level. *Total Lessons Containing Technology Standards* is the number (*f*) and percent of lessons containing technology standards (%).

Four (3.33%) lessons contained engineering standards (see Table 20). Two (50%) engineering standards were taught at the 10th grade level. One (25%) engineering standard was taught at the 9th grade and 11th grade levels, respectively (see Table 20).

Table 20

The Frequency and Percentage of Engineering Standards Identified in Pre-service Teachers' Lesson Plans by Grade Level (N = 4)

Grade Level	*f*	%
<7	0	0
7	0	0
8	0	0
9	1	25
10	2	50
11	1	25
12	0	0
Total Lessons Containing Engineering Standards	4	3.33

Note: Percentages per grade level are the percentages for all engineering standards at that grade level. *Total Lessons Containing Engineering Standards* is the number (*f*) and percent of lessons containing engineering standards (%).

Mathematics standards represented all grade levels from below 7th grade to 12th grade (see Table 21). The greatest frequency of mathematics standards ($f = 12$, 31.58%) were taught at the 7th grade level and below. Six (15.79%) standards each were taught at the 9th and 10th grade levels, respectively. In all, mathematics was represented by 38 total standards across eighteen (20%) lessons (see Table 21).

Table 21

The Frequency and Percentage of Mathematics Standards Identified in Pre-service Teachers' Lesson Plans by Grade Level (N = 38)

Grade Level	*f*	%
<7	12	31.58
7	4	10.53
8	2	5.26
9	6	15.79
10	6	15.79

11	6	15.79
12	2	5.26
Total Lessons Containing Mathematics Standards	18	20.00

Note: Percentages per grade level are the percentages for all mathematics standards at that grade level. *Total Lessons Containing Mathematics Standards* is the number (*f*) and percent of lessons containing mathematics standards (%).

The STEM standards found in the 54 lesson plans encompassed all grade levels (see Table 22). Many of the standards identified crossed multiple grade levels. The most frequent STEM standards identified in pre-service teachers' lesson plans occurred at the 10th grade level (f = 43, 31.20%), followed by the 11th grade level (f = 33, 23.90%) and the 9th grade level (f = 26, 18.84%).

Table 22

The Frequency and Percentage of STEM Standards Identified in Pre-service Teachers' Lessons by Grade Level (N = 138)

Grade Level	*f*	%
<7	12	8.69
7	5	3.62
8	10	7.20
9	26	18.84
10	43	31.20
11	33	23.90
12	9	6.52
Lessons Containing STEM Standards	54	60.00

Note: Percentages per grade level are the percentages for all STEM standards at that grade level. *Total Lessons Containing STEM Standards* is the number (*f*) and percent of lessons containing STEM standards (%).

Findings Related to Research Question Seven

Research question seven sought to determine the relationship between a pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., interest, value and self-perceived STEM ability). Correlational significance was designated as ** for the 0.01 level and * for the 0.05 level (see Table 23). There were both positive and negative correlations. Most of the correlations were weak. However, there were four moderate and four strong correlations.

Science and mathematics abilities had moderately positive correlation of $r = 0.661$** and was statistically significant at the 0.01 level. Self-perceived STEM ability and science ability had a moderately negative correlation of $r = -0.381$* and was statistically significant at the 0.05 level. Self-perceived STEM ability and STEM interested had a moderately positive correlation of $r = 0.541$** and was statistically significant at the 0.01 level. STEM value and self-perceived STEM ability had a moderately positive correlation of $r = 0.469$** and was statistically significant at the 0.01 level.

STEM value and STEM interest had a strong positive correlation of r = 0.85** and was statistically significant at the 0.01 level. STEM attitude and STEM interest had a strong positive correlation of $r = 0.954$** and was statistically significant at the 0.01 level. STEM attitude and self-perceived ability had a strong positive correlation of $r = 0.712$** and was statistically significant at the 0.01 level. STEM attitude and STEM value had a strong positive correlation of $r = 0.913$** and was statistically significant at the 0.01 level.

Several correlations were negative weak correlations. Two of these correlations were STEM attitude with both science and mathematics abilities (see Table 23). Another two weak negative correlations were between STEM interest and both science and mathematics ability (see Table 23). Creativity had a weak positive correlation with all other items except self-perceived

STEM ability. The weak negative correlation between creativity and self-perceived STEM ability was r = -0.167.

Table 23

The Correlational Variance for Pre-Service Teachers' Science and Mathematics Aptitudes, Self-Perceived Creativity, STEM Interest and Value, and Self-Perceived STEM Ability to the Percentage of Lessons Containing STEM Concepts

Variable	1	2	3	4	5	6	7
Math Ability	1						
Science Ability	.661**	1					
STEM Interest	-.036	-.239	1				
STEM Ability	-.148	-.381*	.541**	1			
STEM Value	.118	-.174	.850**	.469**	1		
STEM Attitude	-.015	-.285	.954**	.712**	.913**	1	
Creativity	.058	.256	.027	-.167	.106	.004	1

Note. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tail).

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS

This chapter is a presentation of the summary, conclusions, recommendations, and implications of this study. It contains a summary of the research design, subjects studied, instrumentation, data collection and data analysis procedures. Then, Chapter V presents the conclusions and implications of the study and finishes with implications and discussion.

Summary

Purpose of the Study

The purpose of this study was to determine the extent to which pre-service teachers in agricultural education at OSU planned to incorporate STEM content into their agricultural education lessons during the 12-week student teaching internship. This study also sought to determine the correlation between pre-service teachers' science and mathematics aptitudes, self-perceived instructional creativity, and STEM attitude (i.e., interest, value and self-perceived ability).

Research Questions

The following research questions guided this study.

1. What are the personal and professional characteristics of pre-service agricultural teachers in agricultural education during the Fall 2011 and Spring 2012 semesters?
2. What are pre-service agricultural teachers' self-perceived instructional creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability) and science and mathematics aptitudes?
3. What percentage of pre-service agricultural teachers' lesson plans contained STEM concepts during the 12-week student teaching internship?
4. What quality level are pre-service agricultural teachers' lesson plans per the departmental lesson plan rubric?
5. What aspects of STEM do pre-service agricultural teachers plan to teach most frequently?
6. What grade level of STEM standards do pre-service agricultural teachers plan to integrate into their lesson plans?
7. What is the relationship between pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (i.e., STEM interest, value, and self-perceived STEM ability)?

Limitations

This study can be applied only to the population of pre-service agricultural education teachers at OSU. The creativity instrument limited the study to the context of instruction resulting from its created purpose (Aschenbrener, 2008). Further, this study was limited by participants' self-perception of their abilities. It also was assumed each pre-service agricultural education teacher intended to integrate the STEM highlighted in the individual lesson plans. Finally, lesson plan quantity and quality varied from one participant to the next and might have reduced the capacity of STEM panel members' ability to identify STEM concepts the pre-service teacher intended to teach. An additional limitation of the study was with its lack of generalizability. Because of the purposive sample used in the study, generalizing the findings is restricted to pre-service agricultural teachers at OSU.

Research Design

A substantial portion of this study design was descriptive in nature with a singular correlational component, which is used widely in educational research (Ary et al., 2002; Aschenbrener, 2008; Gay et al., 2009; Huberty, 2003). Multiple correlational studies are used to understand relationships between complex variables and construct theories (Aschenbrener, 2008; Ary, Jacobs, & Razavieh, 2002; Huberty, 2003). "Correlational research seeks to examine the strength and direction of relationships among two or more variables (Ary et al., 2002, p. 25)."

Research Participants

Participants for the study were selected purposively from OSU students enrolled in AGED 4200-*Student Teaching in Agricultural Education*. The population was selected as a result of the instructional preparation of this course as well as the uniform lesson plan format which participants were instructed to utilize.

Measures

Mahoney's (2009) SAT STEM instrument was used to measure participants' STEM attitude (i.e., interest, value, and self-perceived ability). The pilot study provided alpha ratings of the content areas: science (.94), technology (.91), engineering (.93), and mathematics (.96) (Mahoney, 2009). Mahoney (2009) concluded there was a strong reliability coefficient of .92 alpha for the revised instrument regarding all content areas from the Cronbach's alpha procedure.

Aschenbrener's (2009) CETAI instrument was used to measure participants' self-perceived creativity. Aschenbrener (2009) used a panel of experts composed of two content experts and two instrumentation experts to address content, construct, and face validity. Cronbach's alpha resulted in a .84 (n = 28) for the four creative constructs in the instructor pilot test (Ashenbrener, 2009). Coefficients for each individual construct were as follows: fluency (.46), flexibility (.74), originality (.77), and elaboration (.68) (Ashenbrener, 2008).

Lesson plans were evaluated for quality as well as STEM content. The Lesson Plan Quality Rubric developed by the OSU Agricultural Education Teacher Preparation Program was used to evaluate participants' lesson plans. All students in agricultural education courses use the same lesson plan template founded around Allen's (1919) four-step instructional model and Tyler's (1950) four questions. Three OSU agricultural graduate students who were familiar with using the rubric were commissioned to evaluate the quality of participants' lesson plans. Inter-rater reliability for the panel members began at 48% agreement and increased to 70% agreement after initial discussion of scoring the same set of lesson plans. A Fleiss kappa coefficient of 0.67 was calculated and identified as moderate agreement per McHugh (2012). Further, 70% was deemed acceptable per guidelines utilized throughout literature per Stemler (2004), Jonsson and Svingby (2007), and Brown, Glasswell, and Harland (2004).

Four panel members in each STEM area assessed the STEM content level of each lesson plan. Each panel member had extensive preparation and teaching experience in his/her academic domain. STEM content panel members' experience ranged from five to twenty-eight years. The intra-rater reliability for each panel member was as follows: science panel member = 93%, technology panel member = 100%, engineering panel member = 100%, mathematics panel member = 100%. All reliability scores were above the typical guideline of 70% per Stemler (2004), Jonsson and Svingby (2007), and Brown et al. (2004). All panel members used the provided STEM depth form to assist in recording the STEM content identified in the lessons, as well as the grade level it addressed and the STEM standard the content met.

Procedure

The pre-service agricultural teachers enrolled in AGED 4200 during the Fall 2011 and Spring 2012 semesters were invited to volunteer for the study through a formal letter. Participants were provided 24 hours to complete the STEM Attitude instrument in the Fall; however, participants were scheduled for a different, specific time in the Spring to reduce complications. Participants completed the CETAI instrument during the one-day capstone seminar after completion of their student teaching internship. Randomly selected lesson plans were provided to the panel of experts to analyze after the completion of the student teaching capstone experience.

Data Analysis

Analysis of data began once all data were collected at the end of the Spring 2012 semester. Descriptive data from the pre-service agricultural education teachers was entered and mostly analyzed in Microsoft Excel ®. The remaining data (i.e., lesson plan quality and STEM competencies and crosswalks evident in lesson plans) were provided to the designated panel members for analysis during the Summer of 2012. After analysis from the panel members, data were entered into Microsoft Excel ® for further evaluation. Multiple correlation data were entered into SPSS and the Pearson correlation coefficients were used to calculate the alpha levels for the multiple correlational portion of the study (Miller, 1998).

Findings

Research Question One

Research question one sought to describe the personal and professional characteristics of pre-service agricultural teachers in agricultural education during the Fall 2011 and Spring 2012 semesters. Pre-service teachers were 63% female and 37% male and ranged between the age of

21 to 23 years old. Majority of the participants were white (86.7 %) with minority ethnicities being Native American (10%) and Hispanic (3.33%). Grade Point Averages were split predominantly between the ranges of 2.5 to 2.9 (36.67%) and 3.5 to 4.0 (36.67%).

Seventeen (56.67%) participants completed five or more science courses. Although majority of the participants ($f = 9$, 30%) failed to take a course in technology. Eight (26.67%) participants completed two courses in technology. Fifteen (50%) participants failed to take a course in engineering, and fourteen (46.67%) completed two courses in mathematics. The minimum total numbers of courses taken by participants were as follows: science with 118, technology with 59, engineering with 41, and mathematics with 80, for a combined minimum total of 298. Regarding after-school programs, the minimum total numbers taken were as follows: science with 49, technology with 24, engineering with 19, and mathematics with 30, for a combined minimum total of 122. The top four courses taught by preservice agricultural education teachers were Agricultural Education I ($f = 23$), Agricultural Exploration ($f = 19$), Agricultural Mechanics I ($f = 18$), and Animal Science ($f = 13$).

Research Question Two

Research question two sought to describe the pre-service agricultural education teachers' self-perceived creativity, STEM attitude (including STEM interest, value, and self-perceived STEM ability), and science and mathematics aptitudes. Most of the participants ranged from slightly agree to strongly agree regarding their perception of their ability to be creative in their instruction. Mean scores for STEM interest fell between most (one) and less (three) reaction intensity. The Majority, seventeen, participants maintained a mean score between more (2) and slightly less (2.5) STEM interest reaction intensity. Pre-service teachers' STEM value mean scores fell below 2.5, slightly less reaction intensity. The majority (16) of the participants' mean scores fell between most (one) and more (two) on STEM value reaction intensity. Pre-service teachers' self-perceived STEM ability mean scores fell between one (most) and three (less) with most of the participants having less favorable reaction intensity. All participants STEM attitude mean score fell between 1.00 (most) and 2.59 (less) reaction intensity. The majority of the participants' mean scores were between more (2.00) and less (2.59) for STEM attitude reaction intensity.

On average, participants had higher OGET scores in mathematics than they did in science. Regarding science competency, the top four ranges for participants' OGET science scores were 241 to 250 (n = 4), 261 to 270 (n = 5), 281 to 290 (n = 4), and 291 to 300 (n = 4). Regarding mathematics competency, the top four ranges for participants' OGET mathematics scores were 261 to 270 (n = 4), 271 to 280 (n = 3), 281 to 290 (n = 6), and 291 to 300 (n = 13).

Research Question Three

Research question three sought to describe the percentage of STEM concepts exhibited in lesson plans developed by pre-service agricultural teachers during the 12-week student teaching internship. Science standards were found in over half (f = 46, 51.11%) of the lesson plans that were evaluated. In contrast, only one lesson plan (1.1%) contained a Technology standard. Three (3.33%) of the lesson plans contained Engineering standards, and 18 lesson plans (20%) contained Mathematics standards. In all, 54 lesson plans (60%) contained concepts related to STEM standards.

Only one pre-service agricultural education teacher failed to have a randomly selected lesson plan contain STEM standards. Eleven participants had at least one lesson plan with STEM standards. Eleven participants had two lesson plans which contained STEM standards, and seven participants had three lesson plans which contained STEM standards.

Research Question Four

Research question four sought to describe the quality of pre-service agricultural teachers' lesson plans developed during the 12-week student teaching internship per the departmental lesson plan rubric. Majority of the lesson plans, two thirds, held a quality score over fifty percent, score of 10. Twenty-five lessons held a score over 17.51. The rest of the two thirds were distributed as follows: fifteen scored 15.1 to 17.5, eight scored 12.51 to 15, and seven scored 10.1 to 12.5. Overall quality had a mean score of 13.22 (*SD*=5.37) of the possible 20 total points. Each category on the rubric contained a mean score above 50% except for the two application categories. These categories held mean scores of 0.94 (*SD*=0.73) and 0.88 (*SD*=0.77).

Research Question Five

Research question five sought to describe the aspects of STEM pre-service teachers planned to teach most frequently. Twenty-two science standards were found in forty-five lesson plans encompassing biology, environmental science, physical science, physics, and chemistry courses. Five technology standards were included in one lesson plan; while five engineering standards were taught in three lesson plans. Seven mathematics standards spanned eighteen lesson plans. Thus, 54 total lesson plans contained STEM standards.

There were thirteen biology standards included in forty-two lesson plans. The top five Biology standards were process standard B1, standard H2, standard K2, standard J1, and standard G3. Process standard B1: using observable properties, place cells, organism, and/or events into a biological classification system was the most standard found with nine lessons. Standard H2: a sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents was the second most taught in seven lessons. Biology Standard K2: as matter energy flows through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures, matter and energy are conserved in each change fell in six lessons. Standard J1: organisms both cooperate and compete in ecosystems (i.e., parasitism and symbiosis) (e.g., symbiotic relationships) was taught in five lessons. Four lessons had plans to teach standard G3: specialized cells enable organisms to monitor what is going on in the world around them (e.g. detect light, sound, specific chemicals, gravity, plant tropism, sense organs, homeostasis).

Environmental Science included five standards in seven lessons. The two standards which were found in the most lessons with two each were standard K3B and standard H2. Standard K3B was individuals and groups have the ability and responsibility to help maintain environmental quality and resolve environmental problems and issues. Standard H2 was ecosystems are composed of biotic and abiotic factors. Matter and energy move between these factors. Each of the remaining three standards were found in one lesson each. Those last three standards were standard J1, standard J1B, and standard H4 (see Table 14).

The remaining science courses represented were physical science, physics, and chemistry. Physical science standard J2 and C5 were found in a total of five lessons. Standard J2 was found in two lessons; while standard C5 was found in three lessons. Physics standard I4: electricity and magnetism are two aspects of a single electromagnetic force (e.g., series/parallel/complex circuits, electromagnets, induction, Ohm's Law, generators, motors, capacitors) was the only standard found in two lessons. Lastly, chemistry standard C5: recognize potential hazards and proactive safety procedures in all chemistry laboratory activities was the only standard found in one lesson.

Only five technology standards were taught in one lesson. Technology standards included standard 12, 13.1, 13.2, 13.3, and 13.4 (see Table 14). These standards encompassed safe use of tools, collecting and analyzing data, as well as interpreting and synthesizing to make conclusions.

Three lessons contained engineering standards with five standards being present. Engineering standards present included IED 1.1, IED 1.13, IED 1.4, DE 1.1.1, and POE 1.2.5 (see Table 14). These standards addressed topics such as generating non-technical concept sketches, creating drawings or diagrams, generating and documenting solutions through brainstorming, practicing proper safety with electronics, and calculating circuit resistance, current, and voltage using Ohm's Law.

There were seven mathematic standards found in eighteen lessons. The four standards CCSS Math Content 2.MDA.1; CCSS Math Content ASSE.2; CCSS Math Content 6.EEA.2, and CCSS Math Practice MP1 were each found in one lesson by themselves. Standard CCSS Math Content A.SSE.2 was found in two lessons. The remaining two standards were found in four lessons each. These two standards representing majority of the standards found were CCSS Math Content 6.RP.3.C and CCSS Math Content 6.RP.3. CCSS Math Content 6.RP.3.C and CCSS Math Content 6.RP.3 both dealt with percent. The other mathematic standards revolved around measuring length; using expressions; write, read, and evaluate expressions; making sense of problems; and identify ways to rewrite expressions.

Research Question Six

Research question six sought to describe the grade level of STEM standards pre-service teachers planned to integrate into their lessons. Multiple standards spanned several grade levels resulting in a larger number of grade levels being taught than the number of standards being taught. Science standards taught did not fall below seventh grade. Majority of the science standards were taught at the ninth (19 standards), tenth (35 standards), and eleventh (26 standards) grade levels. There were 95 grade levels in 45 lessons under science standards. Technology standards only addressed the eighth-grade level in one lesson. Engineering had one standard at the ninth-grade level, two standards at the tenth-grade level, and one at the eleventh-grade level. All grade-levels were represented in mathematics standards. While majority of the standards were above the ninth-grade level, below seventh grade level had the single highest number of standards with twelve. Ninth-grade, tenth grade, and eleventh grade were each represent in six mathematic standards. Mathematics was represented by 38 total standards across eighteen lessons. Most of the grade levels represented in all STEM standards were ninth grade and above.

Research Question Seven

Research question seven sought to determine the relationship between pre-service agricultural teachers' science and mathematics aptitude, self-perceived instructional creativity, and STEM attitude (including interest, value, and self-perceived ability). Most of the correlations were weak. The weak correlations contained seven negative and six positive correlations. Four correlations were moderate in strength with one of those being negative. The moderately negative correlation was -.381 between self-perceived STEM ability and science aptitude. All the moderate correlations were significant at the 0.01 level except for the negative correlation of -.381 being significant at the 0.05 level. Four correlations were strong and positive with the lowest being .712. All the strong positive correlations were significant at the 0.01 level.

Conclusions and Implications

Research Question One

The majority of the participants in this study were white females between the age of 21 and 23 which met the required GPA and OGET scores for student teaching. The student teaching interns participated in a substantial number of STEM courses throughout their time at OSU, which provided them with a strong mathematics and science ability. After-school programs were not as numerous as were the courses that were taken. Pre-service teachers invested time outside of class to be involved in STEM related activities. This implies pre-service teachers had a desire to learn STEM content and be involved in STEM activities. However, this study did not measure the impact the courses or after-school programs had on pre-service teachers' STEM attitude (i.e., interest, value, and self-perceived ability). It could be extrapolated from the amount of STEM courses and after-school programs taken that pre-service teachers had a favorable STEM attitude under TPB's Behavioral Beliefs domain (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Conner & Armitage, 1998; Kraft et al., 2005; Sommer, 2011).

"People do what they intend to do and do not do what they do not intend" (Sheeran, 2002, p. 1). From this statement, the number of STEM courses and after-school programs taken, it can be concluded that the subjective norm is set up to allow pre-service teachers to take STEM courses more so than after-school programs. Perceived behavioral control can be impacted depending on whether the courses are deemed as being required or as electives. Perceived behavioral control could play a part in the number of after-school programs and courses in which a pre-service teacher participates.

Research Question Two

Pre-service agricultural teachers perceived themselves to be creative in their instruction and thus value creativity. STEM attitude (including STEM interest, value, and self-perceived STEM ability) fell between less (three) favorable reaction intensity and most (one) favorable reaction intensity on the Likert scale. Thus, favorable attitude, interest, value and perceived ability toward STEM existed. It is granted that this favorable intensity is not overwhelming. The slightly favorable self-perceived ability may explain the slightly favorable interest and attitude toward STEM. Since pre-service teachers at OSU are required to create some STEM integrated lessons prior to student teaching, the slightly favorable attitude may be reflective of Balschweid and Thompson (2000) and Kotrlik et al. (2003) findings. Balschweid and Thompson (2000) found perceived time necessary to incorporate science adequately was a concern of pre-service teachers. Kotrlick et al. (2003) found teachers' perceptions toward barriers to technology integration as powerful predictors of technology integration. Also, pre-service teachers' perception of their control to integrate STEM could potentially reduce their attitude and thus reduce their intention to integrate STEM (Ajzen, 2005, 2012; Ferguson et al., no date; Morris et al., 2012). Also, under the TPB's subjective norms and perceived behavioral control, the number of required STEM courses to take may contribute to the favorable STEM attitude.

Research Question Three

Agriculture is considered an applied science (Thompson and Warnick, 2007; Warnick et al., 2004) and may explain a portion of STEM standards being found, especially regarding science standards. The use of mathematics being used in some science content may account for it being the second most standards found in lessons. Both technology and engineering standards were sparsely represented potentially resulting from perceptual barriers to their integration (Kotrlick et al., 2003). Further, Balschweid and Thompson (2000) found the intended level of science integration by pre-service teachers was 74% prior to student teaching but fell to 54% after three months of student teaching. The integration of science alone fell below what Balschweid and Thompson (2000) found in their study with only 51.11% science integration. However, the overall 60% STEM integration level found in this study falls between the levels found by Balschweid and Thompson (2000). Thus, measures OSU DAELC are currently using have an impact on STEM integration levels. Resultingly though, are the measures OSU DAELC currently employing enough? What other activities in or out of course work could be implemented to increase the level of integration?

Oklahoma agricultural education utilizes its state curriculum development branch (CIMC) very well. What impact would occur if CIMC sold more STEM integrated curriculum? What would happen to CIMC if the CASE curriculum was adopted to be used in Oklahoma? One might think it easier to just adopt a nationally recognized STEM integrated agricultural curriculum versus having to design and build it from scratch. Would CIMC be willing, able and determined to integrate more STEM into their curriculum?

Research Question Four

Despite two thirds of the lesson plans scoring over 50% (score of 10), lesson plan quality impacted the capacity of panel members to determine STEM content in lesson plans. The mean score of 13.22 out of 20 clearly demonstrates key components of lessons were missing or lacking in detail. This is further demonstrated regarding the application portion having a mean score (0.94) less than 50% for each of the two application categories. Torres and Ulmer's (2007) findings that pre-service teachers spent 26.19% of their student teaching internship planning. However, from this study's findings, is this amount of time sufficient? Could there be a way to improve planning quality during this time? Did pre-service teachers become more efficient planners during this study (Torres & Ulmer, 2007)? Is there a way to change pre-service teachers' focus from the internal planning process to the external process of writing formal lesson plans (Ball et al., 2007)? Lesson planning is an important part of teaching (Ball et al., 2007; Baylor & Kitsantas, 2005; Bond & Peterson, 2004; Duke & Madsen, 1991; Kitsantas & Baylor, 2001; Reiser & Dick, 1996; Sung, 1982; Torres & Ulmer, 2007) and means should be taken to improve this for STEM integration.

What is the subjective norm for lesson planning required of current agriculture teachers? Do school districts require lesson plans to be turned in on a regular basis? What is the quality of those lesson plans? If current agriculture teachers do not have to turn in lesson plans or have no standard of quality, then pre-service teachers might have reduced their lesson planning efforts as a result of this subjective norm.

Research Question Five

Five science courses were represented in pre-service teachers' lesson plans. Those five courses were biology, environmental science, physical science, physics, and chemistry. Biology standards were the most found in lesson plans. Biology process standard B1: using observable properties, place cells, organisms, and/or events into a biological classification system was the most used in nine lessons. Biology standard H2: a sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents was found in seven lessons. Biology standard K2: as matter energy flows through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures, matter and energy are conserved in each change was found in six lessons. Seeing that classification, genetics, and energy flow in living systems encompass a huge portion of plant and animal science course, agriculture as an applied science plays some part in these findings (Thompson & Warnick, 2007; Warnick et al., 2004).

Technology and engineering were not integrated significantly in sampled lessons. Is this a result of the courses taught by pre-service teachers? Where the technology and engineering standards used to determine if integration was present the best standards to go by? Technology and engineering standards may need upgrading to account for different technologies and engineering present in career and technology education courses outside their specific areas? An example of technology would be the use of welding equipment and global positioning systems. Examples of engineering would be designing and constructing trailers or utilizing tissue culture to grow new plants. Did the STEM depth panel members consider such activities as part of their field?

Research Question Six

Majority of the standards taught utilizing science, engineering and mathematics were at high school level while technology was just below at eighth-grade level. Science was the one STEM area which contained a more even distribution of grade level with majority at the ninth (19 standards), tenth (35 standards), and eleventh (26 standards) grade levels. This may be a result of agriculture being considered an applied science (Thompson and Warnick, 2007; Warnick et al., 2004). Despite majority of the standards being at high school level, some concern should be present when considering many of these standards crossed multiple grade levels. This concern is apparent regarding the mathematic standards reaching below the seventh-grade level. Incorporating lower level standards or those which cross multiple pathways could result from low perception of control as well as the slightly favorable self-perceived STEM ability of pre-service teachers (Ajzen, 2005, 2012; Balschweid and Thompson, 2000; Ferguson et al., no date; Kotrlick et al., 2003; Morris et al., 2012). Review of the STEM standards may indicate there is an issue with the STEM standards. More specifically, majority of the STEM standards may cross grade levels. Thus, how are students supposed to progress through STEM courses building on previous learned content? Concern should be raised if STEM standards to not progress to higher order thinking as one move from lower level courses to higher level courses.

Research Question Seven

While majority of the correlations were weak in nature, STEM attitude has a strong positive correlation to STEM interest, value, and self-perceived ability. The fact that mathematics is used in science may explain the strong correlation between science and mathematics aptitudes. Oddly, self-perceived STEM ability had a negative moderate correlation to science aptitude. Perceptional control may play a part in this negative relationship. Another interesting correlation is the weak negative correlation between self-perceived STEM ability and creativity. The low favorable self-perceived STEM ability seems to impact all items outside Mahoney's (2009) SAT STEM instrument in a negative way. Self-efficacy, behavioral control, and behavioral beliefs impact intentions and ultimately behavior. Thus, lower self-perception of ability has a negative impact on STEM integration. Also, the low favorable attitude toward STEM through low perceptional control (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Conner & Armitage, 1998; Ferguson et al., no date; Hartmann, 2009; Kraft et al., 2005; Montano & Kasprzyk, 2002; Morris et al., 2012; Sommer, 2011) may explain the lack of variance to self-perceived instructional creativity. This study did not collect the pre-service teachers' intentions regarding STEM integration during the student teaching experience which (Azjen, 1985, 1987, 1991; Azjen and Fishbein, 1977, 1980; Conner & Armitage, 1998; Ferguson et al., no date; Fishbein & Ajzen, 1975) executes a significant role in determining behaviors. However, the low favorable STEM attitude could have impacted the level of STEM integration due to attitudes informing intentions which turn into behaviors (Ajzen, 2002, 2005, 2012; Conner & Armitage, 1998; Feldman & Lynch, 1988; Sommer, 2011).

Recommendations for Practice

Research Question One

The demographics of study participants should be reflected upon when considering future practice. Females are still considered minorities (U.S. Congress, 1998) in agriculture when reporting secondary agriculture program information in government reports. However, recruiting other minority groups to the agricultural education field would help reflect the diversity of student populations across Oklahoma.

OSU should at a minimum maintain the subjective norm which permits pre-service teachers to take the STEM courses participants took. However, means should be developed to allow for more STEM after school programs. This could be done by pre-service teachers teaching

STEM courses with 4H and FFA students as well as participating in programs such as drone certification programs.

Research Question Two

Focusing efforts to demonstrate advanced level STEM integration into lesson plans during OSU course work would give pre-service teachers a better example of what STEM integration should look like. Adding more assignments to course work requiring STEM integration could increase pre-service teacher's comfort level and perceived ability to plan for, integrate, and teach STEM in the context of agriculture by reducing perceived barriers (Balschweid and Thompson, 2000; Kotrlik et al., 2003; Murphrey et al., 2009). Development of more STEM after school program opportunities would allow pre-service teachers to gain more STEM knowledge as well as potential increased perceptional control.

Research Question Three

Balschweid and Thompson (2000) found the intended level of science integration by pre-service teachers was 74% prior to student teaching but fell to 54% after three months of student teaching. Perceived time necessary to incorporate science adequately and the uncertainty to accurately teach the scientific principles once incorporated was the reason for the decrease (Balschweid & Thompson, 2000). The 60% STEM integration level found in this study falls between the levels found by Balschweid and Thompson (2000). Thus, measures OSU DAELC are currently using is making a difference and should be continued. One must ask, what more can be done to improve the subjective norm and perceived behavioral control?

From Balschweid & Thompson (2000), it is my recommendation that pre-service teachers be required to break down agricultural course standards and crosswalk them with STEM standards. This would allow pre-service teachers to see what STEM is already in agriculture courses. Pre-service teachers will also know where they should naturally be teaching STEM concepts. Also, requiring pre-service teachers to identify perceived barriers as well as ways to address identified barriers prior to entering a classroom would assist in overcoming barriers while teaching (Balschweid and Thompson, 2000; Kotrlik et al., 2003; Murphrey et al., 2009).

Despite the perception that students are better prepared in and understand science after participating in a science enhanced agricultural course (Thoron & Myers, 2010), pre-service teachers felt it would take about three years to be willing to integrate science (Balschweid & Thompson, 2000). Agricultural teachers perceive additional time for preparation is needed for the integration of science into agricultural programs (Myers & Washburn, 2008; Myers et al., 2009). Giving pre-service teachers more time to prepare for STEM integration prior to entering the classroom could help address this issue. Further, Washburn and Myers (2010) advocated for developing more intrinsic motivation for educators to integrate science into their curricula rather than forcing them to react to external pressures. More opportunities to plan for and practice STEM integration may also be a metaphorical double-edged sword. More opportunities may give the impression of forced integration. Thus, the extra opportunities must be given in a manner which does not seem forceful in nature.

The amount of STEM integration is admirable. However, could there be more? Utilizing the CASE curriculum which was already cross walked with STEM would give pre-service teachers and current teachers the ability to move the needle toward 100 percent STEM integration. Oklahoma Legislators, state staff, and school personnel would need to buy into using the CASE curriculum. OSU faculty would need to help train current agriculture teachers in the CASE curriculum. The subjective norm of the state curriculum distributor, CIMC, would create resistance to the adoption of the CASE curriculum. On the other hand, would CIMC be willing to integrate more and further crosswalk their curriculum to match or surpass the CASE curriculum?

Current state subjective norms, such as FFA contests and livestock shows are prime locations for STEM integration through informal environments. However, these same activities would hinder the adoption of the CASE curriculum. Thus, Oklahoma agriculture teachers, state staff and school districts would need to determine which is more important, STEM integration or the informal instructional activities.

Research Question Four

Lesson plan quality is a legitimate concern in this study. Emphasis should be placed on helping pre-service teachers improve their lesson planning abilities in their teacher preparation courses as well as during their student teaching internship. Specifically, attention should be devoted to helping students develop presentation and application phases of their lesson plans. In addition, faculty at Oklahoma State University should consider adding a minimum expectation for lesson plan quality. The creation of such expectations during the student teaching internship might assist pre-service teachers' planning for the integration of STEM concepts more accurately and improve their teaching effectiveness generally.

Further, expectations should be placed on cooperating teachers regarding lesson planning. Despite the school district requirements regarding detailed lesson plans, cooperating teachers need to model quality lesson planning for pre-service teachers. Thus, in-service should be done with cooperating teachers to outline lesson plan quality expectations as well as train or refresh cooperating teachers on what a quality lesson plan contains. School districts should develop an expectation of quality lesson planning. If school districts are failing to set expectations for lesson planning, then the Oklahoma Department of Education should step in and do so.

Research Question Five

Recommendations regarding research question five are partly the same as research question three. Utilizing Balschweid & Thompson (2000), requiring pre-service teachers to break down agricultural course standards and crosswalk them with STEM standards would allow familiarity with STEM present in agricultural courses. Knowing the standards overlap gives pre-service teachers awareness of STEM currently in agricultural courses and may spark ideas of where more STEM standards could be incorporated. Again, identification of barriers to integrate STEM into agriculture courses and determining ways to address these barriers, gives pre-service teachers a template for how to address such problems when in the classroom (Balschweid and Thompson, 2000; Kotrlik et al., 2003; Murphrey et al., 2009; Torres and Ulmer, 2007).

Curriculum providers such as CIMC, MyCAERT, iCEV, etc. should align their agricultural curriculum with national STEM standards. This would allow pre-service and agriculture teachers to see what STEM they are teaching using a specific curriculum. Legislators and the Oklahoma State Department of Education (OSDE) could place mandates on schools to only purchase curriculum from providers which align their curriculum with STEM standards. Legislators and the OSDE would improve STEM integration in agricultural education by adopting the CASE curriculum.

Research Question Six

Further, offering preparation for incorporating more advanced STEM standard competencies could allow for increasing the grade level of STEM standard integration. While science standards were taught at the ninth (19 standards), tenth (35 standards), and eleventh (26 standards) grade levels, the other STEM areas were mainly tenth grade and below or were generic enough to cross multiple grade levels. Currently, few of the STEM competencies evident in pre-service teachers' lesson plans were targeted at seniors. In fact, majority of the STEM being integrated encompasses the 9th grade level in some regards. Preparing pre-service teachers for teaching STEM at an elevated level could increase their self-efficacy (Ajzen, 2005, 2012; Balschweid & Thompson, 2000; Ferguson et al., n.d.; Kotrlik et al., 2003; Morris et al., 2012), which might allow for consistent upper grade-level STEM integration with more upper grade level specific STEM standards. More focused efforts to demonstrate advance level STEM integration into lesson plans while students are on campus could provide additional examples for pre-service teachers to follow as well as increase their comfort level and perceived ability to plan for, integrate, and teach STEM in the context of agriculture (Ajzen, 2005, 2012; Balschweid & Thompson, 2000; Ferguson et al., n.d.; Kotrlik et al., 2003; Morris et al., 2012).

STEM standards should be reviewed to determine how they progress from course to course. The potential for too many process standards exists. Students should be progressing in higher order thinking as they move through STEM course work. STEM content area standards should be evaluated to determine if the standards themselves do not reflect the level students should be progressing through during their secondary STEM course work. Depending on this STEM standard evaluation, changes to what and how we integrate STEM into agricultural education classrooms may need to change.

Research Question Seven

The strong positive correlations among STEM attitude and STEM value, interest, and self-perceived ability reinforce the ability of Mahoney's (2009) SAT STEM instrument to determine STEM attitude. This attitude may or may not correlate to the level of STEM integration planned for by pre-service teachers. Although intentions were not collected, the favorable STEM attitude may contribute some part to the level of STEM integration we received in this study. Thus, OSU DAELC should continue its efforts regarding STEM integration. Other efforts such as opportunities to practice STEM integration could raise pre-service teachers' STEM self-perceived ability and ultimately raise their STEM attitude (Azjen, 1985, 1987, 1991; Azjen and Fishbein, 1977, 1980; Conner & Armitage, 1998; Ferguson et al., no date; Fishbein & Ajzen, 1975). The OSU DAELC needs to work on improving perceptional control and subjective norms in efforts to increase the low favorable attitude toward STEM (Ajzen, 2005, 2012; Ajzen & Madden, 1986; Conner & Armitage, 1998; Ferguson et al., no date; Hartmann, 2009; Kraft et al., 2005; Montano & Kasprzyk, 2002; Morris et al., 2012; Sommer, 2011). Placing pre-service teachers with cooperating teachers which adequately plan for STEM integration would allow pre-service teachers to see STEM integration firsthand.

The OSDE and school districts should work to make educational environments more friendly to STEM integration by providing more grant money and professional development regarding STEM integration. Also, curriculum providers should develop STEM integrated curriculum to assist in reducing barriers for STEM integration. Pre-service teachers perceived behavioral control along with an environment which supports them using purchased curriculum and lesson containing STEM integration should boost the behavior of STEM integration.

Recommendations for Research

Research Question One

This study was limited to pre-service agricultural teachers during the Fall 2011 and Spring 2012 semesters at Oklahoma State University. Therefore, this study should be replicated with other preservice teacher preparation programs across the country. Replicating the study on a larger scale with an increased sample size would allow for the comparison of results between and across states related to pre-service teachers' ability to plan for and integrate STEM into their existing lessons. In addition, replicating the study across the country would allow for greater generalizability of results, which could ultimately lead to the development of policy or expectations related to teaching STEM competencies in the context of agriculture.

Research should be conducted to determine what STEM courses and after school programs pre-service teachers are taking. What is it about the subjective norm that allows for courses but limits the after-school programs? Is it a demographic data point such as pre-service teachers having jobs which hinders their after-school program participation? Are there just too few after school programs to participate in?

Research Question Two

Improvements to the study could be made by adding several data collection points. Initially, a non-self-perception creativity test, such as the Torrance Test, should be conducted to allow for comparison of self-perceived creativity versus actual creativity. Then, incorporating qualitative components to the data collection process could be a valuable addition to future research in this area. Specifically, allowing pre-service teachers to reflect on their experiences in weekly journals could assist in understanding the trials and struggles of incorporating STEM in agricultural lessons. Further, conducting observations of pre-service teachers' teaching in action and assessing the STEM that is taught in each class period could be informative as to the question's and struggles they have in learning the content. Such observations also would allow for the understanding of instructional creativity pre-service teachers possess for teaching STEM during the student teaching experience. Individual and focus group interviews prior to, during, and after the student teaching internship would assist in understanding pre-service teachers' attitudes and intentions regarding STEM integration as they change throughout their student teaching internship. Adding a post STEM attitudinal assessment also would allow for understanding changes in attitudes toward STEM integration regarding the student teaching experience. Based on a required minimal OGET score prior to student teaching internship, all pre-service teachers possess a basic, passing competency to teach STEM. However, individual interviews could shed light on why their self-perceived ability to teach STEM might differ from their standardized OGET scores.

Longitudinal studies evaluating STEM attitude and creativity would help determine if the coursework is appropriate and impactful. Experimental studies can be conducted on potential solutions to improving STEM attitude, perceptional control, and reduction of any existing barriers research may find. Also, incorporating training on how to incorporate more advanced STEM concepts into agricultural curriculum should increase the grade level of integrated STEM content.

Research Question Three

Research comparing agricultural course standards to STEM standards determining where standard overlaps occur would allow understanding of what STEM concepts should be planned for due to standards overlapping. Analyzing agriculture course standards for cross over with science standards might shine light on what makes agriculture an applied science. The same can be said for technology, engineering, and mathematics. Cross walking the agricultural course standards with STEM standards will provide evidence as to the specific STEM which is already present. Also, is the current STEM overlap the appropriate integration level? Should there be more than the current overlap? Is the appropriate level the 74% level of intended science integration by preservice educators which Balschweid and Thompson (2000) found the appropriate level? Or is the lower 54% intended science integration by preservice educators which Balschweid and Thompson (2000) found the appropriate level? Research is needed to determine the appropriate level of STEM integration into agricultural education as a whole and even more specifically per course taught.

Additionally, qualitative observations would assist in determining the level of STEM integration present in instruction versus the STEM present in lesson which plans. Knowing which lessons and units meet both agriculture and STEM standards would allow researchers to compare planning versus execution. Such research would allow identification of existing barriers to STEM integration. Oklahoma agricultural education has highly competitive FFA chapters and stout SAE programs. Are these barriers to STEM integration, especially in the formal learning environment/classroom/laboratory? Does focus in Oklahoma agricultural education need to shift from the FFA and SAE circles to more of the classroom/laboratory portion of the three-circle model? Further, if the CASE curriculum is adopted, what impact would there be on the state curriculum development branch (CIMC)? CIMC is a staple in Oklahoma agricultural education curriculum. Is there a way for CIMC to integrate more STEM into their curriculum? What STEM integration level is CIMC curriculum at compared to the CASE curriculum?

Research Question Four

Regarding lesson plan quality, further efforts should include adding objectives for determining the hindrances to developing quality lesson plans during the student teaching internship. Due to other responsibilities compounded with potential barriers, pre-service agricultural education teachers reduce time spent planning for daily teaching activities (Balschweid & Thompson, 2000; Kotrlick et al., 2003; Murphrey et al., 2009; Torres and Ulmer, 2007). Therefore, understanding the time, or lack thereof, that pre-service teachers can devote to lesson planning might point to a new template and set of expectations being developed, which could lead to improved lesson plan uniformity. Then, a more accurate picture of the STEM competencies pre-service teachers' intended to integrate and teach could be depicted.

What expectations do school districts have regarding lesson plans? Are cooperating teachers expected to turn in quality lesson plans throughout the school year? What are the subjective norms of school districts regarding lesson plans (Ajzen, 1985, 1991, 2005, 2012; Madden, Ellen, & Ajzen, 1992; Morris, Marzano, Dandy, & O'Brien, 2012; Sommer, 2011)? Additional research should be conducted to highlight the expectations for current teachers regarding lesson plans.

Research Question Five

Research has shown that intentions are a good predictor of behavior (Azjen, 1985, 1987, 1991; Azjen & Fishbein, 1977, 1980; Conner & Armitage, 1998; Ferguson et al., n.d.; Fishbein &

Ajzen, 1975). Yet, intentions are different than performances. Therefore, what pre-service teachers planned to teach regarding STEM might have differed in what they actually taught. As such, future work should focus on evaluating the extent to which STEM competencies were taught during the student teaching experience. Further, research should be conducted to determine how such intentions and performances led to student learning and achievement related to STEM competencies and agricultural knowledge. In other words, does teaching STEM in the context of agriculture increase students' STEM abilities while diminishing their agricultural knowledge? Understanding the answer to this question could impact the rate at which STEM is taught by future pre-service teachers.

Incorporating qualitative components to the data collection process could be a valuable addition to future research in this area. Specifically, allowing pre-service teachers to reflect on their experiences in weekly journals could assist in understanding the trials and struggles of incorporating STEM in agricultural lessons. Further, conducting observations of pre-service teachers' teaching in action and assessing the STEM that is taught in a given class period could be informative as to the questions students have about and the struggles, they have in learning the content. Such observations also would allow for the understanding of instructional creativity pre-service teachers possess for teaching STEM during the student teaching experience. Individual and focus group interviews prior to, during, and after the student teaching internship would assist in understanding pre-service teachers' attitudes and intentions regarding STEM integration. Adding a post STEM attitudinal assessment also would allow for understanding changes in attitudes toward STEM integration regarding the student teaching experience. Based on a required minimal OGET score prior to student teaching, all pre-service teachers possess a basic, passing competency to teach STEM. However, individual interviews could shed light on why their self-perceived ability to teach STEM might differ from their standardized OGET scores.

Research comparing agricultural course standards to STEM standards determining where standard overlaps occur would allow understanding of what STEM concepts should be planned for due to standards overlapping as previously stated. Then, researchers would know what STEM concepts should be expected to be present in pre-service teachers' lesson plans. Also, what subjective norms are hindering STEM integration (Ajzen, 1985, 1991, 2005, 2012; Madden, Ellen, & Ajzen, 1992; Morris et al., 2012; Sommer, 2011)? Are their district policies which schools have in place which hinders STEM integration? Are their responsibilities which the OSDE places on teachers which hinder STEM integration? Does legislation hinder STEM integration? Researching subjective norms of legislation, policies, funding, and other environmental factors will allow for a clearer picture of barriers to STEM integration.

Research Question Six

Cross walking STEM standards and agricultural standards will assist in understanding the grade levels of STEM standards present in agricultural courses. While this study found majority of the science and engineering standards were high school level, the technology and mathematic standards were not. What STEM standard grade levels already exist in agricultural standards? On face value, one might want all STEM standards taught in agricultural courses to be at high school level. Should all STEM standards taught in agricultural courses be at the high school level? Knowing what is already present will allow for research to determine what grade level standards should be integrated past what is already present.

STEM standards themselves should be evaluated for their validity as a STEM standard. Would research into STEM standards show that they are too broad and contain more lower-level standards than they should? Do technology standards allow for non-educational technologies to be taught such as global positioning systems and robotic welders? Research comparing older STEM standards to those in present day would present how STEM standards have changed over the years. Have they changed for the better or the worse? Should researchers be working to integrate STEM standards that are subpar to their own field? Only research and expert discussion would help answer such a question.

Research Question Seven

This study found statistical significance between several pre-service agricultural teachers' descriptive data (science and mathematics aptitude; STEM attitude, interest; value, and self-perceived STEM ability; along with STEM self-perceived ability and science aptitude). The findings warrant more research on these correlations. Also, duplication of this study on a larger scale should assist in analyzing the relationship between the variables studied. Findings of similar nature to this study's findings is just as important as the alternative. Other variables which potentially share a relationship to STEM integration by agriculture teachers, pre-service or not, should also be researched. Understanding those variables which are related to the integration of STEM will create future research and positive impact on the agricultural education profession.

Discussion

Practically, pre-service teachers are planning to teach modest levels of science and mathematics in their agricultural lessons. Additional emphasis is needed to encourage pre-service teachers to plan for the integration or highlighting of STEM concepts in agricultural lessons where they naturally exist.

This study highlighted a disconnect between pre-service teachers self-perceived and actual STEM ability. It also pointed out the lack of overall lesson plan quality during the student teaching experience. Both the STEM self-perceived to actual ability gap and lesson plan quality are items which can be addressed in practice as well as research to improve STEM integration.

In 2015, The National Council for Agricultural Education (The Council) developed the Agriculture, Food, and Natural Resources (AFNR) content standards. Therefore, future studies should assess how pre-service teachers' lesson plans integrate AFNR standards with STEM standards. In addition, it could be important to note the overlap in both sets of standards. Understanding the overlap might improve the quality and increase the grade level of STEM integration in pre-service teachers' agricultural lesson plans, which could positively impact secondary students' ability to learn and apply STEM within a known context.

Further, Balschweid and Thompson (2000) found the intended level of science integration by pre-service teachers was 74% prior to student teaching but fell to 54% after three months of student teaching. Balschweid and Thompson's findings as well as the findings of this study cause me to ask: What level of STEM integration is appropriate for agricultural education? What subjective norms are hindering STEM integration? There are numerous programs and organizations which call for STEM integration as well as integration of other content areas across all agricultural courses. If research does not determine the level at which STEM or any other content should be integrated into agricultural courses, we will never know our target integration level or if we are meeting the appropriate levels. Inversely, who will decide the appropriate level of STEM integration if research is not conducted?

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

Oklahoma State University Institutional Review Board

Date:	Monday, August 08, 2011
IRB Application No	AG1143
Proposal Title:	STEM Integration into Agricultural Education: Can We Determine What Contributes to the Level of Pre-Service Educators Plan for STEM Integration
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/7/2012

Principal Investigator(s):

Jeffrey H. Whisenhunt	Shane Robinson
545G Ag Hall	440 Ag Hall
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia M. Kennison

Shelia Kennison, Chair
Institutional Review Board

APPENDIX B

PARTICIPANT RECRUITMENT LETTER

Department of Agricultural Education, Communications and Leadership

448 Agricultural Hall
Stillwater, Oklahoma 74078-6031
405-744-8036
Fax: 405-744-5176
http://aged.okstate.edu

Dear :

You have completed all requirements necessary to participate in a student teaching internship. Congratulations! Several of your prior requirements allowed you to ponder science, technology, engineering, and mathematics (STEM) integration in agricultural education. Recent reports by the President's Council of Advisors on Science and Technology (PCAST) (2010) have called for the integration of STEM throughout education. Further, the U.S. Bureau of Labor Statistics (BLS) (2007) reported a 22% increase in STEM occupations by 2014. Therefore, the Department of Agricultural Education, Communications and Leadership at Oklahoma State University is conducting a quantitative research study to determine the level of planned STEM integration by pre-service agricultural educators. The study also seeks to determine the role a pre-service educator's mathematics and science aptitude, creativity, STEM interest and value, and how perceived STEM ability contributes to the level of planned STEM integration. The research study will consist of two questionnaires, a focus group interview, and a content analysis of lesson plans created during the 12-week student teaching internship. Once identified, appropriate instruction can be added to courses for the advancement of pre-service educators' ability to plan STEM integration within their curricula. The information you provide will remain confidential.

Although this research study is strictly voluntary, I hope you will agree to participate, as your responses will provide valuable insight for the faculty in our department. The purpose of this correspondence is to inform you of the research study and request your participation. Please read the attached consent form for further understanding of the research study. A STEM Attitudinal questionnaire and a corresponding focus group interview will be conducted during the first four weeks of the semester. The focus group interview will be videotape recorded and transcribed by the researcher. Transcriptions are to assure accuracy of responses while instituting confidentiality through pseudonyms. After transcriptions are complete, video recordings will be destroyed. The second questionnaire will be conducted during the capstone seminar at the end of the semester. Copies of your lesson plans will also be collected at the capstone seminar at the end of the semester.

If you are interested in participating in this research study, please sign and return the consent document. Should you have any questions or concerns about this research study, please feel free to contact me at jeffrey.whisenhunt@okstate.edu.

Thank you in advance for your assistance and participation in this research study. With your help, we can continue to produce quality secondary agricultural educators!

Sincerely,

Jeffrey Whisenhunt
Graduate Teaching and Research Associate
Oklahoma State University

Okla. State Univ.
IRB
Approved 8/8/11
Expires 8/7/12
IRB# AG-11-43

APPENDIX C

INFORMED CONSENT DOCUMENT

Okla. State Univ.
IRB
Approved 8/8/11
Expires 8/7/12
IRB# AG-11-43

INFORMED CONSENT DOCUMENT

Project Title:	STEM Integration into Agricultural Education: Can We Determine What Contributes to the Level Pre-service Educators Plan for STEM Integration?
Investigators:	Jeffrey Whisenhunt – Teaching and Research Associate – Agricultural Education, Oklahoma State University
Purpose:	The purpose of this study is to determine what extent pre-service agricultural educators plan for STEM integration into the agricultural education curriculum during the 12-week student teaching internship. Even more specifically, this study seeks to determine if pre-service educators' science and mathematics aptitudes, creativity, STEM interest and value, and perceived STEM ability contributes any variance toward their level of planned STEM integration throughout the student teaching internship.
Procedures:	This quantitative research study seeks to determine the role a pre-service educator's mathematics and science aptitude, creativity, STEM interest and value, and perceived STEM ability contributes to the level of planned STEM integration. The research study will consist of two questionnaires, a focus group interview, and a content analysis of lesson plans that students created during their 12-week student teaching internship. During the first week of the semester, the researcher will solicit participation voluntarily. Over the next three weeks, the researcher will provide participants a 24-hour period to complete the STEM Attitudinal questionnaire at home. This questionnaire should take around 20 minutes and will measure STEM interest and value along with perceived STEM ability. The end of the 24-hour period will correspond with the start of the focus group interview which will last no longer than two hours. Participants will turn in the STEM Attitudinal questionnaire prior to participating in the focus group interview. The focus group interview will be conducted, video recorded and transcribed by the researcher. The interview is planned to take place in 439 Ag Hall or 101 4H Building, depending on availability. Participants will then enter the student teaching internship as required by AGED 4200. Per AGED 4200 requirements, participants will create lesson plans for the courses they teach. Upon completion of the student teaching internship, participants will attend the capstone seminar, as usual, for the course. Participants will take the creativity questionnaire during the capstone seminar and turn in a copy of their lesson plans created during the student teaching internship. The creativity questionnaire will be given in the last 10 minutes of the seminar. All identifying marks will be destroyed by the completion of the data analysis period which runs from December 19, 2011 to June 1, 2012.
Risk of Participation:	There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.
Benefits:	This study seeks to determine how much a pre-service educator's mathematics and science aptitude, creativity, STEM interest and value, and perceived

STEM ability contributes to planning STEM integration in agricultural education curriculum lesson plans. With this data, professors and instructors can determine ways to advance pre-service agricultural educators' abilities to plan for STEM integration by raising their creativity, mathematics and science aptitudes, STEM interest and value, and perceived STEM ability. The researcher hopes that one day a regression model will be developed to help predict the level pre-service educators will integrate STEM into agricultural curriculum in order to assist in increasing the level of STEM integration in agricultural education courses. Thus, more benefits include producing professional and employable agricultural educators.

Confidentiality: The researcher will maintain the data stored on his office computer for analyzing procedures in 545G Ag Hall. Because the researcher desires to ascertain the amount of variance a pre-service educator's mathematics and science aptitude, creativity, STEM interest and value, and perceived STEM ability contributes to their planned STEM integration, it is imperative to be able to match respondents with their responses. However, no names will be reported in the findings of this research study. Further, video recorded focus groups along with the names of the respondents will be destroyed at the end of the data collection period (May 2012).

The records of this study will be kept private. Any written results will reveal group findings, and will not include information that will identify the participants, individually. Research records will be stored securely. Only the researchers, Jeffrey Whisenhunt and Shane Robinson, will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Contacts: **If you have general questions concerning the research study, please contact Jeffrey Whisenhunt via email at jeffrey.whisenhunt@okstate.edu or phone at (405) 744-8143. You may also contact Shane Robinson via email at shane.robinson@okstate.edu or phone at (405) 744-3094.**

If you have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

Participant Rights: While the results of this study are warranted for instructional improvement, you are not obligated to participate. Please know your participation in this study is completely voluntary. You have the right to discontinue the research activity at any time without reprisal or penalty. Thank you for your consideration of participating in this study.

Signatures: I have read and fully understand the consent form. I understand that by signing below I give my consent to participate in this research study. A copy of this form has been made available to me upon request.

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in the study.

______________________________ ______________________________
Signature of Participant Date

APPENDIX D

SAT STEM INSTRUMENT

Student attitude toward STEM
Initial Instrument Review

In cooperation with
OKLAHOMA STATE UNIVERSITY

Researchers:
Jeffrey Whisenhunt, Principal Investigator
Dr. Shane Robinson, Co-investigator

IRB Protocol number: AG1143
IRB Protocol approval date: 08-08-2011

The following definitions are to clarify what is implied by each of the STEM subjects; science, technology, engineering, and mathematics. Please review these definitions provided before proceeding on to the survey.

Science:

The systematic observation of natural events in order to obtain facts about them and to formulate laws and principles based on these facts. Science is the organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation. There are several sections of the general body of knowledge relating to science; such as biology, physics, chemistry, geology, or astronomy.
(Academic Press Dictionary of Science & Technology)

Technology:

Technology is the process by which humans modify nature to meet their needs and wants. Most people, however, think of technology in terms of its artifacts: computers and software, aircraft, pesticides, water-treatment plants, birth-control pills, and microwave ovens, to name a few. But technology is more than these tangible products. Technology includes the entire infrastructure necessary for the design, manufacture, operation, and repair of technological artifacts, from corporate headquarters and engineering schools to manufacturing plants and maintenance facilities. The knowledge and processes used to create and to operate technological artifacts -- engineering know-how, manufacturing expertise, and various technical skills -- are equally important part of technology.
(National Academy of Engineering)

Engineering:

The profession of or work performed by an engineer. Engineers are problem solvers who search for quicker, better, and less expensive ways to use the forces and materials of nature to meet today's challenges. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgment and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind.
(American Society for Engineering Education)

Mathematics:

Study of abstract patterns and relationships that results in an exact language used to communicate about them. Mathematics is also considered science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing the shapes of objects. It deals with logical reasoning and quantitative calculation, and its development has involved an increasing degree of idealization and abstraction of its subject matter.
(Webster-Merriam, Encyclopedia Britannica)

PART I
Demographic information

Please place a **check-mark** or an **X** in the column that best corresponds with the question or statement provided. Some questions or statements will require you to write in a response.

Name (please print):	

Current Age (in years):	

Gender:	Male	Female

OGET Mathematics and Science Scores:	Mathematics	Science

Ethnicity:	Black	White	Asian	Hispanic
If other, please specify:				

G.P.A.(Grade point average):	<1.0	1.0 – 1.9	2.0 – 2.9	3.0 – 3.4	3.5 – 4.0

How many classes/courses have you taken in:	0	1	2	3	4	5+
Science						
Technology						
Engineering						
Mathematics						

How many after-school, weekend, or summer programs have you participated with involving:	0	1	2	3	4	5+
Science						
Technology						
Engineering						
Mathematics						

This completes PART I
Please continue on to the next page.

Before moving on to **PART II**, please read the directions below:

In this part of the packet you will find a series of blocks like the one below:

Question A	Most ---------------	More ---------------	Less ---------------	Least
I like:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Each block contains a single statement. In this case, the statement is "I like:" as you can see above. To the right of the statement are four columns, each containing the acronym of S.T.E.M. listed vertically. S.T.E.M. refers to each of the four subjects we are measuring in this packet: ***science, technology, engineering,*** and ***mathematics***.

Above the four columns is a scale, ranging from Most to Least (shown below in detail)

Question A	Most --------------- More --------------- Less --------------- Least

This scale assigns a level of intensity to each of the columns provided. Let's look at an example to see how one of these blocks work.

Question A	Most ---------------	More ---------------	Less ---------------	Least
I like:	~~S~~	S	S	S
	T	~~T~~	T	T
	E	E	~~E~~	E
	M	M	M	~~M~~

The student that filled out this question block is indicating the following:

I like science a lot (most)
I like technology (more)
I don't like engineering (less)
I don't like mathematics a lot (least)

Let's examine a few more to be sure you understand this new concept.

Please continue on to the next page.

Question A	Most --------------- More --------------- Less --------------- Least			
I like:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

The student that filled out this block is indicating the following:

I like science (more)
I like technology (more)
I like engineering a lot (most)
I like mathematics (more)

Question A	Most --------------- More --------------- Less --------------- Least			
I like:	S	S	S	[redacted]
	T	[redacted]	T	T
	E	E	[redacted]	E
	M	M	[redacted]	M

The student that filled out this block is indicating the following:

I do not like science a lot (least)
I like technology (more)
I do not like engineering (less)
I do not like mathematics (less)

Each of the blocks above indicates how a student may react to the four different subjects of S.T.E.M. The scale (most – least) allows the student to select a level of intensity for each subject reaction. In the examples, we see that subjects can both share and differ with their assigned level of intensity, depending on what the student decides. It is vital that the student look upon *each subject independently* with the provided statement (i.e. I like Science) and *not at the whole* (i.e. I like science, technology, engineering, and mathematics).

IMPORTANT:

1- **Clearly mark only ONE SUBJECT per row.**
2- **Place a mark for each of the four subjects (STEM), do not omit any. (i.e. there should always be 4 subjects marked per completed block)**
3- **Look at each question and subject independently, do not go back and forth through the subjects/questions.**
4- **Work quickly, your first and natural impression is what we are trying to measure. Do not try to 'over think' each scale or question.**

PART II begins on the following page.

Question 1	Most --------------- More --------------- Less --------------- Least			
I do **not** like:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 2	Most --------------- More --------------- Less --------------- Least			
I enjoy learning about:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 3	Most --------------- More --------------- Less --------------- Least			
I am curious about:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 4	Most --------------- More --------------- Less --------------- Least			
I am **not** interested in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 5	Most --------------- More --------------- Less --------------- Least			
I like:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Please continue on to the next page.

Question 6	Most --------------- More --------------- Less --------------- Least			
(subject) is appealing to me:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 7	Most --------------- More --------------- Less --------------- Least			
(subject) is **difficult** for me:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 8	Most --------------- More --------------- Less --------------- Least			
I do well in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 9	Most --------------- More --------------- Less --------------- Least			
I am **not** confident about my work in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 10	Most --------------- More --------------- Less --------------- Least			
I have a **hard-time** in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Please continue on to the next page.

Question 11	Most --------------- More --------------- Less --------------- Least			
Assigned work in (subject) is easy for me:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 12	Most --------------- More --------------- Less --------------- Least			
I can **not** figure out:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 13	Most --------------- More --------------- Less --------------- Least			
(subject) is important to me:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 14	Most --------------- More --------------- Less --------------- Least			
I feel there is a need for:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 15	Most --------------- More --------------- Less --------------- Least			
I do **not** need:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Please continue on to the next page.

Question 16	Most --------------- More --------------- Less --------------- Least			
It is valuable for me to learn:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 17	Most --------------- More --------------- Less --------------- Least			
(subject) is good for me:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 18	Most --------------- More --------------- Less --------------- Least			
I do **not** care about:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 19	Most --------------- More --------------- Less --------------- Least			
I will continue to enjoy:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 20	Most --------------- More --------------- Less --------------- Least			
I am **not** interested in a career involving:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Please continue on to the next page.

Question 21	Most ---------------- More ---------------- Less ---------------- Least			
I am interested in alternative programs in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 22	Most ---------------- More ---------------- Less ---------------- Least			
I would like to learn more about:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 23	Most ---------------- More ---------------- Less ---------------- Least			
I do **not** wish to continue my education in:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

Question 24	Most ---------------- More ---------------- Less ---------------- Least			
I am committed to learning:	S	S	S	S
	T	T	T	T
	E	E	E	E
	M	M	M	M

STOP

Please place this document along with the required materials in the provided envelop, seal the envelop, and bring the materials back to school to be collected by the researcher.

THANK YOU

APPENDIX E

CETAI INSTRUMENT

Creative and Effective Teaching Assessment
Instructor Assessment

Please provide your name and a list of agricultural courses you taught during the 12-week student teacher internship.

1) Please print your name: ______________________________
2) Please enter the agricultural courses you taught during your student teaching internship:

_________________________ _________________________ _________________________

_________________________ _________________________ _________________________

_________________________ _________________________ _________________________

As you reflect upon teaching this course, please indicate <u>your level of agreement</u> with the following statements.

3) In this course, I …

	1 Strongly Disagree	2 Disagree	3 Slightly Disagree	4 Undecided	5 Slightly Agree	6 Agree	7 Strongly Agree
Frequently used illustrations to teach course content.	☐	☐	☐	☐	☐	☐	☐
Taught using novel ideas about course content.	☐	☐	☐	☐	☐	☐	☐
Provided original solutions to content discussed during classes.	☐	☐	☐	☐	☐	☐	☐
Used unique methods to teach course content.	☐	☐	☐	☐	☐	☐	☐
Frequently provided multiple solutions to issues presented in the course content.	☐	☐	☐	☐	☐	☐	☐
Used multiple methods to teach course content.	☐	☐	☐	☐	☐	☐	☐
Used unique student activities to teach course content.	☐	☐	☐	☐	☐	☐	☐
Frequently provided multiple ideas about the content presented in classes.	☐	☐	☐	☐	☐	☐	☐

1

4) In this course, I …

	1 Strongly Disagree	2 Disagree	3 Slightly Disagree	4 Undecided	5 Slightly Agree	6 Agree	7 Strongly Agree
Adjusted course content based on students' interests.	☐	☐	☐	☐	☐	☐	☐
Elaborated on course content while teaching classes.	☐	☐	☐	☐	☐	☐	☐
Provided more than one method to solve problems for concepts presented in this class.	☐	☐	☐	☐	☐	☐	☐
Welcomed input from students during classes.	☐	☐	☐	☐	☐	☐	☐
Adjusted teaching when logical approaches did not work.	☐	☐	☐	☐	☐	☐	☐
Provided examples to reinforce course content.	☐	☐	☐	☐	☐	☐	☐
Explained new content presented to students classes.	☐	☐	☐	☐	☐	☐	☐
Provided vivid details when explaining course content.	☐	☐	☐	☐	☐	☐	☐

APPENDIX F

LESSON PLAN EVALUATION RUBRIC

OKLAHOMA STATE UNIVERSITY
Department of Agricultural Education,
Communications, & Leadership

AGED 3103/4103
Lesson Plan Evaluation

Participant: ______________________________ Evaluator: ________________________

Criteria	Comments	Points	Score
Course, unit, and lesson are identified		1	
Objectives are listed and each includes a behavior, condition, and criteria (degree); appropriate OK PASS standard(s) identified		2	
Equipment, materials and other resources needed are listed		1	
Preliminary announcements and routines are listed		.5	
An interest approach (preparation) is adequately described		1.5	
Interest approach includes link to prior learning, motivation ("Why?"), and overview		1.5	
New material (presentation) to be taught is outlined and described in sufficient detail		2	
New material is listed in a logical sequence		1	
Methods, techniques, and media to be used to teach the new material are described		1.5	
Appropriate activities (application) are described to apply the concepts, principles, and/or skills learned		2	
Methods and materials used in application activities are described		2	
Plans are described to bring closure to the lesson		1	
Appropriate means to assess and evaluate the learners are listed and described in detail		2	
References and resources are identified		1	
	TOTAL	**20**	________

Comments:

APPENDIX G

STEM DEPTH EVALUATION FORM

STEM Depth Evaluation Form

Participant: ________________________________ **Evaluator**: ________________________

Evaluator STEM Area: ______________________________ **Date**: _________________

Directions: Place any STEM content related to your subject area in the Lesson Plan STEM Content column. **If no STEM content is present, write none in the Lesson plan STEM Content column.** Identify the grade level the STEM content is traditionally learned by one of the following identifiers: 12th, 11th, 10th, 9th, or below 9th. Then identify the Oklahoma standard the STEM content meets within your subject area.

Lesson Plan STEM Content	Grade Level	OK STEM Standard
Example: plant cell parts such as nucleus, cell wall, cytoplasm, etc.	10th	Section 210:15-3-80 (Biology 1) Standard G1: cells are composed of a variety of structures such as the nucleus, cell/plasma membrane, cell wall, cytoplasm, ribosomes, mitochondria, and chloroplasts.

STEM Content in Lesson Plan	Grade Level	OK STEM Standard

VITA

Jeffrey Hayden Whisenhunt

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE LEVEL PRE-SERVICE TEACHERS PLAN TO INTEGRATE STEM INTO THEIR AGRICULTURAL EDUCATION LESSONS

Major Field: Agricultural Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Agricultural Education at Oklahoma State University, Stillwater, Oklahoma in December 2019.

Completed the requirements for the Master of Education in Divergent Learning at Columbia College, Columbia, South Carolina in 2009.

Completed the requirements for the Bachelor of Science in Agricultural Education at Clemson University, Clemson, South Carolina in 2004.

Experience:

Agricultural Educator, Union County Career and Technology Center (July 2016—Present)
Agricultural Educator, Estill High School (July 2015—June 2016)
Agricultural Educator, Cane Bay High School (August 2012—June 2015)
Graduate Teaching & Research Assistant, Oklahoma State University (August 2009—June 2015)
Agricultural Educator, Buford High School (August 2004—June 2009)

Professional Memberships:

National Association of Agricultural Educators
South Carolina Association of Agricultural Educators
South Carolina Educational Association