IDENTIFICATION OF STEM CONCEPTS ASSOCIATED WITH JUNIOR LIVESTOCK PROJECTS: A DELPHI STUDY

A Thesis

by

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ABSTRACT

Science, technology, engineering, and mathematics (STEM) education is intended to provide students with a cross-subject, contextual learning experience. In order to more fully prepare our nation's students for entering the globally competitive workforce, STEM integration allows students to make connections between the abstract concepts learned in core subject classrooms and real-world situations. FFA and 4-H programs, by nature, are intended to provide students with hands-on learning opportunities where abstract core subject principles can be applied and more fully understood. Junior livestock projects through FFA and 4-H can provide rich connections for students between what they learn in school and how it is applied in the real world through their livestock project.

Using a modified Delphi technique, this study identified STEM concepts associated with junior livestock projects. The study also examined whether STEM concepts should be integrated into the supervision of junior livestock projects and identified barriers which would prevent the incorporation of STEM concepts into local 4-H and FFA programming and instruction. The experts identified several (13 of 19) STEM concepts associated with junior livestock projects, four reasons local 4-H and FFA leaders/advisors should incorporate STEM concepts into their programming and instruction, and no barriers which would prevent local 4-H and FFA leaders/advisors from incorporating STEM concepts into their programming and instruction. This paper explores rationale regarding why STEM integration is important and makes recommendations for the integration of STEM concepts into the supervision of junior livestock projects.

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CHAPTER I

INTRODUCTION

Traditionally, the United States' education system has been based on the separate-subject approach offering one distinct subject per classroom period. This method has been relied on for over a century in the United States and is systematically failing to prepare students for the highly technical, globally competitive workforce (Dickman, Schwabe, Schmidt, & Henken, 2009). Science, technology, engineering, and mathematics (STEM) integration, an initiative of modern education, touted most recently by the Obama Administration, aims to provide a "robust learning environment" (Sanders, 2009, p. 21) through integration of science, technology, engineering, and mathematics concepts into other related subjects, broadening student knowledge through context and application (President's Council of Advisors on Science and Technology, 2010).

Agricultural education courses provide the context and the content that helps students be successful in the STEM areas (Melodia & Small, 2002). These organizations operate based on the belief that the application of knowledge through experience in context allows students to learn at a higher, deeper, more realistic level (Melodia & Small, 2002). Agricultural education programs offer students the opportunity to increase STEM knowledge through participation in a livestock SAE project. 4-H programs offer students similar opportunities for exhibiting livestock projects (Rusk, Summerlot-Early, Machtmes, Talbert, & Balschweid, 2003). Grounded in science and mathematical principles, raising a livestock project provides students with firsthand experience in animal anatomy and physiology, genetics, nutrition, health, marketing, accounting, and record keeping, all of which are related to STEM concepts (Gamon, Laird, & Roe, 1992; Melodia & Small, 2002).

Theoretical Framework

A review of literature was conducted by the researcher to identify relevant research and to build the theoretical framework supporting the purpose and objectives of the study. An extensive review of literature pertaining to experiential education, agricultural education, experiential learning in agricultural education and 4-H, livestock projects, STEM, and STEM and livestock projects is provided.

Experiential Education

John Dewey (1938), referred to as the most influential educational theorist of the twentieth century (Kolb, 1984), believed that there is an intimate and necessary relationship between experience and education. The study of experiential learning goes back to the 1800's when "learning through doing" and "education through experience" were the common philosophies (Barrick, 1989). As America began to grow, agriculture was the main occupation and agriculture was being taught in schools and demonstrated through field agents across the country (Moore, 1987). Demonstrations and projects were methods commonly used by Extension agents and agricultural educators to allow agriculturalists "practical, applied, and hands-on" experience with new methods and products (Knobloch, 2003; Mabie & Baker, 1996).

Seaman A. Knapp, known as the father of Extension, lived by the motto, "what a man hears, he may doubt; what he sees, he may also doubt, but what he does, he cannot doubt" (Lever, 1952, p. 193). A foundational tenet of agricultural education, past and present, learning by doing inspired Knapp to improve adult agricultural education by taking education to the farm (Knoboch, 2003). Similarly, Rufus W. Stimson, known as the father of the project method, encouraged agricultural education to reach beyond text books, and encouraged actual practice on the farm (Knobloch, 2003). Many researchers have agreed that agricultural education has been experiential in nature since its inception (Baker & Robinson, 2011; Cheek, Arrington, Carter, & Randell, 1994; Hughes & Barrick, 1993; Knobloch, 2003; Stewart & Birkenholz, 1991).

In 1917, experiential learning became a requirement of agricultural education in schools programs as part of the Smith Hughes Act of 1917 (Phipps, 1980). Students in agricultural education courses were required to have "directed or supervised practice in agriculture" where students utilized the skills learned within the traditional classroom on an agriculturally-related project outside of class (Phipps, 1980, p. 594). Originally, this act provided for experience on the farm. While modern supervised practice, today known as a student's supervised agricultural experience (SAE), can occur on a farm, the scope has been expanded to include many other types of experiences (Stewart & Birkenholz, 1991).

These experiential learning opportunities have been referred to as a form of "authentic learning" where tasks completed are comparable to realistic problems (Knobloch, 2003). Knobloch (2003) asserted that authentic experiences "reflect the type of cognitive experiences that occur in real life" (p. 23), fostering innovation and creativity and setting the stage for problem solving in the future. Dewey (1938) stated that personal experience shapes individual knowledge and recognized that "every experience lives on in further experiences" (p. 27). Similarly, Kolb (1984) suggested that learning is a process through which students create knowledge by reflecting upon and transforming an experience.

Many benefits of experiential learning have been uncovered. Mabie and Baker (1996) found that learning by doing improved critical thinking and Griffin (1992) posited that students gained responsibility. Brinkley and Hammonds (1970) developed a list of benefits to include improved "personal finance, maturation, increased responsibility, development of employment skills…" (as cited in Stewart & Birkenholz, 1991, p. 3).

Kolb (1984) stated that an experience is simply one stage of the learning cycle. A four-step, cyclical process, Kolb's (1984) model of experiential learning incorporates four components: Concrete experience, reflective observation, abstract conceptualization, and active experimentation. It is the reflection, connection with abstract principles, and experimentation where Kolb (1984) asserts that students begin to grasp and transform information (Figure 1).

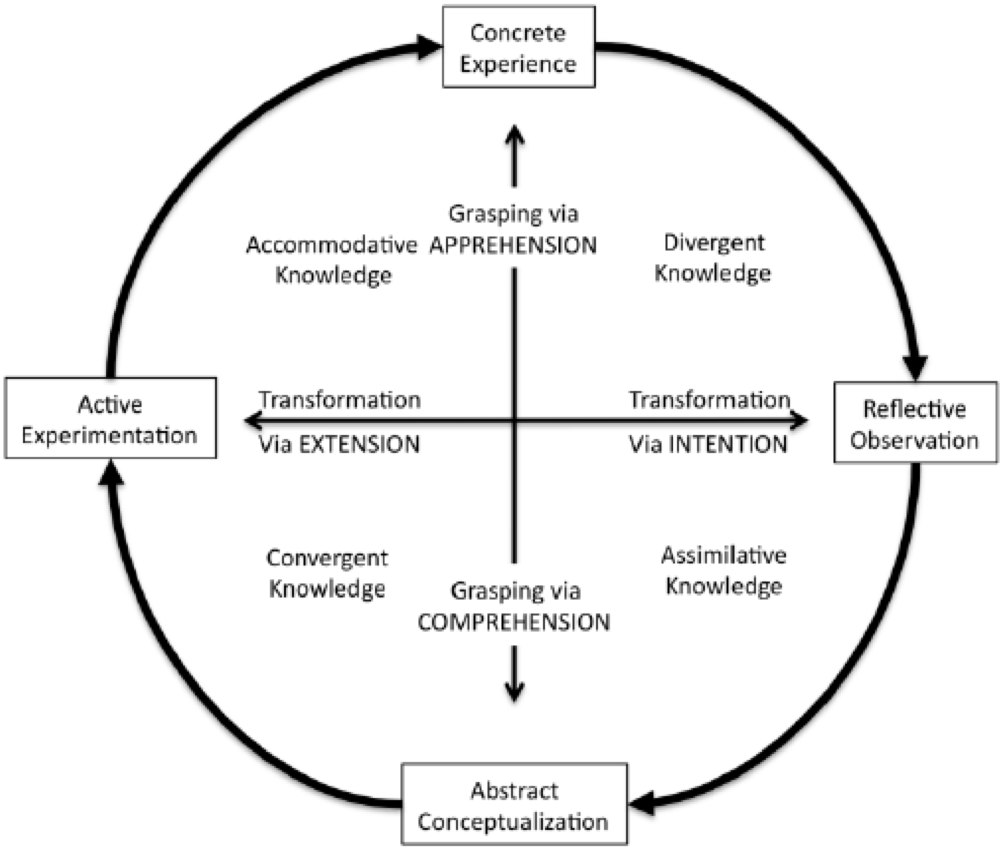

Figure 1. Kolb, David A., Experiential Learning: Experience as a Source of Learning & Development, 1st Edition, © 1984. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ

Thought to be the cornerstone of 4-H programs (Boyd, Herring, & Briers, 1992), experiential learning is also a critical component of a comprehensive agricultural education model (Baker & Robinson, 2011). Similarly, Lewis, Rayfield, and Moore (2012) ascertain that agricultural education students follow Kolb’s Model of the Experiential Learning Process. Students gain “concrete experience” in the agricultural education classroom, “through hands-on activities or engagement in learning, which can spark their interests” (Lewis, Rayfield, & Moore, 2012, p. 217). Students then enter “reflective observation” as they begin to internalize their experiences from class. As students begin to develop postulations and generalizations about their experience, they enter the “abstract conceptualization” stage. Lastly, students enter “active experimentation” by applying knowledge learned in the classroom to FFA activities and SAE projects. Whether inside the classroom or laboratory or through participation in a supervised agricultural experience (SAE) program, agricultural education provides authentic, inquiry or problem-based instruction within a real-world context (Roberts & Ball, 2009).

Agricultural Education

The Smith-Hughes Act of 1917 established federally-funded vocational education in public schools (Roberts, 1957; Roberts & Ball, 2009). Brand (2003) suggested Career and Technical Education (CTE) courses, of which agricultural education belongs, can aid in “interdisciplinary, integrated, and contextual” learning that is rigorous and in line with academic standards (p. iii). Career-focused courses, such as agricultural education, as Brand (2003) described, help increase student interest and motivation in school while providing a “positive, successful, rigorous, and relevant experience” for students (p. iv).

Agricultural education courses were designed to teach students agricultural knowledge and skills in preparation for their return to the farm (Roberts, 1957; Roberts & Ball, 2009). More recently, the Carl D. Perkins Career and Technical Education Improvement Act of 2006 focused on career preparation through career and technical education courses, although without the specific agricultural context (Budke, 1991). As the expectations of agricultural education programs shift from preparation for students to return to the farm to preparing students for the workforce or post-secondary education, agricultural education teachers also have a responsibility to increase the scientific and technological nature of agricultural education (Budke, 1991).

Experiential Learning in Agricultural Education

Experiential learning is highly valued within the agricultural education (Hughes & Barrick, 1993). Traditionally represented using a diagram of three overlapping circles representing classroom/laboratory instruction, FFA and supervised experience, the model of agricultural education is founded in classroom, laboratory, and real-world experience where students gain context for the content which is taught (Talbert, Vaughn, Croom, & Lee, 2007). Kolb, as cited in Baker & Robinson (2011), pointed out the abundance of experiential learning opportunities present throughout agricultural education, saying "more education should be occurring outside of the classroom because classrooms are some of the most sterile environments imaginable" (p. 358).

The classroom or laboratory instruction portion of agricultural education provides the foundation for students. Here, the agricultural education teacher provides formal instruction on agricultural subjects. Whether in the classroom or in the laboratory, students are encouraged to gain experience and knowledge within the context of the situation (National FFA Organization, 2012b).

The SAE portion of the model takes place outside of the traditional classroom. SAE is considered the component rich in experiential learning (Warren & Flowers, 1992). Rooted in Stimson's philosophy of the "project method," supervised experience allows students to take the knowledge acquired in the classroom and apply it to agricultural projects at home (Moore, 1988). Mandated as a requirement of the Smith Hughes Act of 1917, SAE was designed to provide supervised practice in agriculture for each student either at home or at the school for at least six months of each year (Stimson, 1919). The current definition of an SAE is "a practical application of classroom concepts designed to provide 'real world' experiences and develop skills in agriculturally related career areas" (National FFA Organization, 2012a, PowerPoint slides). Traditionally, SAE programs were related to production agriculture and were intended to produce income (Stewart & Birkenholz, 1991). As agricultural education programs expanded to meet the needs of the more modern student, outcomes of the SAE program have also changed to meet the needs of the learner (Stewart & Birkenholz, 1991). Today's SAEs are categorized into the following categories: Exploratory, Research/Experimentation, Placement, Improvement, and Ownership/Entrepreneurship.

SAEs provide students an opportunity to learn through "cognitively complex tasks, which provide opportunities for solving real problems" (Blumenfeld et al.,1991, p. 371). A type of experiential learning, Blumenfeld et al. (1991) found that project-based learning helped engage the student in investigation, making predictions, asking questions, designing plans, conducting experiments, analyzing data, and communicating their ideas and findings to others.

The agricultural education teacher's role has also changed over the years. Rather than delivering content to the student that the student might use within the scope of an SAE program, Kolb revealed to Baker and Robinson (2011) in an interview that teachers should recognize the meta-skills which students are developing through their SAE and then take an opportunity to aid “students in achieving the goals of a project over time” (p. 358). Knobloch (2003) posited that, “Agricultural educators who engage students to learn by experience through authentic pedagogy will most likely see the fruits of higher intellectual achievements, not only in classrooms and schools, but more importantly, in their roles as adults as contributing citizen of society” (p. 32).

FFA, the third component of the agricultural education model, is an intracurricular component, making it an integral component of the program (Talbert et al., 2007). Agricultural education students are expected to also be a member of FFA. Members can compete in career development events (CDEs) which hone career-related skills in many different agricultural areas.

An intracurricular program, agricultural education is formal in nature. Conversely, the Cooperative Extension Service was established in 1914 by the Smith-Lever Act as a non-formal education system (Boleman, 2003). 4-H is the youth development component of the Cooperative Extension Service. 4-H’s mission is to assist youth in acquiring knowledge, developing life skills, and forming attitudes that will enable them to become self-directing, productive, and contributing members of society. In order to accomplish this mission, students select and carry out projects similar to SAE projects in agricultural education.

Livestock projects are just one of the projects or SAE types students can participate in through 4-H and FFA. Membership in these youth organizations provides students the opportunity to exhibit livestock at the local, state, and national levels.

Livestock Projects

Rufus Stimson (1919), father of the home project, touted that agricultural projects contribute to the improvement of knowledge, and thus the improvement of the farm. FFA and 4-H both offer opportunities for students to raise livestock animals for exposition at shows and fairs at the community or county level, state level, and nationally.

A great deal of research is available on the benefits of junior livestock projects and the attainment of life skills. Few studies have emerged dealing with the core subject knowledge livestock projects help students learn. Sawer (1987) stated that developing animal science knowledge and gaining life skills are important for students to learn through participation in beef, sheep, and swine projects. Many acts associated with raising a livestock animal—cleaning pens and stalls, watering, grooming, and training their animals—resulted in an increase of responsibility (Sawer, 1987). The same study found that students gained skills in decision-making, communication, sociability, and leadership through livestock projects. Rusk, Summerlot-Early, Machtmes, Talbert, and Balschweid (2003) concluded that students involved in livestock projects use their project-related skills to further develop life skills such as responsibility, self-confidence, people skills, decision-making, problem-solving, and sportsmanship necessary for becoming a successful adult.

Limited research is available on specific science, technology, engineering, or mathematics (STEM) skills gained through participation with livestock projects. Sawer's (1987) study provided some evidence that students are learning knowledge beyond life skills. He found that 75% of students utilized the knowledge and skills gained through participation in a livestock projects to care and maintain another livestock animal. Similarly, Rusk et al. (2003), found that 4-H members who exhibited livestock “have higher skill levels in the areas of animal health care, animal grooming and animal selection” (p. 9). Rusk et al. (2003) results align with Gamon, Laird, & Roe (1992) who found that 4-H members who raised livestock projects developed skills related to “training, grooming … selecting proper equipment, choosing feed rations, and keeping accurate records.”

While respondents were confident in the life-skills learned through livestock projects, they were significantly less confident in their knowledge of animal health such as identification of animal diseases, taking an animal’s temperature, and administering medication (Rusk et al., 2003). Many researchers admit that knowledge level varies depending on the amount of time students have been involved with raising a livestock animal (Boyd et al., 1992; Rusk et al., 2003; Sawer, 1987).

Science, Technology, Engineering, and Mathematics (STEM)

According to Dickman, Schwabe, Schmidt, and Henken (2009), the United States’ future workforce lacks the technological skills and knowledge necessary to enter new jobs or replace today’s workforce. Brand (2003) noted that almost half of all employers reported difficulty in hiring workers with the literacy, numeracy, and technical skills necessary to fill the position. Brand (2003) cited the Organization for Economic Cooperation and Development’s report which ranked the United States 4.5 on a scale from 1-7 on our education system's ability to produce a globally competitive workforce; Canada, India, Japan, and several European countries out ranked the U.S.

Similar to the United States' reaction after the Soviet's launch of Sputnik in 1957 (Kliever, 1965), the modern STEM initiative is intended to increase student knowledge and interest in studying and entering careers associated with science, technology, engineering and mathematics and boost U.S. output in these areas (President's Council of Advisors on Science and Technology, 2010). Touted as a cure-all for our nation's educational lag, the basic principles of STEM education are not necessarily innovative; many educators realize that STEM concepts have always been present within each of the subsequent subjects (Budke, 1991). The advancement lies within the purposeful focus on STEM knowledge outcomes during educative experiences (Sanders, 2009).

STEM was first introduced in 2001 by Judith A. Ramaley, former director of the National Science Foundation's (NSF) Education and Human Resources Division to refer to science, technology, engineering, and mathematics curriculum (Breiner, Johnson, Harkness, & Koehler, 2012; Morrison, 2006). Since 2001, STEM has gained momentum and more recently has become part of the Obama-Biden Plan (2009) for educational improvement (Breiner et al., 2012). In 2010, President Obama established the President's Council of Advisors on Science and Technology (PCAST). The President's Council of Advisors on Science and Technology's report (2010) details recommendations to improve and rejuvenate STEM education, knowledge, and interest for the Federal Government, schools, teachers, and students. Ultimately, PCAST's Executive Report (2010) emphasized the critical need for shareholders, at all levels, to transform STEM education now, in order to pave the way for America’s future success and advancement.

More specifically, the STEM education initiative involves bridging concepts of science, technology, engineering, and mathematics into other disciplines in schools (Morrison, 2006). Fundamentally, STEM integration is “‘trans-disciplinary’ in that it offers a ‘multi-faceted whole’ with greater complexities and new spheres of understanding that ensure the integration of disciplines” (Kaufman, Moss, & Osborn, 2003). Morrison (2006) suggested several characteristics of STEM education: Emphasize technology and engineering in math and science courses, expect innovation and invention from students, active and student centered, foster spontaneous questioning and planned investigation, classroom and laboratory are physically one, and supports teaching in multiple modes. Furner and Kumar (2007) state that a student’s “ability and confidence to do mathematics and science is critical for their future success in our high-tech globally competitive age” (p.185).

Breiner et al. (2012) suggested that STEM education replaces the traditional lecture-style teaching approaches with inquiry and project-based strategies. This style of teaching allows students to better “understand the context in which the problems are embedded” (Furner & Kumar, 2007, p. 186) and rather than seeing each subject separately, to begin to see how all subjects work cohesively (Breiner et al., 2012). Blumenfeld et al. (1991) suggested that as students participate in project-based learning by investigating and solving problems, they develop a more wholesome picture of the concepts associated with the project and are better able to build bridges between classroom instruction and real-life experiences. STEM integration may just be the picture that helps students put the jigsaw puzzle together; learning in an enriched context often leads to a much more meaningful learning experience (Furner & Kumar, 2007).

Integrating STEM concepts into career and technical education programs, such as agricultural education, provides "career preparation, skill development, and lifelong learning" (Brand, 2003, p. 3). As the expectations of agricultural education programs shift from preparation for students to return to the farm to preparing students for college, agricultural education teachers also have a responsibility to increase the scientific and technological nature of agricultural education (Budke, 1991). Budke (1991) suggested that making the shift toward increased scientific and mathematical instruction would not be a great challenge for agricultural education, as so many science and math concepts are already part of the curriculum. Utilizing an agricultural context to implement biological and physical science principles such as genetics, photosynthesis, nutrition, pollution control, water quality, reproduction, and food processing is ideal as students can observe and apply knowledge to a real life situation (Budke, 1991). To improve integration, Budke (1991) proposed partnerships between the agricultural education teacher and core subject teachers to share knowledge, facilities, and equipment and align curriculum.

The experiential nature of agricultural education allows for specific skill development (Brand, 2003).The SAE component of agricultural education specifically offers students the opportunity to "acquire and apply information, concepts, and principles, and … improve competence in thinking (learning and metacognition) because students need to formulate plans, track progress, and evaluate solutions" (Blumenfeld et al., 1991, p. 373). Integration of core subject concepts into agricultural education instruction can include English, mathematics, scientific and historical concepts (Talbert et al., 2007).

STEM and Livestock Projects

Agricultural educators have long touted the scientific and mathematics principles involved in many animal science-related courses and SAEs. Stimson (1919) predicted the effectiveness supervised agricultural experiences would have in science education when he said, “project-study … will probably prove to be one of the most effective means of accumulating first-hand data for the successful study of science…” (p. 96). Kahler and Valentine (2011) proposed that after-school programs, like 4-H, can collaborate with in-school curriculum to improve education in the STEM areas. Livestock projects offer students an often full-circle view of livestock production with aspects of health care, nutrition, reproductive techniques, animal behavior, record keeping and accounting (Rusk et al., 2003).

According to Beane (1995) curriculum integration “revolves around projects and activities rather than subjects … where the [core subject] disciplines come into play as resources from which to draw within the context of the theme and related issues and activities” (p. 616) SAEs such as livestock projects provide the context which allows students the opportunity to apply the once disconnected concepts learned through single-subject courses to real life situations. Kahler and Valentine (2011) highlighted an afterschool program in California which tries to “meld inquiry learning with experiential learning” (p. 26) in order to spark interest in STEM subjects. Curriculum integration calls forth the ideas that are most significant because they actually emerge in life itself (Beane, 1995).

Interestingly, Rusk et al. (2003) found that 32% of Indiana 4-H members admitted to using animal physiology knowledge gained through livestock projects during science courses in school. One student commented, “What many kids read in books, I’ve seen and done” (Rusk et al., 2003, p. 7). The qualitative responses Rusk et al. (2003) obtained provided insight into some specific skills students learned through their livestock project: Reproduction, birth, mortality, disease, nutrition, energy conversion, the digestive system, and genetics. Rusk’s study is one of the few studies which begins to uncover the link between STEM and junior livestock projects.

Purpose

The purpose of this study was to identify STEM concepts associated with junior livestock projects and the factors influencing the integration of STEM into local 4-H and FFA programming and instruction.

Objectives

The objectives of the study were to:

1. Identify STEM concepts embedded in livestock projects as identified by a panel of experts;
2. Determine whether 4-H and FFA leaders/advisors should incorporate STEM concepts into their programming and instruction; and
3. Identify barriers to integration of STEM concepts in 4-H and FFA programming and instruction.

Design

This baseline Delphi study was descriptive in nature, in that it investigated a relationship more completely and utilized a purposive sample that was "uniquely suited to the intent of the study" (Fraenkel & Wallen, 2009, p. 426). STEM concepts were identified as a categorical and dependent variable. Utilizing three rounds of researcher-designed questionnaires as the instruments, the Tailored Design Method (Dillman, Smyth, & Christian, 2009) was followed for data collection. The questionnaire was distributed by email through Qualtrics™, an online survey program. Questions from the round one questionnaire were tailored to obtain data related to the objectives listed in Chapter I. Questions from round one were open-ended, while questions from rounds two and three were Likert-type 6-point scale rating items designed to reach a certain level of agreement which was set *a priori*.

Panel of Experts

To identify STEM concepts associated with junior livestock projects, a study involving the opinions of STEM and livestock experts was conducted. Selection of the panel of experts is essential to the quality and success of the study (Goodman, 1987). According to Duffield (1993), Delbecq, Van de Ven, and Guftafson (1975), and Fink, Kosecoff, Chassin, and Brook (1991), panel members should be representative of their profession, unlikely to be challenged as experts in their field, and have the power to implement the findings of the study. The number of panel members necessary, according to Taylor-Powell (2002), depends more on the diversity of the target population than the purpose of the study and suggests 10 to 15 participants may be the adequate number when participants are not greatly varied. A panel size of 13 would provide reliability within a 0.90 correlation coefficient (Dalkey, Rourke, Lewis, & Snyder, 1972). In order to create a panel which equally represents the diversity of regions and livestock species, a 26 member panel was chosen for this study.

The purposive sample of 26 STEM and livestock project experts included college professors, agricultural educators, Extension personnel, and livestock producers from across the country. Based on the demographic makeup the judges from three of the most recognized national livestock shows, The North American International Livestock Exposition, The American Royal, and The National Western, the expert panel was a true representation of the demographic portrait of the people involved. Recruitment for this study was grounded in three specific requirements. Panel members met two of the three following qualifications:

1. 10+ years of experience in livestock and/or education.
2. National reputation in evaluation of junior livestock projects at the state level or higher.
3. Knowledgeable of STEM concepts as related to livestock projects as evidenced by publishing or education in the field.

Instrumentation

In order to obtain group consensus, the Delphi method involves three or more rounds of surveys until consensus is reached (Couper, 1984; Linstone & Turoff, 1975). This study utilized a three-round Delphi method to garner consensus from the panel of experts. The questions from round one were checked for content and face validity by an expert panel of faculty at a major land grant university.

The study began with a pre-notice email to all panel members. The round one questionnaire was sent one week later to the expert panel via Qualtrics™, a web-based online survey software (see appendix). Panel members were posed three open-ended questions via Qualtrics™:

1. "List all STEM (science, technology, engineering, and mathematics) concepts that you believe to be associated with junior livestock projects,"
2. "Should local 4-H and FFA leaders/advisors incorporate STEM concepts into their programming and instruction? If yes, please explain,"
3. "What barriers, if any, do you believe prevent the incorporation of STEM concepts into their programming and instruction?"

Responses were compiled, combining like items, and the lists were sent back to the expert panels for round two.

During round two, the experts were asked to rate each item using a six point Likert-type scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Somewhat Agree, 5 = Agree, 6 = Strongly Agree). Each member was asked to make any revisions to the list that they felt were necessary to more accurately reflect their beliefs. The results from round two were used to create the instrument for round three. It was decided *a priori* that any item receiving a mean score greater than 5.0 was not retained for round three.

Round three consisted of a list of items and the level of agreement for each item from round two. The panel was asked to rate their level of agreement on each item. All items failing to reach m=5.0 from the expert panel were removed from the final list of concepts. The complete survey instruments are found in Appendix A.

Data Collection

Data were collected with an online questionnaire via Qualtrics™, a web-based online survey software. Panelists completed the survey on their own time. A personalized email was sent to panelists two days before the first survey, notifying them of the questionnaire and its requirements. A second personalized email was sent through Qualtrics™, two days after the pre-notice, with a link to the actual study. Follow-up personalized emails were sent to non-respondents after the initial distribution, for approximately seven days. Seven days after concluding round one, panelists received a personalized email with a link to the round two survey. Follow-up personalized emails were sent to non-respondents after the initial distribution, for approximately seven days. Ten days after concluding round two, panelists received a personalized email including a link to the final round three survey. Participants' names and email addresses remained confidential. After completion of the questionnaires, a thank you email was sent to panel members through Qualtrics™.

CHAPTER II

STEM CONCEPTS ASSOCIATED WITH JUNIOR LIVESTOCK PROJECTS

Introduction

Traditionally, the United States' education system has been based on the separate-subject approach offering one distinct subject per classroom period. This method, relied on for over a century in the United States, is systematically failing to prepare students for the highly technical, globally competitive workforce (Dickman, Schwabe, Schmidt, & Henken, 2009). Based on the results of a 2006 national survey of over 400 employers, high school graduates are "woefully ill-prepared" to enter today's highly technical workplace (Casner-Lotto & Barrington, 2006, p. 9). More specifically, employers responded that young people lack many basic skills and often, the ability to apply skills and knowledge once employed (Casner-Lotto & Barrington, 2006).

Science, technology, engineering, and mathematics (STEM) integration, an initiative of modern education, touted most recently by the Obama Administration, aims to provide a "robust learning environment" (Sanders, 2009, p. 21) through integration of science, technology, engineering, and mathematics concepts into other related subjects, broadening student knowledge through context and application (President's Council of Advisors on Science and Technology, 2010). Implementation of "integrative STEM education" (Sanders, 2009) involves the inclusion of inquiry and project-based approaches, as opposed to lecture-style instruction (Breiner, Johnson, Harkness, & Koehler, 2012).

Agricultural education courses provide the context and the content which will help students be successful in the STEM areas (Melodia & Small, 2002). Similarly, 4-H encourages its members to acquire project and life skills through project-based learning (Boleman, 2003). These organizations operate based on the belief, similar to that of STEM, that the application of knowledge through experience in context allows students to learn at a higher, deeper, more realistic level (Melodia & Small, 2002).

Livestock projects through FFA and 4-H allow students the opportunity to participate in all aspects of livestock production and witness abstract science, technology, engineering, and mathematics concepts in real-life situations. Grounded in science and mathematical principles, raising a livestock project provides students with firsthand experience in animal anatomy and physiology, genetics, nutrition, health, marketing, accounting, and record keeping, all of which are related to STEM concepts (Gamon, Laird, & Roe, 1992; Melodia & Small, 2002).

This study attempted to identify specific STEM concepts associated with junior livestock projects.

Conceptual Framework

John Dewey, referred to as the most influential educational theorist of the twentieth century (Kolb, 1984), believed that there is an intimate and necessary relationship between experience and education (1938). Demonstrations and projects were methods commonly used by Extension and agricultural educators to allow agriculturalists “practical, applied, and hands-on” experience with new methods and products (Knobloch, 2003; Mabie & Baker, 1996). Seaman A. Knapp, known as the father of Extension, lived by the motto, “what a man hears, he may doubt; what he sees, he may also doubt, but what he does, he cannot doubt” (Lever, 1952, p. 193). Similarly, Rufus W. Stimson, known as the father of the project method, encouraged agricultural education to reach beyond text books, and encouraged actual practice on the farm (Knobloch, 2003).

These experiential learning opportunities have been referred to as a form of “authentic learning” where tasks completed are comparable to realistic problems (Knobloch, 2003). Knobloch (2003) asserted that these authentic experiences “reflect the type of cognitive experiences that occur in real life” (p. 23), fostering innovation and creativity, and setting the stage for problem solving in the future. Kolb pointed out the abundance of experiential learning opportunities present throughout agricultural education, saying “more education should be occurring outside of the classroom because classrooms are some of the most sterile environments imaginable” [(as cited in Baker & Robinson, 2011, p. 186].

According to Dickman, Schwabe, Schmidt, and Henken (2009), the United States’ future workforce lacks the technological skills and knowledge necessary to enter new jobs or replace today’s workforce. Similar to the United States’ reaction after the Soviet’s launch of Sputnik in 1957 (Kliever, 1965), the modern STEM initiative is intended to increase student knowledge and interest in studying and entering careers associated with science, technology, engineering and mathematics and boost U.S. output in these areas (President’s Council of Advisors on Science and Technology, 2010). Touted as a cure-all for our nation’s educational lag, the basic principles of STEM education are not necessarily innovative; many educators realize that STEM concepts have always been present within each of the subsequent subjects (Budke, 1991). The advancement lies within the purposeful focus on STEM knowledge outcomes during educative experiences (Sanders, 2009).

In 2010, President Obama established the President's Council of Advisors on Science and Technology (PCAST). The President's Council of Advisors on Science and Technology's report (2010) details recommendations to improve and rejuvenate STEM education, knowledge, and interest for the Federal Government, schools, teachers, and students. Ultimately, PCAST's Executive Report (2010) emphasized the critical need for shareholders, at all levels, to transform STEM education now, in order to pave the way for America's future success and advancement. More specifically, the STEM education initiative involves bridging concepts of science, technology, engineering, and mathematics into other disciplines in schools (Morrison, 2006).

Fundamentally, STEM integration is "'trans-disciplinary' in that it offers a 'multi-faceted whole' with greater complexities and new spheres of understanding that ensure the integration of disciplines" (Kaufman, Moss, & Osborn, 2003). Breiner et al. (2012) suggested that STEM education replaces the traditional lecture-style teaching approaches with inquiry and project-based strategies. Blumenfeld et al., (1991) suggested that as students participate in project-based learning by investigating and solving problems, they develop a more wholesome picture of the concepts associated with the project and are better able to build bridges between classroom instruction and real-life experiences. Budke (1991) suggested that making the shift toward increased scientific and mathematical instruction would not be a great challenge for agricultural education, as so many science and math concepts are already part of the curriculum. Utilizing an agricultural context to implement biological and physical science principles such as genetics, photosynthesis, nutrition, pollution control, water quality, reproduction, and food processing is ideal as students can observe and apply knowledge to a real life situation (Budke, 1991).

Rooted in Stimson's philosophy of the "project method," supervised agricultural experience (SAE) allows students to take the knowledge acquired in the classroom and apply it to agricultural projects at home (Moore, 1988). Mandated as a requirement of the Smith Hughes Act of 1917, SAE is designed to provide supervised practice in agriculture for each student either at home or at the school for at least six months of each year (Stimson, 1919). A SAE is "a practical application of classroom concepts designed to provide 'real world' experiences and develop skills in agriculturally related career areas (National FFA Organization, 2012a, PowerPoint slides).

Knobloch (2003) posited that, "Agricultural educators who engage students to learn by experience through authentic pedagogy will most likely see the fruits of higher intellectual achievements, not only in classrooms and schools, but more importantly, in their roles as adults as contributing citizen of society" (p. 32). A great deal of the research available on the benefits of junior livestock projects has focused on the attainment of life skills. Limited research is available on specific science, technology, engineering, or mathematics (STEM) skills gained through participation with livestock projects.

Sawer’s (1987) study provided some evidence that students are learning knowledge beyond life skills. He found that 75% students utilized the knowledge and skills gained through participation in a livestock project to care and maintain another livestock animal. Similarly, Rusk, Summerlot-Early, Machtmes, Talbert, and Balschweid (2003), found that 4-H members who exhibited livestock “have higher skill levels in the areas of animal health care, animal grooming and animal selection” (p. 9). Rusk et al. (2003)’s results align with Gamon, Laird, & Roe (1992) who found that 4-H members who raised livestock projects developed skills related to “training, grooming … selecting proper equipment, choosing feed rations, and keeping accurate records.”

Interestingly, Rusk et al. (2003) found that 32% (47 of 147) of Indiana 4-H members admitted to using animal physiology knowledge gained through livestock projects during science courses in school. One student commented, “What many kids read in books, I’ve seen and done” (Rusk et al., 2003, p. 7). The qualitative responses Rusk et al. (2003) obtained provided insight into some specific skills students learned through their livestock project: Reproduction, birth, mortality, disease, nutrition, energy conversion, the digestive system, and genetics. Rusk’s study is one of the few studies which begins to uncover the link between STEM and junior livestock projects.

Agriculturalists have long touted the scientific and mathematics principles involved in many animal science-related courses and SAEs. Stimson (1919) predicted the effectiveness supervised agricultural experiences would have in science education when he said, “project-study … will probably prove to be one of the most effective means of accumulating first-hand data for the successful study of science…” (p. 96).

Livestock projects, in particular, offer students an often full-circle view of livestock production with aspects of health care, nutrition, reproductive techniques, animal behavior, record keeping and accounting (Rusk et al., 2003). SAEs such as livestock projects provide the context which allows students the opportunity to apply the once disconnected concepts learned through single-subject courses to real life situations.

Purpose and Objective

The purpose of this study was to identify STEM concepts associated with junior livestock projects. A modified Delphi technique was used to achieve this purpose. The following objective guided the study: 1. Identify STEM concepts associated with junior livestock projects.

Methods and Procedures

This was a descriptive study that employed a survey research design using the Delphi technique to identify STEM concepts in junior livestock projects. The Delphi method allows an expert panel to identify, react to, and assess differing viewpoints on the same subject (Turoff, 1970). This method allows a group of experts, who might be geographically scattered, to exchange viewpoints and ultimately reach consensus about a problem (Stitt-Gohdes & Crews, 2004). Because face-to-face interaction is not necessary, all panel members have equal input, preventing bias due to title, status, or dominant personalities. The success of the Delphi technique relies not on random selection, but on the informed opinion of the expert panel (Wicklein,1993).

In order to create a panel which was representative of the diversity of regions and livestock species, a purposive sample of 26 livestock project experts including college professors, agricultural educators, Extension personnel, livestock evaluation experts, and livestock producers from across the country was created. Recruitment for this study was grounded in three specific requirements. Panel members must have met two of the three following qualifications:

a. 10+ years of experience in livestock and/or education;
b. National reputation in evaluation of junior livestock projects at the state level or higher; and
c. Knowledgeable of STEM concepts as related to livestock projects as evidenced by publishing or education in the field.

The panel members for this study were "uniquely suited to the intent of the study" (Fraenkel & Wallen, 2009, p. 426). Due to the nature of the necessary qualifications of panel members for this study, the researcher gauged the demographic makeup the judges of three of the premier national livestock shows in America: the North American International Livestock Exposition (NAILE) in Louisville, KY, the American Royal in Kansas City, MO, and the National Western in Denver, CO. The gender and ethnicities of the judges for the past five years of these livestock shows was similar to the demographic makeup of the expert panel.

Utilizing three rounds of researcher-designed questionnaires as the instruments, the Tailored Design Method (Dillman, Smyth, & Christian, 2009) was followed for data collection. The questionnaire was distributed by email through Qualtrics™, an online survey program.

The question from round one was open-ended, while questions from rounds two and three were Likert-type 6-point scale rating items designed to reach a certain level of agreement which was set *a priori*.

Agricultural Leadership, Education, and Communications faculty members at Texas A&M University established both content and face validity for the initial instrument used in this study. The number of panel members necessary, according to Taylor-Powell (2002), depends more on the diversity of the target population than the purpose of the study and suggests 10 to 15 participants may be the adequate number when participants are not greatly varied. A panel size of 13 would provide reliability within a 0.90 correlation coefficient (Dalkey, Rourke, Lewis, & Snyder, 1972). In order to create a panel which equally represents the diversity of regions and livestock species, a 26 member panel was chosen for this study.

Panelists were sent a pre-notice prior to the beginning of the start of the first round. For round one, panelists were asked to respond to one open-ended question regarding the STEM concepts students learn through participation through a junior livestock project. The first round question: "STEM is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real world lessons as students apply science, technology, engineering, and mathematics in context that make connections between school, community, work, and the global enterprise (Tsupros, Kohler, & Hallinen, 2009). As an integral component of agricultural education, junior livestock projects allow students an opportunity to gain livestock production knowledge. Thus, the question must be asked: Do these projects incorporate STEM (science, technology, engineering, and mathematics) concepts? As an expert, we are asking you to identify essential STEM concepts embedded within junior livestock projects. Please list all STEM (science, technology, engineering, and mathematics) concepts that you believe to be associated with junior livestock projects."

Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date to encourage the return of round one responses. From round one 25 panelists responded for a 96% response rate and 316 statements were provided by panelists. The researcher analyzed each statement. Similar or duplicate responses (i.e., concepts) were combined or eliminated and compound statements were separated (Shinn, Wingenbach, Briers, Lindner, & Baker, 2009). Of the 316 original statements, 116 were retained for presentation to panelists in round two. Of the 116 retained statements, the researcher collapsed the responses into 19 categories which best represented the statements. Eleven original panelist responses were unable to be categorized.

Round Two

The round two instrument asked panelists to rate their level of agreement on the STEM concept categories retained from round one. On the round two instrument, panelists were asked to respond to a total of 30 statements: 19 classified concept categories and 13 unclassified concept categories. Panelists were asked to use a Likert-type 6-point response scale to rate the 17 categorized concept categories: "1" = "Strongly Disagree," "2" = "Disagree," "3" = "Somewhat Disagree," "4" = "Somewhat Agree," "5" = "Agree," "6" = "Strongly Agree." Six concept categories, which scored either a “5” = “Agree” or “6” = “Strongly Agree” remained for further investigation as a result of round two (Hsu & Sandford, 2007). Twenty-four panelists responded to round two for a response rate of 92%.

The 11 responses which were unable to be categorized were also included on the round two survey under the heading, “Other Concepts.” Panelists were asked to rate their level of agreement on the same Likert-type 6-point scale for each uncategorized statement. Panelists were then asked to classify the statement into a STEM subject: Science, technology, engineering, mathematics, or none. Statements which scored a “5” = “Agree” or “6,” = “Strongly Agree” remained for further investigation under their panelist-classified subject as a result of round two (Hsu & Sandford, 2007). Four concept categories, which scored either a “5” = “Agree” or “6” = “Strongly Agree” remained for further investigation as a result of round two (Hsu & Sandford, 2007). Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date encouraging the return of round two responses.

Round Three

The round three instrument asked panelists to rate their level of agreement for those concept categories that at least 51% but less than 75% of panelists had selected “Agree” or “Strongly Agree” in round two. The round three instrument included the mean score for each concept in round two. Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date encouraging the return of round three responses. Twenty-four panelists responded to round three for a response rate of 92%. Compared to the previous round, only a slight increase in “consensus of agreement” among the panelists was expected (Dalkey et al., 1972).

Findings

Round One Findings: STEM Concepts

The 316 concepts provided by STEM and junior livestock project experts in round one ranged from “Gestation” to “Marketing Livestock” to “Calculating Feed Conversions.” The number of concepts identified by subject were Science, 136; Technology, 46; Engineering, 38; and Mathematics, 96. After removing duplicate items and compound statements (Linstone & Turoff, 2002), 116 items were retained and condensed into 19 categories for presentation to panelists in round two.

Round Two Findings: STEM Concepts

In round two, the panelists were asked to rate their level of agreement on 19 concept categories of STEM concepts and 11 uncategorized statements, 30 total category concepts. The number of categories reaching “consensus of agreement” (i.e., ≥ 75% indicated “Agree” or “Strongly Agree”), by subject, were Science = 8; Technology = 4; Engineering = 1; and Mathematics = 4. In total, 17 of the 30 categories reached the level of agreement defined as “consensus” *a priori.*

On the instrument, each subject (i.e., Science, technology, engineering, and mathematics) contained several categories. Each category which reached “consensus of agreement,” listed below in Table 2.1, was followed by a list of descriptors. The science categories which reached consensus and their descriptors are listed: Anatomy and physiology (i.e., structure, muscle biology, growth and development, and ruminant physiology); Animal health (i.e., Disease diagnosis and treatment, parasite control and treatment, biosecurity, analyze urine and stool samples, digestive health, medicine withdrawal times, vaccinations, implants, and animal care and management); Genetics (i.e., Specific breed reproduction, artificial insemination and embryo transfer, sire selection, gene purity and consistency, selection of replacement and cull animals, read pedigrees, cloning, DNA samples, and EPDs); Nutrition (i.e., Determining appropriate feed rations, adjusting protein and energy requirements, importance of water and roughage, nutrition's impact on growth and development, feed additives, rate-of-gain, growth and carcass merit, feed utilization, and optimum weight and finish); Reproduction (i.e., Reproductive physiology, gestation, reproductive health, and sound husbandry); Livestock evaluation; Animal handling techniques; and Animal behavior.

The technology categories which reached consensus and their descriptors are listed: Herd Management (i.e., Scales, electronic animal ID, vaccinations, mixing and preparing grain, feed additives, growth promotants, and carcass estimates); Marketing and networking (i.e., Use internet to buy and sell livestock, marketing, build websites/marketing programs, communicate through social media, find resources to support projects, and delivering and disseminating education materials); record keeping (i.e., Use of laptops, cell phones, and iPads to communicate, find new information, and store records); and Utilizing older youth to teach younger students.

The engineering category which reached consensus and its descriptors are listed: Presentation of the animal (i.e., Relationship of animal's dimensions to achieve balance—width, depth, length, position of exhibitor when presenting animal, and presentation of the animal in terms of angles, leg placement, touching loin to straighten top line).

The mathematics categories which reached consensus and their descriptors are listed: Animal health (i.e., Angle of joints in feet and legs, scales, measurements, and calculating medicine dosage); Marketing (i.e., Comparative analysis of animals, economic impact, and marketing and purchase of livestock); Nutrition (i.e., Feed efficiency, stocking rates, determining amount and type of feed for an animal, average daily gain, adjusting rations for different stages of animal development, feed efficiency, calculate weigh backs, balance rations, meat science, and determining energy and protein content of feeds); and record keeping (i.e., Financial literacy, cost analysis of insurance and farming programs, accrued interest, track costs associated with raising and showing animals, profit and loss, business analysis, budgets, return on investment, profitability, and financing).

Table 2.1

STEM Concept Categories Associated with Junior Livestock Projects that Reached Consensus of Agreement after Two Rounds of the Modified Delphi Study (N = 23)

STEM Concept Categories Associated with Junior Livestock Projects	Mean
Science	
Livestock evaluation	5.70
Animal health	5.57
Nutrition	5.48
Animal handling traits	5.48
Animal behavior	5.48
Anatomy and physiology	5.22
Genetics	5.00
Reproduction	5.00
Technology	
Herd management	5.57
Record keeping	5.35
Utilizing older youth to teach younger subjects	5.22
Marketing and networking	5.00
Engineering	
Presentation of the animal	5.87
Mathematics	
Nutrition	5.35
Animal health	5.35
Record keeping	5.30
Marketing	5.04

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Each category which failed to reach consensus, listed below in Table 2.2, was followed by a list of descriptors. The science categories which did not reach consensus and their descriptors are listed: Meat science (i.e., Food safety and market readiness); Chemical analysis of soils; Chemical analysis of water; Entomology; Understanding Flight Zones; and Principles of heating and cooling.

The technology categories which did not reach consensus and their descriptors are listed: Animal husbandry (i.e., Check estrus and gestation, artificial insemination, embryo transfer, palpation, ultra sound, and EPDs); and Technology needed to properly apply fertilizer.

The engineering categories which did not reach consensus and their descriptors are listed: Building facilities (i.e., Design and construction of livestock housing or enclosures, working pens, building fence, setting up barn or stalls, determining and installing environmental controls, installing protection systems, and selection of materials for construction); Electricity (i.e., motor inner-workings, selection and use of generator, why breakers flip, and what is a circuit); Hauling livestock (i.e., Selection of proper trailer—aluminum or steel); and Rubber Feed Pans on Ground or Feed Pans Hanging on Fence.

The mathematics category which did not reach consensus and its descriptors are listed: Genetics (i.e., EPD comparison, carcass predictions, days to parturition, days from birth to rebreeding, animal performance, and growth and development).

Table 2.2

STEM Concept Categories Associated with Junior Livestock Projects that Failed to Reach Consensus of Agreement after Two Rounds of the Modified Delphi Study (N = 23)

STEM Concept Categories Associated with Junior Livestock Projects	Mean
Science	
Meat science	4.87
Understanding flight zones	4.65
Principles of heating and cooling	4.04
Entomology	3.91
Chemical analysis of soils	3.26
Chemical analysis of water	3.13
Technology	
Animal husbandry	4.91
Technology needed to properly apply fertilizer	3.26
Engineering	
Building facilities	4.96
Hauling livestock	4.87
Rubber feed pans on ground or feed pans hanging on fence	4.35
Electricity	4.04
Mathematics	
Genetics	4.83

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Round Three Findings: STEM Concepts

The panelists were asked to rate their level of agreement on the 12 concept categories that had not reached the established “level of agreement” (i.e., ≥ 51% but < 75%) for consensus in round two. Four concept categories reached consensus in round three (Table 2.3).

Table 2.3

STEM Concepts Associated with Junior Livestock Projects that Reached Consensus of Agreement after Three Rounds of the Modified Delphi Study (N = 23)

STEM Concept Categories Associated with Junior Livestock Projects	Mean
Science	
Meat science	5.26
Technology	
Animal husbandry	5.22
Engineering	
Building facilities	5.17
Hauling livestock	5.17

Note. Scale: "1" = "Strongly Disagree," "2" = "Disagree," "3" = "Somewhat Disagree," "4" = "Somewhat Agree," "5" = "Agree," "6" = "Strongly Agree."

The eight concept categories which did not reach the established "level of agreement" (i.e., ≥ 51% but < 75%) for consensus in round three are included in table 2.4.

Table 2.4

STEM Concept Categories Associated with Junior Livestock Projects that Failed to Reach Consensus of Agreement after Three Rounds of the Modified Delphi Study (N = 23)

STEM Concept Categories Associated with Junior Livestock Projects	Mean
Science	
Understanding flight zones	4.61
Principles of heating and cooling	4.26
Entomology	3.65
Chemical analysis of soils and water	3.09
Technology	
Technology needed to properly apply fertilizer	3.09
Engineering	
Rubber feed pans on ground or feed pans that hang on fence	4.87
Electricity	4.26
Mathematics	
Genetics	4.96

Note. Scale: "1" = "Strongly Disagree," "2" = "Disagree," "3" = "Somewhat Disagree," "4" = "Somewhat Agree," "5" = "Agree," "6" = "Strongly Agree."

After three rounds, 21 concept categories reached consensus (m = 5.00 or higher) of agreement (Table 2.5).

Table 2.5

STEM Concept Categories Associated with Junior Livestock Projects that Reached Consensus of Agreement during the Study

STEM Concept Categories Associated with Livestock Projects	Mean
Science	
Livestock Evaluation	5.70
Animal Health	5.57
Nutrition	5.48
Animal Handling	5.48
Animal Behavior	5.48
Meat Science	5.26
Anatomy and Physiology	5.22
Reproduction	5.00
Genetics	5.00
Technology	
Herd Management	5.57
Record Keeping	5.35
Utilizing Older Youth to Teach Younger Students	5.22
Animal Husbandry	5.22
Marketing and Networking	5.00
Engineering	
Presentation of the Animal	5.87
Hauling Livestock	5.17
Building Facilities	5.17
Mathematics	
Nutrition	5.35
Animal Health	5.35
Record Keeping	5.30
Marketing	5.04

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Conclusions

Concerning the objective, a panel of experts in the field of livestock evaluation and STEM education reached consensus of agreement on 21 STEM concepts which students may be exposed to or experience during participation in a junior livestock project (Table 2.5). These concept categories included: Genetics, reproduction, anatomy and physiology, meat science, nutrition, animal handling, animal behavior, animal health, livestock evaluation, marketing and networking, utilizing older youth to teach younger students, animal husbandry, record keeping, herd management, building facilities, hauling livestock, presentation of the animal, marketing, and nutrition. It may be concluded that there are many science, technology, engineering, and mathematics concepts present in a junior livestock project environment. Panelists reached consensus of agreement on the highest number of concepts from the subject of science. Accordingly, it may be concluded that there are more science-related concepts present in a junior livestock project environment. These results align with Sawer (1987) who identified animal science knowledge as a benefit of raising livestock. However, the highest mean score (*M* = 5.87) was received on the engineering concept of presentation of the animal. It can be concluded that the panel of experts believe students who participate in junior livestock projects have a greater opportunity to learn about proper presentation of the animal. While an engineering concept received the highest mean, this subject area had the lowest number of concept categories identified in round one, thus the lowest number of concepts which reached consensus. What is the cause of this disconnect between engineering concepts and STEM competencies? This subject requires further investigation.

The second highest concept category is livestock evaluation (*M* = 5.70). It may be concluded that the expert panel sees a great opportunity for students involved in junior livestock projects to gain knowledge in the area of livestock evaluation. Being around livestock and attending shows, students have ample opportunity to learn characteristics which make a livestock animal desirable or valuable. Listening to judges' oral reasons or justifications for placing a class often involves meat science or reproduction terminology. This knowledge can help develop the student's ability to select desirable livestock in the future.

Three concepts reached consensus at the lowest mean (*M* = 5.00): Reproduction, genetics, and marketing and networking. Although junior livestock projects can deal with reproduction, genetics, and marketing and networking, it is concluded that many of these higher level processes are handled by adults involved in the project. These projects are often completed before the animal is bred, therefore the student may miss the reproduction or genetic selection of a mate for the animal. Also, students may not be involved in the sale of the animal after the show season is complete, therefore lacking the marketing or networking knowledge.

Per Rusk et al. (2003), students who participate in junior livestock projects are able to see parallels in their core subject classrooms. The concepts on which the panel reached consensus of agreement are often taught in a core subject classroom. If each concept is re-taught in a contextual manor during participation in a junior livestock project, these projects can provide context for those abstract core concept principles. This connection may help agricultural education and 4-H stay relevant in today's educational system as a current and relevant way to apply complex concepts.

Recommendations

Recommendations for Future Practice

The link between science, technology, engineering, and mathematics core subject education and the concepts present in junior livestock projects should be emphasized. It is the responsibility of the teacher/advisor to highlight STEM concepts while supervising junior livestock projects, but the student is also responsible for being involved in all aspects of raising livestock.

Teachers/advisors should work with core subject teachers to use a standardized STEM curriculum. Using a standardized curriculum increases the likelihood of formulas or vocabulary repetition, helping students make a connection between the core subject concepts they learn in math or science with the livestock production concept. This connection allows students to see how these concepts are used in the real world. It may also be recommended that the current curriculum in place be updated to include STEM connections. Providing the connection for teachers could help increase the consistency with which STEM concept connections were made.

Neither leaders nor advisors are provided with STEM curriculum in the area of junior livestock projects. If leaders and advisors had a standardized curriculum from which to pull, teaching these concepts would be much easier. Knowing which concepts are to be taught and the STEM connections to each concept, teachers would feel less stress trying to teach STEM concepts during project supervision.

Recommendations for Future Research

Rusk et al. (2003) found that 32% of respondents admitted to using animal physiology knowledge gained through livestock projects during science courses in school. Results of this study suggest that concepts such as animal physiology, and many others, are associated with participation in junior livestock projects. However, research should be conducted to determine which concepts and to what degree students are actually learning through involvement in these projects. Also, do students who participate in livestock projects score higher on mathematics and/or science standardized exams? If 4-H leaders and FFA advisors are responsible for teaching these concepts, research should be conducted to determine best practices for teaching STEM concepts to students. Moreover, how is teaching STEM concepts through participation in junior livestock projects benefitting students in the core subject classroom? One student from the Rusk et al. (2003) study specifically said, “In biology, my 4-H animal experience has given me more of a hands-on approach to various life processes like reproduction, birth, death, disease, etc.” (p. 7). Another respondent said, “I was able to relate to the [advanced biology] class what I already knew from being involved with my own 4-H livestock and I was able to fully understand what was being taught” (Rusk et al., 2003, p. 7). This warrants additional inquiry.

According to the panel of experts math and science concepts were more prevalent in junior livestock projects. Conversely, experts identified fewer technology and engineering concepts as being present within junior livestock projects. Additional study is needed to understand more clearly the potential for STEM integration in all areas through junior livestock projects.

The concepts which did not reach consensus of agreement may reflect the nature of junior livestock projects. Rusk et al. (2003) pointed out that “knowledge gained and experience gained” during livestock projects are closely related (p. 1). It is quite possible that those concepts which failed to reach consensus are areas which the expert panel felt students were not involved in as actively. The amount of STEM concept knowledge a student gains through participation in junior livestock projects depends on how deeply the student was involved in all aspects of their project. Further investigation is necessary to determine the level to which students are involved with their livestock project.

CHAPTER III

REASONS TO SUPPORT AND BARRIERS TO INTEGRATION OF STEM CONCEPTS INTO THE SUPERVISION OF JUNIOR LIVESTOCK PROJECTS

Introduction

A hot topic in modern education, the science, technology, engineering, and mathematics (STEM) integration initiative is intended to help students develop greater knowledge and understanding of STEM subjects through interconnected-subject, contextual education. Agricultural education programs offer students the opportunity to increase STEM knowledge through participation in a livestock SAE project (Rusk, Summerlot-Early, Machtmes, Talbert, & Balschweid, 2003). Grounded in science and mathematical principles, raising livestock provides students with firsthand experience in animal anatomy and physiology, genetics, nutrition, health, marketing, accounting, and record keeping, all of which are related to STEM concepts (Gamon, Laird, & Roe, 1992; Melodia & Small, 2002).

Conceptual Framework

According Dickman, Schwabe, Schmidt, and Henken (2009), the United States' future workforce lacks the technological skills and knowledge necessary to enter new jobs or replace today's workforce. Brand (2003) noted that almost half of all employers reported difficulty in hiring workers with the literacy, numeracy, and technical skills necessary to fill the position. Brand (2003) cited the Organization for Economic Cooperation and Development's report which ranked the United States 4.5 on a scale from 1-7 on our education system's ability to produce a globally competitive workforce; Canada, India, Japan, and several European countries out ranked the U.S.

Similar to the United States' reaction after the Soviet's launch of Sputnik in 1957 (Kliever, 1965), the modern STEM initiative is intended to increase student knowledge and interest in studying and entering careers associated with science, technology, engineering and mathematics and boost U.S. output in these areas (President's Council of Advisors on Science and Technology, 2010). Touted as a cure-all for our nation's educational lag, the basic principles of STEM education are not necessarily innovative; many educators realize that STEM concepts have always been present within each of the subsequent subjects (Budke, 1991). The advancement lies within the purposeful focus on STEM knowledge outcomes during educative experiences (Sanders, 2009).

Integrating STEM concepts into career and technical education programs, such as agricultural education, provides "career preparation, skill development, and lifelong learning" (Brand, 2003, p. 3). As the expectations of agricultural education programs shift from preparation for students to return to the farm to preparing students for college, agricultural education teachers also have a responsibility to increase the scientific and technological nature of agricultural education (Budke, 1991). Budke (1991) suggested that making the shift toward increased scientific and mathematical instruction would not be a great challenge for agricultural education, as so many science and math concepts are already part of the curriculum. Utilizing an agricultural context to implement biological and physical science principles such as genetics, photosynthesis, nutrition, pollution control, water quality, reproduction, and food processing is ideal as students can observe and apply knowledge to a real life situation (Budke, 1991). To improve integration, Budke (1991) proposed partnerships between the agricultural education teacher and core subject teachers to share knowledge, facilities, and equipment and align curriculum.

Agricultural educators have long touted the scientific and mathematics principles involved in many animal science-related courses and SAEs. Stimson (1919) predicted the effectiveness supervised agricultural experiences would have in science education when he said, "project-study … will probably prove to be one of the most effective means of accumulating first-hand data for the successful study of science…" (p. 96). Kahler and Valentine (2011) propose that after-school programs, like 4-H and FFA offer, can collaborate with in-school curriculum to improve education in the STEM areas. Livestock projects, in particular, offer students an often full-circle view of livestock production with aspects of health care, nutrition, reproductive techniques, animal behavior, record keeping and accounting (Rusk et al., 2003).

According to Beane (1995) curriculum integration "revolves around projects and activities rather than subjects … where the [core subject] disciplines come into play as resources from which to draw within the context of the theme and related issues and activities" (p. 616) SAEs such as livestock projects provide the context which allows students the opportunity to apply the once disconnected concepts learned through single-subject courses to real life situations. Kahler and Valentine (2011) highlighted an afterschool program in California which tries to "meld inquiry learning with experiential learning" (p. 26) in order to spark interest in STEM subjects. Curriculum integration calls forth the ideas that are most significant because they actually emerge in life itself (Beane, 1995).

Experiential learning is precisely what FFA and 4-H programs, and more specifically livestock projects, provide for students. Through FFA and 4-H students have the opportunity to have first-hand experience with the livestock industry. Kolb’s (1984) model of experiential learning states that experience is just one of four steps to learning. He posits that students cycle from the experience to reflection on the experience, to abstract conceptualization on the experience, and finally active experimentation where students being to grasp and transform information (Kolb, 1984).

Sawer (1987) stated that developing animal science knowledge and gaining life skills are important for students to learn through participation in beef, sheep, and swine projects. Many acts associated with raising a livestock animal—cleaning pens and stalls, watering, grooming, and training their animals—resulted in an increase of responsibility (Sawer, 1987). The same study found that students gained skills in decision-making, communication, sociability, and leadership through livestock projects. Rusk et al. (2003) concluded that students involved in livestock projects use their project-related skills to further develop life skills such as responsibility, self-confidence, people skills, decision-making, problem-solving, and sportsmanship necessary for becoming a successful adult.

Sawer’s (1987) found that 75% of students utilized the knowledge and skills gained through participation in a livestock project to care and maintain another livestock animal. Similarly, Rusk et al. (2003), found that 4-H members who exhibited livestock “have higher skill levels in the areas of animal health care, animal grooming and animal selection" (p. 9). The same study found that 32% (47 of 147) of respondents admitted to using animal physiology knowledge gained through livestock projects during science courses in school (Rusk et al., 2003, p.7). One student commented, "What many kids read in books, I've seen and done" (Rusk et al., 2003, p. 7). The qualitative responses Rusk et al. (2003) obtained provided insight into some specific skills students learned through their livestock project: Reproduction, birth, mortality, disease, nutrition, energy conversion, the digestive system, and genetics. Rusk's study is one of the few studies which begins to uncover the link between STEM and junior livestock projects.

However, there is limited research available on why 4-H and FFA leaders/advisors should integrate STEM concepts into the supervision of junior livestock projects and the barriers preventing the incorporation of STEM concepts into 4-H and FFA programming and instruction.

Purpose and Objectives

The purpose of this study was to identify reasons 4-H and FFA leaders/advisors should incorporate STEM concepts into their local programming and instruction and barriers that prevent STEM concepts from being incorporated into 4-H and FFA programming and instruction. The following objectives guided the study:

1. Determine whether local 4-H and FFA leaders/advisors should incorporate STEM concepts into their programming and instruction; and
2. Identify barriers to incorporation of STEM concepts into 4-H and FFA programming and instruction.

Methods and Procedures

This was a descriptive study that employed a survey research design using the Delphi technique to identify STEM concepts in junior livestock projects. The Delphi method allows an expert panel to identify, react to, and assess differing viewpoints on the same subject (Turoff, 1970). This method allows a group of experts, who might be geographically scattered, to exchange viewpoints and ultimately reach consensus about a problem (Stitt-Gohdes & Crews, 2004). Because face-to-face interaction is not necessary, all panel members have equal input, preventing bias due to title, status, or dominant personalities. The success of the Delphi technique relies not on random selection, but on the informed opinion of the expert panel (Wicklein,1993).

In order to create a panel which was representative of the diversity of regions and livestock species, a purposive sample of 26 livestock project experts including college professors, agricultural educators, Extension personnel, livestock evaluation experts, and livestock producers from across the country was created. Recruitment for this study was grounded in three specific requirements. Panel members must have met two of the three following qualifications:

a 10+ years of experience in livestock and/or education;

b. National reputation in evaluation of junior livestock projects at the state level or higher; and

c. Knowledgeable of STEM concepts as related to livestock projects as evidenced by publishing or education in the field.

The panel members for this study were "uniquely suited to the intent of the study" (Fraenkel & Wallen, 2009, p. 426). Due to the nature of the necessary qualifications of panel members for this study, the researcher gauged the demographic makeup the judges of three of the premier national livestock shows in America: the North American International Livestock Exposition (NAILE) in Louisville, KY, the American Royal in Kansas City, MO, and the National Western in Denver, CO. The gender and ethnicities of the judges for the past five years of these livestock shows was similar to the demographic makeup of the expert panel.

A pre-notice was sent to panel members before the start of round one. For round one, panelists were asked to respond to two open-ended questions regarding the STEM concepts students learn through participation in a junior livestock project:

1. Should local 4-H and FFA leaders/advisors incorporate STEM concepts into their programming and instruction? If yes, please explain.
2. What barriers, if any, do you believe prevent the incorporation of STEM concepts into their programming and instruction?

Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date to encourage the return of round one responses. From round one 25 panelists responded for a 96% response rate and 91 statements were provided by panelists. The researcher analyzed each statement. Similar or duplicate responses were combined or eliminated and compound statements were separated (Shinn, Wingenbach, Briers, Lindner, & Baker, 2009). Of the 91 original statements, 39 were retained for presentation to panelists in round two. The 39 retained statements were grouped into 11 broad categories: Advance the livestock profession, garner support, relate to education, prepare for real life, higher cost, lack of facilities, lack of student engagement, lack of understanding of leader/advisor, no standardized curriculum, leaders/advisors not willing to change, and lack of time.

Round Two

The round two instrument asked panelists to rate their level of agreement on the statements retained from round one. All panelists were asked to respond to the 11 categories of statements presented in round two. Panelists were asked to use a six-point response scale to rate the concepts: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.” Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date encouraging the return of round two responses. Twenty-four panelists responded for a 92% response rate. Seven categories which scored a “5” = “Agree” or “6” = “Strongly Agree,” remained for further investigation as a result of round two (Hsu & Sandford, 2007)..

Round Three

The round three instrument asked panelists to rate their level of agreement for those concepts that panelists had selected “Agree” or “Strongly Agree” in round two. The round three instrument included the mean score for each concept in round two. Electronic reminder messages were sent to panelists approximately one week prior to the assigned due date encouraging the return of round three responses. Compared to the previous round, only a slight increase in “consensus of agreement” among the panelists was expected (Dalkey et al., 1972). There was a 92.3% response rate for round three.

Findings

Round One Findings: STEM Concepts

The 91 statements provided by STEM and junior livestock project experts in round one ranged from “lack of time,” to “creating lifelong ambassadors for the livestock cause.” Forty-three statements were provided about why STEM concepts should be incorporated into 4-H and FFA programming and instruction. Forty-eight statements were provided about barriers to the incorporation of STEM concepts into 4-H and FFA programming and instruction. After removing duplicate items and compound statements (Linstone & Turoff, 2002), 39 items, which fell into 11 categories, were retained for presentation to panelists in round two.

Round Two Findings: STEM Concepts

In round two, the panelists were asked to rate their level of agreement on four concept categories for the integration of STEM concepts by local 4-H and FFA leaders/advisors and seven concept categories of barriers to the incorporation of STEM concepts by local 4-H and FFA leaders/advisors. The number of items reaching “consensus of agreement” (i.e., ≥ 75% indicated “Agree” or “Strongly Agree”), by question were: Why should local 4-H and FFA leaders/advisors incorporate STEM concepts into their programming and instruction = 4; What barriers prevent the incorporation of STEM concepts into 4-H and FFA programming and instruction = 0. In total, four of the 11 categories reached the level of agreement described as “consensus” *a priori.*

On the instrument, each question contained several categories. Each category which reached “consensus of agreement,” listed below in table 3.1, was followed by a list of descriptors. All categories from question one reached consensus, while none of the categories from question two reached consensus. The four categories from question one and their descriptors are listed: Advance the livestock profession (i.e., Relate show ring to real life livestock production, improve animal welfare, create lifelong ambassadors for the cause, and associate genetic improvement with the livestock industry); Garner support (i.e., Gain credibility within the school system and industry, survival factor due to the academic push for the implementation of STEM, garner support and donations, and increase rigor); Relate to education (i.e., Connect 4-H or FFA activities to core subject classes, able to apply concepts learned through core subjects, correlates 4-H and FFA with academic performance standards, helps students understand complicated concepts in concrete way, and real-life application of STEM principles); and Prepare for real life (i.e., Shows how interconnected all aspects of STEM are to each other, skills learned will be valuable for the rest of the student’s life, become problem solvers, provides real-world experience with abstract STEM concepts, multi-disciplinary education, allows students to make important decisions in a supervised way, and skills and abilities are transferable to career path).

Table 3.1

Reasons to Incorporate STEM Concepts into Junior Livestock Projects that Reached Consensus of Agreement after Two Rounds of the Modified Delphi Study (N = 23)

	Mean
Why Should leaders/advisors incorporate STEM?	
Prepare for real life	5.70
Relate to education	5.57
Advance the livestock profession	5.52
Garner support	5.22

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Each concept that failed to reach consensus is listed below in Table 3.2. None of the seven proposed barriers from question two reached consensus. Each category and their descriptors are listed: Higher cost; Lack of facilities; Lack of student engagement; Lack of understanding of leader/advisor (i.e., Unsure of what STEM is and how to teach those concepts, not properly trained, and figuring out how to teach those subjects); No standardized curriculum (i.e., No curriculum, material not easily accessible, and not a requirement); Leaders/Advisors not willing to change (i.e., Lack of vision or importance, not comfortable with material, stuck in their ways, not willing to go out of the box, and resists change), and Lack of time (i.e., Limited time to create materials necessary, do not have the student in the classroom setting, takes time to teach complicated subjects, and many students are involved).

Table 3.2

Barriers to the Incorporation of STEM Concepts in Junior Livestock Projects that Failed to Reach Consensus of Agreement after Two Rounds of the Modified Delphi Study (N = 23)

	Mean
Barriers preventing incorporation of STEM	
No standardized curriculum	4.87
Lack of understanding of leader/advisor	4.87
Lack of time	4.52
Leaders/advisors not willing to change	4.48
Lack of facilities	4.13
Higher cost	4.00
Lack of student engagement	3.83

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Round Three Findings: STEM Concepts

The panelists were asked to rate their level of agreement on seven categories of concepts that had not reached the established “level of agreement” (i.e, ≥ 51% but < 75%) for consensus in round two. None of the seven concept categories presented in round three reached consensus of agreement (Table 3.3).

Table 3.3

Barriers to the Incorporation of STEM Concepts in Junior Livestock Projects that Failed to Reach Consensus of Agreement after Three Rounds of the Modified Delphi Study (N = 23)

	Mean
Barriers that Prevent the Incorporation of STEM Concepts	
No Standardized curriculum	4.83
Lack of understanding of leader/advisor	4.78
Leaders/advisors not willing to change	4.61
Lack of time	4.57
Higher cost	3.96
Lack of facilities	3.87
Lack of student engagement	3.74

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

In all three rounds, four of 11 concept categories reached consensus of agreement (Table 3.4). Preparing students for real life received the highest mean score (*M* = 5.70), while garnering support received the lowest mean score (*M* = 5.22). The complete table can be found in table 3.4.

Table 3.4
Reasons to Incorporate STEM Concepts into Junior Livestock Projects that Reached Consensus of Agreement during the Study

	Mean
Why Should leaders/advisors incorporate STEM?	
Prepare for real life	5.70
Relate to education	5.57
Advance the livestock profession	5.52
Garner support	5.22

Note. Scale: “1” = “Strongly Disagree,” “2” = “Disagree,” “3” = “Somewhat Disagree,” “4” = “Somewhat Agree,” “5” = “Agree,” “6” = “Strongly Agree.”

Conclusions

Concerning the first objective, a panel of experts in the field of livestock evaluation and STEM education reached consensus of agreement on all categories after round two (Table 2.1). So, it may be concluded that the panel of experts values the incorporation of STEM concepts into local 4-H and FFA programming and instruction. The panel agreed that the incorporation of STEM concepts into 4-H and FFA programming and instruction could have the following benefits: Advance the livestock profession through the creation of lifelong ambassadors for the cause, garner credibility within a school system and support and donations, relate junior livestock projects to core subject education, and prepare students for real life situations. Eighty-five percent of panelists reported the highest mean (*M* = 5.70) for the category which stated integration of STEM concepts into 4-H and FFA programming and instruction helps prepare students for real life. Only 77% of panelists agreed (*M* = 5.22) on the category which stated the integration of STEM concepts into 4-H and FFA programming and instruction can help garner support, either within the school system or monetarily.

Regarding objective two, panelists did not reach consensus of agreement on any of the categories concerning barriers which prevent the incorporation of STEM concepts into 4-H and FFA programming and instruction. It may be concluded that the panelists do not perceive cost, facilities, lack of student engagement, lack of understanding of leader/advisor, lack of standardized curriculum, leaders/advisors not willing to change, or lack of time as barriers which prevent the incorporation of STEM concepts into 4-H and FFA programming and instruction. The category of barrier concepts which had the highest mean (*M* = 4.83) was no standardized curriculum for leaders and advisors. The categories of barrier concepts which had the lowest means were lack of student engagement (M = 3.74) and lack of facilities (M = 3.87). The panelists do not perceive that lack of student engagement or lack of facilities are barriers to the incorporation of STEM concepts into 4-H and FFA programming and instruction.

Supervised agricultural experiences (SAEs) such as livestock projects provide the context which allows students the opportunity to apply the once disconnected concepts learned through single-subject courses to real life situations. This connection may help agricultural education and 4-H stay relevant in today’s ever-changing education system. Kahler and Valentine (2011) highlighted an afterschool program in California which tries to “meld inquiry learning with experiential learning” (p. 26) in order to spark interest in STEM subjects. Rusk et al. (2003) surveyed many students who felt they applied the knowledge learned through junior livestock projects in their core subject classrooms. Per the findings of this study, STEM integration in junior livestock projects can offer many benefits in the core subject classroom. Additionally, experts did not see any barriers which would prevent the incorporation of STEM into 4-H and FFA programming and instruction.

Recommendations

The panel of experts identified many benefits of incorporating STEM into local 4-H and FFA programming and instruction. In order to garner these benefits, 4-H leaders and FFA advisors should work to integrate STEM concepts into the supervision of junior livestock projects. But, the question remains, how should STEM concepts be incorporated into the supervision of livestock projects? Which concepts are most important? Should there be a standardized STEM curriculum for leaders and advisors to follow? If 4-H leaders and FFA advisors begin incorporation of STEM concepts into the supervision of junior livestock projects, how will success be measured? These questions warrant further inquiry.

The expert panel did not come to consensus of agreement on any barriers which would prevent the incorporation of STEM concepts into the supervision of junior livestock projects. If no barriers are agreed upon, why then, is STEM integration not more widely utilized in agricultural education and 4-H programs? If the expert panel could not come to consensus of agreement on any of the seven proposed barriers, do any barriers to incorporating STEM concepts in 4-H and FFA programming and instruction exist? Perhaps, this begs the questions, do leaders and advisors need more education in the area of STEM integration?

The panel agreed that integrating STEM concepts into the supervision of junior livestock projects can advance the livestock profession, garner support, relate experience to education, and prepare students for real life. Panelists also gave the highest mean score (M = 4.83) to the barrier concerned with the lack of a standardized curriculum focused on junior livestock projects. Although this barrier item did not reach consensus of agreement, would the development of a standardized STEM curriculum aid leaders and advisors in teaching STEM concepts to students? Additional research is necessary to determine if a standardized curriculum would be helpful to teachers.

As leaders and advisors consider how to integrate STEM concepts into the supervision of junior livestock projects, thought should be given as to how leaders and advisors determine the results of the STEM integration. How can leaders and advisors determine if and how students are benefitting from STEM integration? The results of this study provide evidence that there are several benefits of STEM integration in junior livestock projects, but unless these benefits are relayed to the school and community, are they actually beneficial? What is the best way to convey the benefits STEM integration in junior livestock projects to chapter and program supporters? The panel of experts suggested that STEM integration in livestock projects can help agricultural education and 4-H programs garner support, can help advance the livestock profession, can help students relate livestock production to their education, and can help prepare students for real life. What will these results provide for the chapter or program? These questions require further investigation.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The results of this study suggest that panel members agreed that there are many STEM concepts associated with participation in junior livestock projects. Additionally, panelists believe there are many reasons and few barriers to support the integration of STEM concepts into 4-H and FFA programming and instruction. Panelists agreed or strongly agreed with the proposed STEM concepts and reasons to support the incorporation of STEM concepts.

Research Implications and Recommendations

Overall, it was found that, panelists generally agreed or strongly agreed with 21 STEM concept categories. It may be concluded that there are many science, technology, engineering, and mathematics concepts present in a junior livestock project environment. The panelists reached consensus of agreement on the highest number of concepts from the subject of science. Accordingly, it may be concluded that there are more science-related concepts present in a junior livestock project environment. Further research should be conducted to determine the specific concepts learned more frequently. Students should be surveyed to determine the concepts they believe are learned through participation in a junior livestock project. A list of specific skills or concepts will be necessary to develop curriculum for 4-H leaders and FFA advisors.

Panelists agreed or strongly agreed with the four proposed reasons to support the incorporation of STEM concepts in 4-H and FFA programming and instruction. It is not surprising that the panelists reached consensus on all four of these categories during round two due to the nature of the panel makeup. However, the panel of experts is believed to have provided true and realistic results. With many livestock project experts on the panel, naturally they would like to see the continuation of such projects and the creation of other livestock industry enthusiasts. STEM concept integration can provide an excellent pro argument for their cause. With many agreed-upon benefits, further research is needed to determine how local 4-H and FFA leaders and advisors market STEM concept integration within their programs in order to garner support both from the school and community. Also, how will 4-H leaders and FFA advisors measure the success of STEM concept integration into the supervision of junior livestock programs? Quantitative data may be necessary to confirm success and garner support.

The panelists disagreed or somewhat disagreed with the seven proposed barriers to the incorporation of STEM concepts in 4-H and FFA programming and instruction. This may be due to the experiential, real-life nature of junior livestock projects. Even without 4-H or FFA leaders/advisors directly teaching STEM concepts, students who participate in such projects directly handle a large portion of raising the animal, from feeding, to medicating, to marketing. There are many science and mathematics STEM principles that students see more frequently during their involvement in a junior livestock project because they deal with them on a daily basis such as nutrition and feeding and anatomy and physiology. The question remains, why are 4-H and FFA leaders/advisors not incorporating STEM concepts into the supervision of junior livestock projects? What would make teaching these concepts easier?

A standardized curriculum would aid leaders and advisors in the identification of STEM concepts and how to teach each concept. If 4-H and FFA aim to remain relevant in today's global society, they should join forces to create and encourage the inclusion of STEM curriculum integration in activities, programming, and lesson plans. The curriculum should be tailored to meet the needs of all students based on grade level to help students bridge theory and practice (Posner, 1994). 4-H leaders and FFA advisors should be encouraged by their local, state, and national organizations to incorporate STEM concepts.

The results of this study align with Rusk et al.'s (2003) findings where one student commented about his livestock project experience, "What many kids read in books, I've seen and done" (Rusk et al., 2003, p. 7). Table 2.5 showed several STEM concepts associated with junior livestock projects which naturally align themselves to the abstract principles taught in the core subject classroom. These results support Kaufman, Moss, and Osborn (2003) who highlight the "trans-disciplinary" nature of STEM integration where students gain a "multi-faceted" view of STEM concepts. Rusk et al. (2003) reported 32% of respondents indicated they had used information about animal physiology in their science classes at school. Morrison (2006) points out that STEM education bridges concepts of science, technology, engineering, and mathematics into core subject disciplines.

The results of this study provide several STEM concepts which a student might have the opportunity to learn during participation in junior livestock projects. These concepts are likely to be taught in a math or science classroom, yet also have practical applications which students can experience during their livestock project. FFA advisors and 4-H and core subject teachers have a duty to work cohesively to help students recognize similarities and apply these concepts in a real-world setting.

Recommendations for Practice

Developing a standardized STEM curriculum and program standards could help 4-H leaders and FFA advisors gain a deeper understanding of how to incorporate STEM concepts into the supervision of junior livestock projects. 4-H leaders and FFA advisors who work to incorporate STEM concepts into the supervision of junior livestock projects should coordinate with core subject teachers to use the same verbiage, vocabulary, formulas, and processes. This would help the student understand how the concept which is learned in the core subject classroom can be applied in the real world.

4-H leaders and FFA advisors should work with science, math, and other core subject teachers to determine what STEM concepts they teach related to junior livestock projects. These concepts should already be familiar to the student and could be expounded upon during supervision of the junior livestock project.

4-H leaders and FFA advisors should make sure STEM concepts are taught at each junior livestock project supervision visit. Concepts taught will depend on the species and age of the student, but should focus on at least one STEM concept and should help the student link theory to practice. Leaders/advisors should teach STEM concepts in a hands-on way and allow the student to experience as much as possible in a safe and educative way. The leader/advisor is responsible and accountable for the depth and amount of STEM concepts students learn while involved in junior livestock projects.

4-H leaders and FFA advisors should encourage students to research STEM-related questions so the student learns the concept more fully. Knobloch (2003) asserts that today's educational reform calls educators to be facilitators of knowledge rather than simply deliverers of content. Depending on the age of the student, leaders/advisors should expect students to determine historical context, methods, purposes, costs, or any other factors which may be important. If little to no research is available, leaders/advisors should assist the student in exploring the subject in more depth. Knobloch calls this type of learning authentic. Authentic tasks provide "connection to the real-life problems and situations that students face outside of the classroom" (Knobloch, 2003, p. 23). Similarly, livestock projects provide the opportunity for students to apply abstract core subject concepts in a real life livestock production situation.

The findings of this study support the notion that STEM integration can help students connect theory to practice (Morrison, 2006). However, more research is necessary to determine which STEM concepts are the most important to teach and the best ways to teach these concepts through supervision of livestock projects. In order for agricultural education to remain relevant in schools, it is necessary to show how leaders/advisors are upholding the expectations of educational initiatives and track the progress of students involved in this type of education.

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APPENDIX A

5/26/12 Survey: STEM & Jr. Livestock Projects

STEM Concepts Associated with Junior Livestock Projects

Information Sheet

Introduction
This study attempts to collect information about science, technology, engineering and mathematics (STEM) concepts embedded in junior livestock projects.

Procedures
This is a multiple-round survey. The first round will ask three open-ended questions and you are asked to type a complete response. Depending on the results from round one, the responses will be summarized and respondents will be asked to agree or disagree with statements on a Likert scale. The results of round two will determine the need for further rounds.

Risks/Discomforts
The things that you will be doing have no more risk than you would come across in everyday life.

Benefits
There are no direct benefits for participants. However, it is hoped that through your participation, researchers will learn more about STEM concepts in junior livestock projects.

Confidentiality
All data obtained from participants will be kept confidential and will only be reported in an aggregate format (by reporting only combined results and never reporting individual ones). All questionnaires will be concealed, and no one other than the primary investigator and assistant researchers listed below will have access to them. The data collected will be stored in the HIPAA-compliant, Qualtrics-secure database until it has been deleted by the primary investigator.

Compensation
There is no direct compensation.

Participation
Participation in this research study is completely voluntary. You have the right to withdraw at anytime or refuse to participate entirely. If you desire to withdraw, please close your Internet browser and notify the principal investigator at this email: kate.wooten@agnet.tamu.edu.

Questions about the Research
If you have questions regarding this study, you may contact Kate Wooten, at 979-458-7983 or kate.wooten@agenet.tamu.edu.

Questions about your Rights as Research Participants
If you have questions you do not feel comfortable asking the researcher, you may contact Dr. John Rayfield, 979-862-3707, jrayfield@tamu.edu. Or contact the Texas A&M Human Subjects Protection Program office at (979) 458-4067 or irb@tamu.edu.

I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

○ Yes

○ No

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STEM is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real world lessons as students apply science, technology, engineering, and mathematics in context that make connections between school, community, work, and the global enterprise (Tsupros, 2009). As an integral component of agricultural education, junior livestock projects allow students an opportunity to gain livestock production knowledge. Thus, the question must be asked: Do these projects incorporate STEM (science, technology, engineering, and mathematics) concepts? As an expert, we are asking you to identify essential STEM concepts embedded within junior livestock projects.

List all STEM (science, technology, engineering, and mathematics) concepts that you believe to be associated with junior livestock projects.

Should local 4-H and FFA leaders/advisors incorporate STEM concepts into their programming and instruction? If yes, please explain.

What barriers, if any, do you believe prevent the incorporation of STEM concepts into their programming and instruction?

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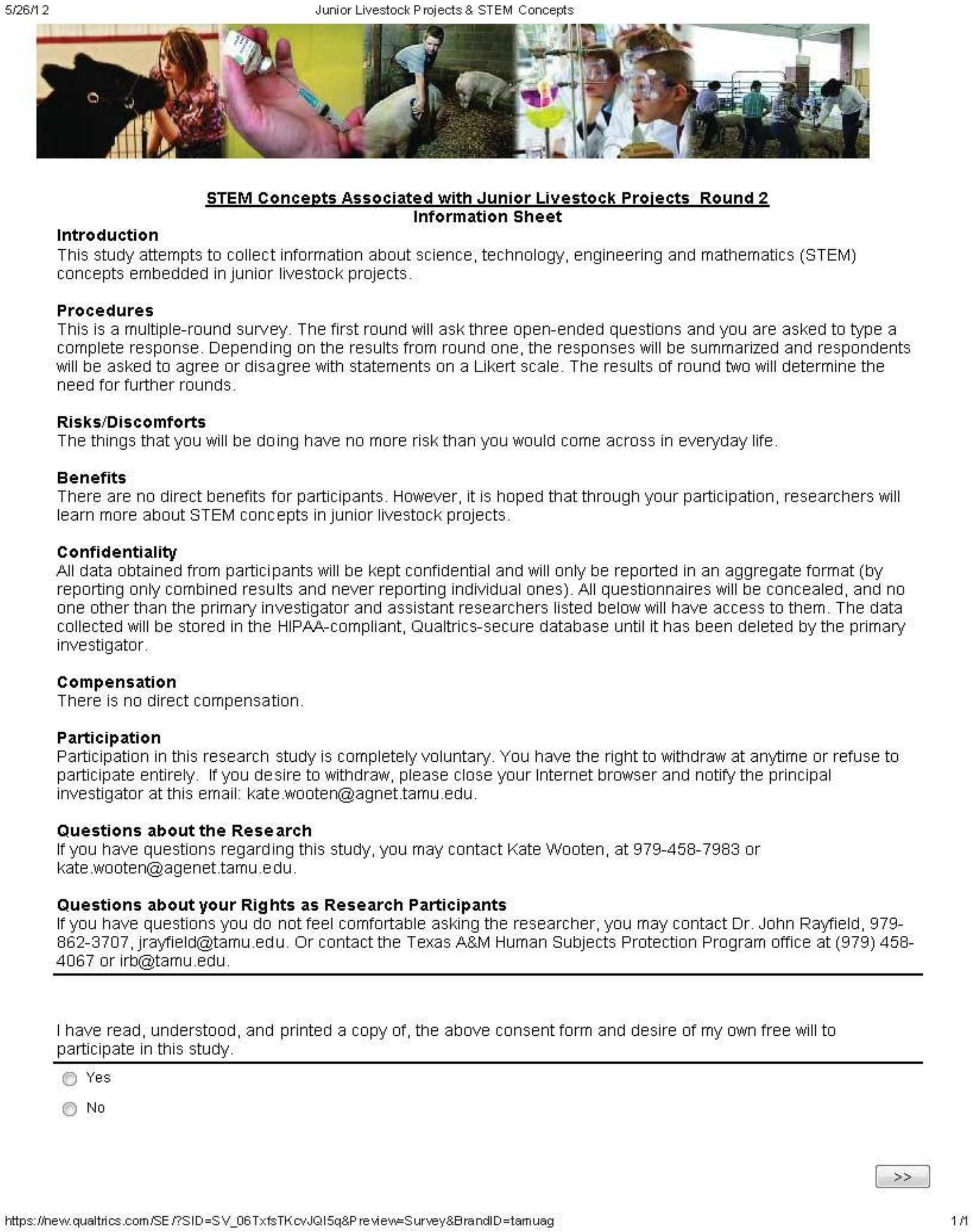
Thank you for your time and thoughtful consideration completing round one of this STEM and Junior Livestock Project Survey.

APPENDIX B



5/26/12 Junior Livestock Projects & STEM Concepts

STEM Concepts Associated with Junior Livestock Projects Round 2
Information Sheet

Introduction
This study attempts to collect information about science, technology, engineering and mathematics (STEM) concepts embedded in junior livestock projects.

Procedures
This is a multiple-round survey. The first round will ask three open-ended questions and you are asked to type a complete response. Depending on the results from round one, the responses will be summarized and respondents will be asked to agree or disagree with statements on a Likert scale. The results of round two will determine the need for further rounds.

Risks/Discomforts
The things that you will be doing have no more risk than you would come across in everyday life.

Benefits
There are no direct benefits for participants. However, it is hoped that through your participation, researchers will learn more about STEM concepts in junior livestock projects.

Confidentiality
All data obtained from participants will be kept confidential and will only be reported in an aggregate format (by reporting only combined results and never reporting individual ones). All questionnaires will be concealed, and no one other than the primary investigator and assistant researchers listed below will have access to them. The data collected will be stored in the HIPAA-compliant, Qualtrics-secure database until it has been deleted by the primary investigator.

Compensation
There is no direct compensation.

Participation
Participation in this research study is completely voluntary. You have the right to withdraw at anytime or refuse to participate entirely. If you desire to withdraw, please close your Internet browser and notify the principal investigator at this email: kate.wooten@agnet.tamu.edu.

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Questions about your Rights as Research Participants
If you have questions you do not feel comfortable asking the researcher, you may contact Dr. John Rayfield, 979-862-3707, jrayfield@tamu.edu. Or contact the Texas A&M Human Subjects Protection Program office at (979) 458-4067 or irb@tamu.edu.

I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

○ Yes

○ No

https://new.qualtrics.com/SE/?SID=SV_06TxfsTKcvJQI5q&Preview=Survey&BrandID=tamuag 1/1

1. Through participation in junior livestock projects, students learn the **science** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Anatomy and physiology (i.e. Structure, muscle biology, growth and development, and ruminant physiology)	○	○	○	○	
b. Animal health (i.e. Disease diagnosis and treatment, parasite control and treatment, biosecurity, analyze urine and stool samples, digestive health, medicine withdrawal times, vaccinations, implants, and animal care and management)	○	○	○	○	
c. Genetics (i.e. Specific breed reproduction, artificial insemination and embryo transfer, sire selection, gene purity and consistency, selection of replacement and cull animals, read pedigrees, cloning, DNA samples, and EPDs)	○	○	○	○	
d. Meat Science (i.e. Food safety and market readiness)	○	○	○	○	
e. Nutrition (i.e. Determining appropriate feed rations, adjusting protein and energy requirements, importance of water and roughage, nutrition's impact on growth and development, feed additives, rate-of-gain, growth and carcass merit, feed utilization, and optimum weight and finish)	○	○	○	○	
f. Reproduction (i.e. Reproductive physiology, gestation, reproductive health, and sound husbandry)	○	○	○	○	

2. Through participation in junior livestock projects, students learn the **technology** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Herd management (i.e. Scales, electronic animal ID, vaccinations, mixing and preparing grain, feed additives, growth promotants, and carcass estimates)	○	○	○	○	○
b. Animal Husbandry (i.e. Check estrus and gestation, artificial insemination, embryo transfer, palpation, ultra sound, and EPDs)	○	○	○	○	○
c. Marketing and networking (i.e. Use internet to buy and sell livestock, marketing, build websites/marketing programs, communicate through social media, find resources to support projects, and delivering and disseminating education materials)	○	○	○	○	○
d. Record keeping (i.e. Use of lap tops, cell phones, and iPads to communicate, find new information, and store records)	○	○	○	○	○

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3. Through participation in junior livestock projects, students learn the **engineering** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Building facilities (i.e. design and construction of livestock housing or enclosures, working pens, building fence, setting up barn or stall, determining and installing environmental controls, installing protection systems, and selection of materials for construction)	○	○	○	○	○
b. Electricity (i.e. motor inner-workings, selection and use of generator, why breakers flip, and what is a circuit)	○	○	○	○	○
c. Hauling livestock (i.e. Selection of proper trailer--aluminum or steel)	○	○	○	○	○
d. Presentation of the animal (i.e. Relationship of animal's dimensions to achieve balance-- width, depth, length, position of exhibitor when presenting animal, and presentation of the animal in terms of angles, leg placement, touching loin to straighten top line)	○	○	○	○	○

4. Through participation in junior livestock projects, students learn the **mathematics** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agr
a. Animal Health (i.e. Angle of joints in feet and legs, scales, measurements, and calculating medicine dosage)	○	○	○	○	○
b. Genetics (i.e. EPD comparison, carcass predictions, days to parturition, days from birth to rebreeding, animal performance, and growth and development)	○	○	○	○	○
c. Marketing (i.e. Comparitive analysis of animals, economic impact, and marketing and purchase of livestock)	○	○	○	○	○
d. Nutrition (i.e. Feed efficiency, stocking rates, determining amount and type of feed for an animal, average daily gain, adjusting rations for different stages of animal development, feed efficiency, calculate weigh backs, balance rations, meat science, and determining energy and protein content of feeds)	○	○	○	○	○
e. Record keeping (i.e. Financial literacy, cost analysis of insurance and farming programs, accrued interest, track costs associated with raising and showing animals, profit and loss, business analysis, budgets, return on invenstment, profitability, and financing)	○	○	○	○	○

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5. Why should local 4-H and FFA leaders/advisors **incorporate STEM concepts** into their programming and instruction?

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Advance the livestock profession (i.e. Relate show ring to real life livestock production, improve animal welfare, create lifelong ambassadors for the cause, and associate genetic improvement with the livestock industry)	○	○	○	○	○
b. Garner support (i.e. Gain credibility within the school system and industry, survival factor due to the academic push for the implementation of STEM, garner support and donations, and increase rigor)	○	○	○	○	○
c. Relate to education (i.e. Connect 4-H or FFA activities to core subject classes, able to apply concepts learned through core subjects, correlates 4-H and FFA with academic performance standards, helps students understand complicated concepts in concrete way, and real-life application of STEM principles)	○	○	○	○	○
d. Prepare for real life (i.e. Shows how interconnected all aspects of STEM are to each other, skills learned will be valuable for the rest of the student's life, become problem solvers, provides real-world experience with abstract STEM concepts, multi-disciplinary education, allows students to make important decisions in a supervised way, and skills and abilities are transferable to career path)	○	○	○	○	○

6. What **barriers prevent the incorporation of STEM concepts** into 4-H and FFA programming and instruction?

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agr
a. Higher cost	○	○	○	○	○
b. Lack of facilities	○	○	○	○	○
c. Lack of student engagement	○	○	○	○	○
d. Lack of understanding of leader/advisor (i.e. Unsure of what STEM is and how to teach those concepts, not properly trained, and figuring out how to teach those subjects)	○	○	○	○	○
e. No standardized curriculum (i.e. No curriculum, material not easily accessible, and not a requirement)	○	○	○	○	○
f. Leaders/Advisors not willing to change (i.e. Lack of vision or importance, not comfortable with material, stuck in their ways, not willing to go out of the box, and resists change)	○	○	○	○	○
g. Lack of time (i.e. Limited time to create materials necessary, do not have the student in the classroom setting, takes time to teach complicated subjects, and many students involved)	○	○	○	○	○

\>>

7. **Other Concepts**

The following responses were not easily classifiable.

Please **rate your level of agreement** that students learn the concept through junior livestock projects AND **select the subject area where each concepts fits best.**

	Rate your level of agreement that students learn the concept through junior livestock projects:						**To which subject does this conc**			
	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Science	Technology	Engineering	Ma
a. Utilizing older youth to teach younger subjects	○	○	○	○	○	○	○	○	○	
b. Technology needed to properly apply fertilizer	○	○	○	○	○	○	○	○	○	
c. Chemical analysis of soils	○	○	○	○	○	○	○	○	○	
d. Chemical analysis of water	○	○	○	○	○	○	○	○	○	
e. Entomology	○	○	○	○	○	○	○	○	○	
f. Understanding flight zones	○	○	○	○	○	○	○	○	○	
g. Principles of heating and cooling	○	○	○	○	○	○	○	○	○	
h. Rubber feed pans on ground or feed pans that hang on the fence	○	○	○	○	○	○	○	○	○	
i. Livestock evaluation	○	○	○	○	○	○	○	○	○	
j. Animal handling traits	○	○	○	○	○	○	○	○	○	
k. Animal behavior	○	○	○	○	○	○	○	○	○	

8. List any **important concepts** you believe **have been omitted** from the previous round.

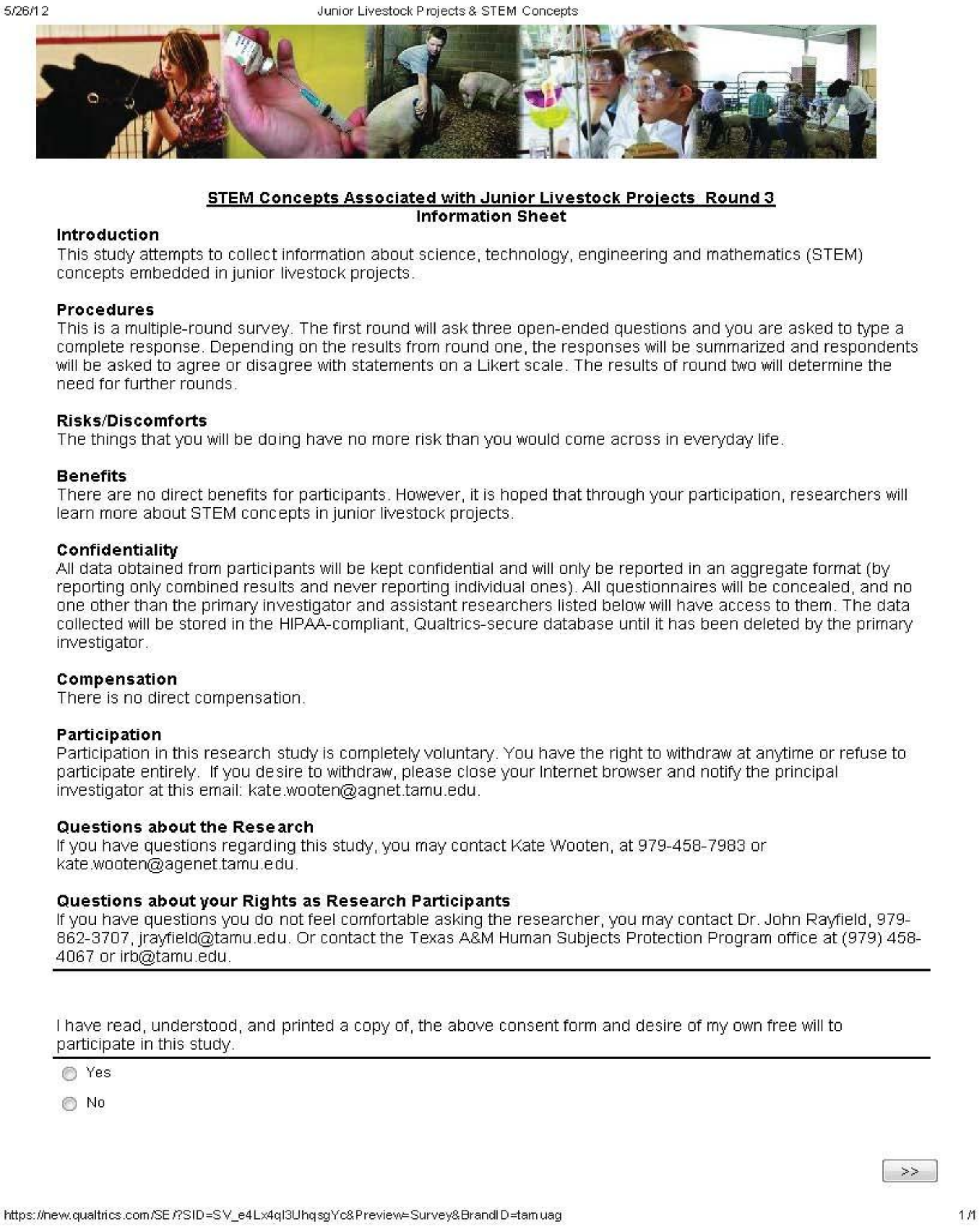
>>

Thank you for completing round 2 of the STEM and junior livestock survey!

Questions?

kate.wooten@agnet.tamu.edu

APPENDIX C



5/26/12 Junior Livestock Projects & STEM Concepts

STEM Concepts Associated with Junior Livestock Projects Round 3
Information Sheet

Introduction
This study attempts to collect information about science, technology, engineering and mathematics (STEM) concepts embedded in junior livestock projects.

Procedures
This is a multiple-round survey. The first round will ask three open-ended questions and you are asked to type a complete response. Depending on the results from round one, the responses will be summarized and respondents will be asked to agree or disagree with statements on a Likert scale. The results of round two will determine the need for further rounds.

Risks/Discomforts
The things that you will be doing have no more risk than you would come across in everyday life.

Benefits
There are no direct benefits for participants. However, it is hoped that through your participation, researchers will learn more about STEM concepts in junior livestock projects.

Confidentiality
All data obtained from participants will be kept confidential and will only be reported in an aggregate format (by reporting only combined results and never reporting individual ones). All questionnaires will be concealed, and no one other than the primary investigator and assistant researchers listed below will have access to them. The data collected will be stored in the HIPAA-compliant, Qualtrics-secure database until it has been deleted by the primary investigator.

Compensation
There is no direct compensation.

Participation
Participation in this research study is completely voluntary. You have the right to withdraw at anytime or refuse to participate entirely. If you desire to withdraw, please close your Internet browser and notify the principal investigator at this email: kate.wooten@agnet.tamu.edu.

Questions about the Research
If you have questions regarding this study, you may contact Kate Wooten, at 979-458-7983 or kate.wooten@agenet.tamu.edu.

Questions about your Rights as Research Participants
If you have questions you do not feel comfortable asking the researcher, you may contact Dr. John Rayfield, 979-862-3707, jrayfield@tamu.edu. Or contact the Texas A&M Human Subjects Protection Program office at (979) 458-4067 or irb@tamu.edu.

I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

○ Yes

○ No

https://new.qualtrics.com/SE/?SID=SV_e4Lx4ql3UhqsgYc&Preview=Survey&BrandID=tamuag 1/1

1. Through participation in junior livestock projects, students learn the **science** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Meat Science (i.e. Food safety and market readiness) - Round 2 mean = 4.87	○	○	○	○	
b. Chemical Analysis of Soils and Water - Round 2 mean = 3.13	○	○	○	○	
c. Entomology - Round 2 mean = 3.91	○	○	○	○	
d. Understanding Flight Zones - Round 2 mean = 4.65	○	○	○	○	
e. Principles of Heating and Cooling - Round 2 mean = 4.04	○	○	○	○	

2. Through participation in junior livestock projects, students learn the **technology** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Animal Husbandry (i.e. Check estrus and gestation, artificial insemination, embryo transfer, palpation, ultra sound, and EPDs) - Round 2 mean = 4.91	○	○	○	○	○
b. Technology needed to properly apply fertilizer - Round 2 mean of 3.26	○	○	○	○	○

3. Through participation in junior livestock projects, students learn the **engineering** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Ag
a. Building facilities (i.e. design and construction of livestock housing or enclosures, working pens, building fence, setting up barn or stall, determining and installing environmental controls, installing protection systems, and selection of materials for construction) - Round 2 mean = 4.96	○	○	○	○	○
b. Electricity (i.e. motor inner-workings, selection and use of generator, why breakers flip, and what is a circuit) - Round 2 mean = 4.04	○	○	○	○	○
c. Hauling livestock (i.e. Selection of proper trailer--aluminum or steel) - Round 2 mean = 4.87	○	○	○	○	○
d. Rubber feed pans on ground or feed pans that hang on fence - Round 2 mean = 4.35	○	○	○	○	○

4. Through participation in junior livestock projects, students learn the **mathematics** concepts of:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agr
a. Genetics (i.e. EPD comparison, carcass predictions, days to parturition, days from birth to rebreeding, animal performance, and growth and development) - Round 2 mean = 4.83	○	○	○	○	○

>>

6. What **barriers prevent the incorporation of STEM concepts** into 4-H and FFA programming and instruction?

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agr
a. Higher cost - Round 2 mean = 4.00	○	○	○	○	○
b. Lack of facilities - Round 2 mean = 4.13	○	○	○	○	○
c. Lack of student engagement - Round 2 mean = 3.83	○	○	○	○	○
d. Lack of understanding of leader/advisor (i.e. Unsure of what STEM is and how to teach those concepts, not properly trained, and figuring out how to teach those subjects) - Round 2 mean = 4.87	○	○	○	○	○
e. No standardized curriculum (i.e. No curriculum, material not easily accessible, and not a requirement) - Round 2 mean = 4.87	○	○	○	○	○
f. Leaders/Advisors not willing to change (i.e. Lack of vision or importance, not comfortable with material, stuck in their ways, not willing to go out of the box, and resists change) - Round 2 mean = 4.48	○	○	○	○	○
g. Lack of time (i.e. Limited time to create materials necessary, do not have the student in the classroom setting, takes time to teach complicated subjects, and many students involved) - Round 2 mean = 4.52	○	○	○	○	○

>>

Thank you for completing round 2 of the STEM and junior livestock survey!

Questions?
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