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Identifying STEM Concepts Associated with Junior Livestock Projects

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Science, technology, engineering, and mathematics (STEM) education is intended to provide students with a cross-subject, contextual learning experience. To more fully prepare our nation's students to enter 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 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. Using a modified Delphi technique, this study identified 21 STEM concepts associated with junior livestock projects. 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. The link between science, technology, engineering, and mathematics, core subject education, and the concepts present in junior livestock projects should be emphasized in curricular and programming efforts.

Keywords: STEM; junior livestock; junior livestock projects

The traditional 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, 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 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 to help students be successful in STEM areas (Melodia & Small, 2002). Similarly, 4-H encourages 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).

FFA and 4-H livestock projects 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, and Roe, 1992; Melodia & Small, 2002).

Theoretical Framework

John Dewey (1938), referred to as the most influential educational theorist of the twentieth-century (Kolb, 1984), believed there is an intimate and necessary relationship between experience and education. 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 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 (as cited in Baker and Robinson, 2011, p. 186) 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".

More specifically, the STEM education initiative involves bridging concepts of science, technology, engineering, and mathematics into other disciplines in schools (Morrison, 2006).
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).

Blumenfeld et al. (1991) suggested 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. 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. Breiner et al. (2012) suggested that STEM education replaces the traditional lecture-style teaching approaches with inquiry and project-based strategies. 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). 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, 2012). 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).

Knobloch (2003) posited "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 citizens of society" (p. 32). Much 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 75% of 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 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, and Roe (1992) who found 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 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 SAEs 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.

Priority area four of the 2011-2015 National Research Agenda (Doerfert, 2011) emphasizes meaningful, engaged learning in all environments. The agenda specifically calls for studies that "Examine various meaningful learning environments in assorted agricultural education contexts for their impact on specific cognitive, affective, and psychomotor learning outcomes" (Doerfert, 2011, p. 9). Identification of STEM concepts within various agricultural education contexts is an important aspect in the overall study of meaningful learning environments.

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 research objective that guided the study was:

1) Identify the STEM concepts associated with junior livestock projects.

Methods and Procedures

This descriptive study 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: 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 and, 3) knowledgeable of STEM concepts 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 researchers gauged the demographic makeup of the judges from 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 education 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.

Round One

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 in junior livestock projects. The first round question was:

> 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 researchers collapsed the responses into 30 categories which best represented the statements.

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 30 classified concept categories using a 6-point summated scale: "1" = "Strongly Disagree," "2" = "Disagree," "3" = "Somewhat Disagree," "4" = "Somewhat Agree," "5" = "Agree," "6" = "Strongly Agree." In order for an item to reach *consensus of agreement*, the item had to receive a mean score of ≥ 5.0 from the panelists. Items not reaching *consensus of agreement* were sent back to panelist in round three. Twenty-four panelists responded to round two for a response rate of 92%. One panelist in round two asked to be removed from the study.

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

The 316 concepts provided by STEM and junior livestock project experts in round one 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 collapsed into 30 categories for presentation to panelists in round two. Table 1 shows all STEM concepts along with descriptors used to define specific concepts.

Table 1

STEM concepts categories and descriptors

Science

- Anatomy and physiology (i.e., structure, muscle biology, growth and development, and ruminant physiology)
- Animal behavior
- Animal handling techniques
- 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)
- Chemical analysis of soils
- Chemical analysis of water
- Entomology
- 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)
- Livestock evaluation
- Meat Science (i.e., Food safety and market readiness)
- 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)
- Principles of heating and cooling
- Reproduction (i.e., Reproductive physiology, gestation, reproductive health, and sound husbandry)
- Understanding of flight zones

Technology

- Animal husbandry (i.e., Check estrus and gestation, artificial insemination, embryo transfer, palpation, ultrasound, and EPDs)
- 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)
- Technology needed to properly apply fertilizer
- Utilizing older youth to teach younger students

Table 1 Continues

Table 1 Continued

Engineering

- 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-working, selection and use of generator, why breakers flip, and what is a circuit)
- Hauling livestock (i.e., Selection of proper trailer—aluminum or steel)
- 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)
- Rubber feed pans on ground or feed pans hanging on fence

Mathematics

- Animal health (i.e., Angle of joints in feet and legs, scales, measurements, and calculating medicine dosage)
- Genetics (i.e., EPD comparison, carcass predictions, days to parturition, days from birth to re-breeding, animal performance, and growth and development)
- 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)
- 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)

In round two panelists were asked to rate their level of agreement on 30 concept categories. On the instrument, each subject area (i.e., Science, Technology, Engineering, and Mathematics) contained several categories. The number of categories reaching *consensus of agreement* ($m \geq 5.0$), by subject were Science = 8; Technology = 4; Engineering = 1; and Mathematics = 4. In total, 17 categories reached the level of agreement defined as "*consensus*" *a priori*. Table 2 displays STEM concepts that reached consensus with a mean score of ≥ 5.0. Livestock evaluation posted the highest mean score in the science category at 5.70. Herd management had the highest score under technology at 5.57. Presentation of the animal received the highest engineering score at 5.87 and nutrition was the highest score under mathematics at 5.35.

Table 2

STEM Concepts that Reached Consensus in Round Two (N = 24)

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 students	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 that failed to reach consensus in round two is listed below in Table 3. The science categories which did not reach consensus were: Meat science; 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 were: Animal husbandry and Technology needed to properly apply fertilizer. The engineering categories which did not reach consensus were: Building facilities, Electricity, Hauling livestock, and Rubber feed pans on ground or feed pans hanging on fence. The mathematics category which did not reach consensus was: Genetics. The panelists were asked to rate their level of agreement on the 13 concept categories that failed to reach the established “level of agreement” $m \geq 5.0$ for consensus in round two. Four concept categories reached consensus in the third and final round (Table 4). The nine concept categories which failed to reach the established “level of agreement” $m \geq 5.0$ for consensus in round three are found in table 5.

Table 3

STEM Concepts that Failed to Reach Consensus in Round Two (N = 24)

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."

Table 4

STEM Concepts that Reached Consensus after Round Three (N = 24)

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."

Table 5

STEM Concepts that Failed to Reach Consensus after Round Three (N = 24)

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	3.09
Chemical analysis of water	3.06
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 of the modified Delphi, 21 concept categories reached consensus (m = 5.00 or higher) with the panel of experts. Nine concept categories failed to reach consensus (m = ≤ 5.00).

Conclusions

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. 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 junior livestock projects. 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 different manner during participation in a junior livestock project, these projects can provide a context for those abstract core concept principles. This connection may help agricultural education and 4-H remain relevant in our educational system as a way to apply complex concepts.

Recommendations

Recommendations for 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 real world livestock production. It is also recommended that the current curriculum be updated to include STEM connections. 4-H leaders and agricultural education teachers struggle to find STEM curriculum in the area of junior livestock projects. Additional curriculum development is needed in order to facilitate quality instruction of STEM related to junior livestock projects. Knowledge of STEM concepts being taught and helping teachers and leaders make connections to STEM, may lead to increased teaching efficacy in STEM related content areas.

Recommendations for Future Research

Rusk et al. (2003) found 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 are 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. Does this signal that our agricultural education teachers and 4-H leaders provide more science and math applications during project supervision? Do the teachers and leaders find engineering and technology concepts more difficult to integrate in their instruction? 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 “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.

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