

Exploring Exemplary STEM Lessons in Agricultural Education

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Abstract

School-based agricultural education offers a rich context to illuminate science, technology, engineering, and mathematics (STEM). Understanding and enhancing STEM learning within agricultural education requires a deep understanding of how agricultural educators currently illuminate STEM concepts within their curriculum. Building upon the work of Integrative STEM Education, we explored agriculture teacher-identified exemplary STEM lessons taught by eight educators in two states using a transcendental phenomenology. Through individual interviews, teachers identified and described one exemplary STEM lesson. Across responding teachers, diverse learning experiences were described as their exemplary STEM lessons, including lessons involving raising broiler chickens, creating flower food formulas, and welding square dice. Analysis of teacher descriptions of their exemplary STEM lessons illustrate these lessons are influenced by the teacher's perspective of STEM; enhanced by relevant facilities, curriculum structure, and opportunities for application; and yield diverse and meaningful student outcomes. Connections between the features of agriculture teacher-identified exemplary STEM lessons and Integrative STEM Education are described alongside identification of elements which may make exemplary STEM lessons in agricultural education unique.

Introduction

Science, technology, engineering, and mathematics (STEM) has been part of educational nomenclature since the early 2000s (Dugger, 2010). STEM education refers to initiatives which emphasize learning STEM content and skills (i.e., as individual disciplines or combinations of disciplines) throughout education. Two primary factors have catalyzed the rise of STEM education. First, STEM education is necessary to prepare individuals with the skills needed to succeed in new and emerging careers throughout society, including in agriculture, food, and natural resource systems (Marcos Fernandez et al., 2020; Stubbs & Myers, 2016). Second, STEM education is a response to declining U.S. student performance in these core academic areas (National Science Board, National Science Foundation, 2021).

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Agricultural education plays an important role in STEM education (Knobloch & Wang, 2024; Scherer et al., 2019; Smith et al., 2015). The connection between STEM and agricultural education emerges from the authentic context agriculture, food, and natural resources offers STEM content and skills (Knobloch & Wang, 2024; Norris et al., 2024; Scherer et al., 2019; Stone, 2011). Further, making STEM more tangible provides learners a better opportunity to grasp the concepts and skills inherent within STEM education. Understanding how agricultural educators incorporate STEM education within their curricula is critical to understanding and expanding the role of agricultural education within STEM education. Thus, the current study explored the experiences of agricultural educators facilitating self-identified “exemplary” STEM lessons within their instruction.

Literature Review

A review of existing literature on STEM within agricultural education resulted in three relevant themes: (a) agriculture teacher perceptions of STEM, (b) outcomes of STEM in agricultural education, and (c) STEM curriculum in agricultural education.

Agriculture Teacher Perceptions of STEM

The first theme within our review of literature on STEM within agricultural education was the perception of agriculture teachers regarding STEM. Consistently, agriculture teachers reported positive perceptions associated with including STEM content within their agricultural curriculum (McKim et al., 2017; Smalley & Hainline, 2024; Smith et al., 2015; Stubbs & Myers, 2016). Scholarship suggested these positive perceptions emerged from teachers viewing agriculture as an effective delivery system for STEM concepts (Swortzel & Brister, 2009); teacher beliefs that STEM had positively contributed to society, especially production agriculture (Stubbs & Myers, 2016); and professional development experiences tailored to STEM in agricultural education (Smalley & Hainline, 2024; Stubbs & Myers, 2016). In addition to positive perceptions, teachers also reported consistently high confidence in their ability to teach STEM concepts, with their confidence teaching science and mathematics exceeding that of technology and engineering (Smith et al., 2015).

Outcomes of STEM in Agricultural Education

The positive perceptions of STEM held by agriculture teachers were reinforced by student achievement resulting from teaching STEM within agriculture. Stubbs and Myers (2016) found teachers reported STEM learning gains as a product of intentional integration of STEM concepts within agriculture. These findings were supported by consistent literature within the discipline finding gains in science and mathematics knowledge when these core academic subjects were integrated within agricultural curricula (Chiasson & Burnett, 2001; Ferand et al., 2022; Myers & Dyer, 2006; Parr et al., 2006; Ricketts et al., 2006; Theriot & Kotrlik, 2009; Young et al., 2009). A less positive outcome, however, was agriculture teachers reporting concern that overemphasizing STEM could reduce student interest in agricultural content and coursework (Stubbs & Myers, 2016).

STEM Instructional Approaches in Agricultural Education

In addition to teacher perceptions and outcomes of STEM within agricultural education, the instructional approaches used to teach STEM in agriculture emerged as a theme of our literature review. In a comprehensive review of STEM in agricultural education literature, Scherer et al. (2019) noted most existing research on the topic fails to specify an instructional approach, noting this as a major limitation of scholarship on STEM in agricultural education. For those specifying an approach, the most common methods of instruction were problem-based and hands-on learning (Scherer et al., 2019). Exploring the origins of STEM lessons, research has found teachers utilize online curricula due to its accessibility

(Erikson et al., 2020; Stubbs & Myers, 2016). Additional sources for STEM lessons within agriculture include teacher preparation, professional development, and teacher-developed ideas (Smalley et al., 2023; Stubbs & Myers, 2016).

In summary, the literature review on STEM in agricultural education suggested teachers hold positive perceptions of STEM, including confidence in their ability to teach STEM concepts. Additionally, scholarship suggested STEM content taught within agriculture curriculum yield significant student learning gains, especially in the areas of science and mathematics. Our literature review also illuminated an area of necessary development within the discipline, suggesting existing scholarship lacks “the depth of descriptions of instructional approaches” (Scherer et al., 2019, p. 41) necessary to inform educators and scholars on *how* STEM is being taught within agricultural education curricula. To address this deficit, the current study explored lessons agricultural educators identified as exemplary STEM lessons within their agricultural instruction.

Theoretical Framework

This study was informed by, and contributes to, the body of literature on Integrative STEM Education. Integrative STEM Education “includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” (Sanders, 2009, p. 21). Integrative STEM Education highlights the need for educational experiences that intentionally integrate STEM concepts and practices within an authentic context like technological design, natural resource systems, or food systems (Sanders, 2012). Learning environments in Integrative STEM Education (a) involve using STEM knowledge and practices to solve authentic problems; (b) result in the development of identifiable STEM dispositions (e.g., reasoning, questioning); and (c) foreground design-based learning, in which learners analyze a problem and design, develop, implement, and evaluate a solution to the problem (Sanders, 2012). The preceding are three core principles of Integrative STEM Education. In the current study, we explored school-based agriculture teachers’ self-identified “exemplary” STEM lessons. Comparing these lessons with the foundations of Integrative STEM Education may illustrate the implementation of Integrative STEM Education within agricultural education while also illuminating opportunities to strengthen STEM education within agricultural education via intentional integration of Integrative STEM principles.

Purpose and Objectives

The purpose of this study was to better understand how STEM education is facilitated within agricultural education. To accomplish this purpose, the following objective was addressed: Explore lessons agricultural educators identify as exemplary STEM lessons within their agricultural instruction.

Methods

A transcendental phenomenology was employed to complete this research. The objective of a transcendental phenomenology is to “determine meaning, deal with the essence of an experience...through what appears and through reflective description” (Mott & Haddad, 2023, p. 6). The phenomenon of interest was the structure of learning experiences agricultural educators self-identified as exemplary STEM lessons.

As researchers of this study, we examined this phenomenon through a constructivist lens, assuming truth and reality are not fixed; rather, truth is co-created. Truth, therefore, was seen as subjective and shaped by personal perspectives. With this lens, we positioned an exemplary STEM lesson from the perspective of the teacher rather than an agreed upon set of standards for *exemplary*. Taking a constructivist approach, we did not define or establish parameters (e.g., student achievement gains) around the term *exemplary*. Further, what could be defined as an exemplary lesson in one context or moment in time, may not be exemplary in

another. Therefore, teachers self-identifying exemplary STEM lessons within the context of their own teaching seemed the most appropriate approach for this study. Participants were recruited knowing they were going to be asked to share their best instance of STEM teaching. We assumed the participants reflected and selected their most exemplary lesson for their specific context.

Participant Recruitment

Participants included school-based agriculture teachers in Utah and Michigan. Participants were recruited via statewide emails inviting them to share their experiences teaching STEM within agricultural curriculum. We did not use the term “expert” in our recruitment because we fundamentally distinguished between an “expert teacher” and a teacher who teaches an exemplary STEM lesson. Teachers who responded to the recruitment emails and who met the criteria for inclusion (i.e., school-based agriculture teacher in Utah or Michigan) in the study were included as participants. In total, eight teachers participated in the interviews, including six teachers from Utah and two teachers from Michigan. Selected teachers represented a diversity of school and classroom types, background experiences, and experience as agricultural educators. A more detailed description of participants is provided later.

Data Collection

Data were collected during the 2022-2023 school year via recorded, one-on-one Zoom interviews that averaged 60 minutes in length. During the interviews, teachers were asked to reflect upon the curriculum taught within a given year to identify “the best instance of STEM education within their AFNR coursework,” operationalized as their “exemplary STEM lesson.” Then, respondents were asked to describe *why* they characterized the identified experience as their best instance of STEM education. Following this, teachers were asked questions to inform our understanding of their exemplary STEM lesson, including questions related to the (a) sequence of the experience within their curricula; (b) expected learning outcomes; (c) teaching methods; (d) assessment approaches; (e) extended learning opportunities (i.e., FFA, SAE, community service); and (f) facilities associated with their self-identified exemplary STEM lesson. The final question had teachers identify ways they could improve the exemplary STEM lesson in the future.

Data Analysis

All interview data were transcribed verbatim in preparation for data analysis. A multi-stage coding process was completed which included open, axial, and selective coding (Flick, 2009; Strauss & Corbin, 1990). Three rounds of analysis were conducted to transform the raw data into themes and sub-themes. During the first round of analysis, we read through and open-coded the data from each interview. Open coding resulted in 12 codes. Round two of data analysis consisted of reading through the transcripts again, examining the codes and concepts that emerged in the first round, and then attempting to link and relate data together. During this stage, codes and concepts were combined and narrowed into five categories. The third and final round of analysis consisted of re-organizing and refining the categories and themes and determining the overarching categories, themes, and sub-themes from the data. Selective coding resulted in the final model, which includes the lesson, teacher perspective, and student outcomes. During this phase, the categories, themes, and sub-themes, which we refer to as codes, were reviewed for accuracy. In the end, data were organized into three major categories, five total themes, and ten total codes. Coding was completed by the lead researcher, with two additional authors serving as auditors to the coding process. The auditing process resulted in minor changes to two themes and their codes. Relevant quotes are reported alongside participant pseudonyms, which were developed by the research team.

Subjectivity Statement and Primary Limitation

All the authors of this paper are deeply integrated within education. While their roles in education are each unique, all authors share the belief that STEM content and practices being taught within a school-based agricultural education program is beneficial for learners, educators, programs, and communities. Additionally, two authors of this work are engaged in a multi-state project supported through the United States Department of Agriculture (USDA) focused on STEM within agricultural education, and this work aligns with a research objective of that multi-state project.

A primary limitation of this study is teachers self-identified their exemplary STEM lessons. It is probable the lessons provided by respondents do not meet all definitions of exemplary STEM learning and that other lessons taught by participants could be classified, by some, as more exemplary STEM learning experiences. A salient result of this limitation is participating teachers shared lessons which primarily feature science as opposed to lessons which equally feature technology, engineering, and mathematics.

Trustworthiness

To establish credibility, we used member checking (Lincoln & Guba, 1985). After a draft of the manuscript's findings was developed, we shared it with all eight participants to seek their approval and agreement (Harvey, 2015). There were no disagreements or suggested edits from participants. Transferability was established using thick, rich descriptions of the study context, the STEM lesson plans, and the participants. We established confirmability by documenting a clear coding schema throughout the process, maintaining an audit trail of all resources, and utilizing a data bank as a reference. Finally, we established dependability by utilizing two outside researchers to conduct an external inquiry audit on the research study. The outside researchers examined the data collection and analysis process as well as the results. Results of the external audit resulted in small adjustments of code and theme names.

Findings and Discussion

An introduction to the eight participants, based on information shared during the interviews, is provided below. Additionally, an introduction to the exemplary STEM lesson they discussed during their interview is included following their introduction.

Participants and the Exemplary STEM Lessons

Jacee had been teaching for 24 years, the previous eight in agricultural education. Jacee taught in a rural high school with approximately 700 students. The school was 60% free and reduced lunch, with 94% of the student body being white. Jacee's average class size was 24. The exemplary STEM lesson Jacee discussed was food nutrition in a broiler raising project which focused on students understanding the food science, chemistry, and biology of raising broiler chickens. This lesson was included within her animal biology content, taught to first- and second-year students in the program.

Jennifer had taught for 22 years in Career and Technical Education, including the previous eight years in agricultural education. Jennifer taught agriculture biology, floriculture, plant science, natural resources, and leadership. At the high school, there were just under 500 students. The exemplary STEM lesson Jennifer highlighted was titled *Cellular Respiration* and was a lesson she gained access to through her training with the Curriculum for Agricultural Science Education (CASE) content. This lesson was taught in her freshman level agriculture biology course.

Kent had taught agriculture for a total of nine years; however, spent 30 years in industry between teaching stints. Kent taught courses in agricultural science, equine science, animal science, agricultural

systems and technology, and agricultural biology. At the high school, there were approximately 450 students. On average, Kent had 28 to 32 students in each of his classes. The exemplary STEM lesson Kent discussed was binomial naming, including teaching students the scientific names for animal breeds and having students write a report on a specific animal breed. This lesson was taught in his freshman agricultural science course.

Michelle was a fifth-year agriculture teacher teaching within her self-described “dream job” at the high school she attended. On average, Michelle taught 32 students per class. For her exemplary STEM lesson, Michelle discussed having freshmen agriculture science students propose an agriscience fair project by writing the first half of a lab report for their self-selected research question. Michelle also noted students have the option of completing their agriscience fair project to compete within an FFA event.

Monica was an early career agriculture teacher within a three-teacher program. Monica’s courseload included agriculture biology, floriculture, and greenhouse management. For her exemplary STEM lesson, Monica focused on a lesson in which her junior/senior level floriculture students are provided household products and tasked with developing and creating a flower nutrition mix for two cut flowers. Monica highlighted that this lesson becomes a competition to see which flowers survive the longest, noting one student’s flowers stayed alive for an impressive two months.

Natalie was also an early career teacher, in her second year as an agricultural educator. Natalie taught within an urban high school, and she indicated most of the students had little to no experience in agriculture. Natalie taught courses in animal science, floral design, and career pathways for middle school students. On average, Natalie taught classes with 40 students enrolled. The exemplary STEM lesson Natalie discussed was a lesson titled *Floral of the Month*, which she teaches in her junior/senior level floral design class. In this lesson, students create floral arrangements to be sold to faculty, staff, and community members. Additionally, students calculate the actual costs of the arrangements.

Ronda was finishing up her tenth year of teaching agriculture and natural resources. Ronda taught at a Career and Technical Education center, which included junior and senior students from seven area high schools. Like Jacee, Ronda also highlighted a broiler raising project as her exemplary STEM lesson. In Ronda’s iteration, the broiler project was used to build student capacity to make and defend claims using data gathered during the project. For example, students might gather and analyze data to answer the question, “which pen of chickens had the best growing conditions?”

Trent was teaching agriculture in a middle school that served students in sixth through eighth grade. Trent said “30% to 40% of our student body are Native Americans.” Trent noted the entire student body included approximately 275 students, and his class sizes ranged from 10 to 32, with an average of 26 per class. Regarding his exemplary STEM lesson, Trent described a unit within his welding and fabrication content in which students measure, cut, and weld a four-inch square dice.

The experiences of agricultural educators teaching self-identified exemplary STEM lessons involved three distinct categories of reflections, (a) the lesson, (b) teacher perspective, and (c) student outcomes. The findings section is organized by these three categories.

The Lesson

The first theme within the lesson category was the *curriculum structure*, which comprised six codes: (a) continuous, (b) application based, (c) spiraling agriculture and science, (d) directed teacher modeling, (e) personal connection, and (f) focused on scientific practices. These six codes, described below, illuminate the facets of the curriculum structure respondents shared when discussing their exemplary STEM lessons.

Respondents noted their exemplary STEM lessons were often ongoing, continuous experiences. When describing their lesson, Jacee shared “it’s an extensive unit that kind of doubles up in different places.” Additionally, respondents recognized their exemplary lessons involved some direct instruction; however, foregrounded students applying the knowledge, typically via hands-on and experimental ways. Monica stated “I lay the groundwork and then we jump in,” with Jennifer adding “they have to listen, then they have to experiment.” Additionally, their exemplary STEM lessons included linking science and agriculture to strengthen student understanding of those connections. Jacee described this as “spiraling of the curriculum” and Michelle noted “they also have to learn how science impacts agriculture and how agriculture utilizes science.”

Another key component of the curriculum structure was the use of directed teacher modeling (i.e., demonstration, providing examples) as an approach to strengthen student learning. Ronda indicated, “we practice the I do, we do, you do method.” Interweaving personal connections was also a facet of the curricular structure, with respondents noting making content personally relevant as important for the success of their lessons. Kent illustrated this when sharing, “it is good because it can relate to kids at so many different levels,” continuing Kent shared, “they’re doing something they’re interested in and in the meantime, they’re doing some basic research skills.”

The final aspect of curriculum structure was respondents utilizing scientific practices like inquiry, analysis, experimentation, and reasoning during their exemplary STEM lessons. Teachers noted “trial and error happened a lot” [Natalie], “they think through it” [Ronda], and that they used “inquiry, a lot of inquiry and analysis” [Jacee] when describing their exemplary STEM lessons.

The second theme within the lesson category was *facilities*, which included (a) resources, (b) challenges, and (c) adapting to challenges as codes. The majority of respondents identified having access to scientific laboratory equipment within their program as a support to their exemplary STEM lessons. Jacee shared, “we’ve got all the equipment and everything to run a full chemistry lab,” and Ronda added “we’re really lucky, we have a really nice barn.” A minority of respondents, however, identified their facilities as a challenge when facilitating STEM learning. Jennifer said, “myself and the other agriculture teacher are now sharing a lab, it’s very old but we do now have a lab that has water and electricity.” A final element of the facilities category were teachers adapting their learning spaces and approaches within their exemplary STEM lessons. When discussing limited lab space, Michelle offered social systems research as an alternative, sharing “I mean, you just need a computer.”

The third theme within the lesson category was *three-circle application*, which included (a) contests support learning (i.e., sub-code: Agriscience Fair), and (b) application of classroom learning as codes. Respondents noted FFA contests often provided structure and motivation to student learning within exemplary STEM lessons. Trent observed the “biggest motivator” for a middle school student in their program was to attend a contest to “see how [they] stacked up against a ninth grader or a sophomore.” Michelle reflected on the past years and suggested COVID diminished student motivation, with students questioning, “What’s the point in doing this experiment if I can’t take it to state convention and tell people about my idea?” A sub-code within the FFA contest discussion was Agriscience Fair, with respondents noting exemplary STEM lessons yielded opportunities for students to present work via science fair projects. Jacee shared “every year, I have every kid do a science fair project,” and Michelle added “I feel like Agriscience Fair is what jumpstarts a lot of our kids in the FFA.”

The last code within the three-circle application category was application of classroom learning. In this dimension, respondents observed FFA and Supervised Agricultural Experiences (SAE) provided opportunities for students to apply what they learned during exemplary STEM lessons. When sharing a story, Natalie noted, “[the student] was using [a notecard developed during the lesson] in her SAE,”

additionally, Monica shared, “I’ve had some kids like ‘yeah, now I can apply this to my flowers’ or ‘I can apply this to my vegetables.’”

Teacher Perspective

The second category included one theme, *teacher perspectives* specific to STEM education. Included in the teacher perspectives theme are two codes, (a) conceptualizing STEM and (b) STEM and agriculture, a natural connection.

Teachers conceptualized STEM as the utilization of STEM knowledge within hands-on and minds-on ways. Ronda shared, “[STEM] is the application of knowledge in critical thinking,” further elaborating that “the goal of STEM is [students] applying general knowledge or academic knowledge in a practical, real-world setting.” Jennifer reinforced the necessity of application within STEM, stating “any kind of hands-on thing is going to be STEM.”

The teacher perspectives theme is elaborated by teachers perceiving STEM and agriculture as reinforcing concepts in real-world and classroom settings. When sharing her perspective, Michelle articulated “it really shows how important science is, how important STEM is in agriculture; agriculture could not function or could not progress without it.” Consistently, teachers articulated sentiments like “CTE is the epitome of STEM” [Ronda] and “I think agricultural education does [integrating other disciplines] better than any other discipline in education” [Kent]. Participating teachers referenced specific instances of science, math, and technology being taught within their exemplary STEM lessons; however, identified engineering as a weak point. Jennifer shared “I’m still trying to figure out how to implement engineering into everything” and Kent included they did “a minimal amount of engineering.”

Student Outcomes

The final category detailing the experience of agricultural educators teaching self-identified exemplary STEM lessons included one theme, *student outcomes*. Five codes made up this theme, (a) agricultural knowledge, (b) problem solving skills, (c) basic math skills, (d) general employability skills, and (e) additional STEM outcomes.

Respondents noted exemplary STEM lessons resulted in students building foundational agriculture knowledge. Specific areas of increased understanding included “basic plant nutrition” [Monica], “how a plant physically works” [Monica], and how to “construct a calorimeter” [Jacee]. Additionally, respondents remarked their lessons supported student development of problem-solving skills. Michelle shared, “the biggest thing they learn is they have to identify problems they see in agriculture and try to come up with a solution.” Natalie shared the ability to “[follow] instructions” and “follow the steps” as an outcome of their exemplary STEM lessons.

Respondents also noted the development of basic math skills during exemplary STEM lessons. Teachers shared “how to use data they collect” [Jacee], “understanding what a tick mark means on a tape measure” [Trent], “calculating an average” [Ronda], “using data tables and making graphs” [Jacee], and “taking weights” [Ronda] as math skills developed during the identified lessons. In addition, respondents noted their exemplary STEM lessons built general employability skills. Example quotes included, “they are learning the skill of caring for those animals” [Ronda], “gain better attitudes” [Jacee], and “long-term planning” [Jacee], illustrating the diversity of general employability skills developed.

In the final code, respondents recognized outcomes focused on engineering, experimental design, and technology. Relevant excerpts from teachers included, “they engineered a little product that would hold any two panels together” [Michelle], “they learn how to set up an experiment and report their findings on

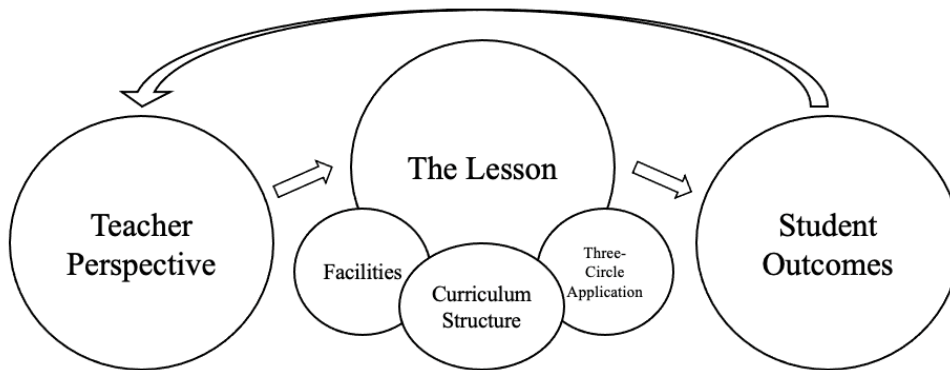
that experiment” [Michelle], and when reflecting upon incorporating technology, “reading a blueprint or researching it” [Trent].

Conclusions and Recommendations

This transcendental phenomenology was conducted to understand the experiences of agriculture teachers when teaching self-identified exemplary STEM lessons. Results suggest this experience includes three discernable dimensions: (a) the lesson, (b) teacher perspective, and (c) student outcomes. Additionally, data support the relationship between these three dimensions (see Figure 1). Specifically, teacher beliefs that agriculture and STEM are strongly connected led them to design exemplary STEM lessons within their agriculture curriculum. These beliefs appear instrumental in how respondents designed their lessons, which included diverse curricular structures, utilization of available facilities, and application beyond classroom learning. Further, exemplary lessons appear to have resulted in related student outcomes, including the development of agricultural knowledge, problem solving skills, basic math skills, employability skills, and additional STEM outcomes. Finally, data support teacher perspectives regarding the interconnectivity of agriculture and STEM are reinforced as teachers observe positive student outcomes as a product of exemplary STEM lessons within agricultural education, illustrated by the arrow connecting student outcomes and teacher perspective.

Figure 1

Model of Exemplary STEM Lessons



The positive perceptions of STEM and agriculture connections held by teachers are supported by prior studies (McKim et al., 2017; Smalley & Hainline, 2024). As is the relationship between positive student outcomes and reinforced perceptions of STEM and agriculture connections (Ferand et al., 2022; Stubbs & Myers, 2016). However, this study identifies crucial components of the exemplary STEM lessons, beyond previously identified problem-based and hands-on learning methods of instruction (Scherer et al., 2019), which bridge the gap between teachers’ perspectives and student outcomes.

The exemplary STEM lessons shared by responding agriculture teachers are intimately connected to the principles of Integrative STEM Education (Sanders, 2009). Namely, the exemplary lessons foregrounded STEM knowledge and practices, resulted in identifiable STEM dispositions (e.g., problem solving), and leveraged design-based learning in which learners identify, analyze, and address authentic problems (Sanders, 2012). A component which may make Integrative STEM Education unique in agricultural education is the application of STEM knowledge and practices within the three-component model (Croom, 2008). Additional research is recommended which explores the salience of applying STEM learning to SAE and FFA within agricultural education. Importantly, this scholarship should consider three-

component experiences (i.e., SAE, FFA) as opportunities to apply and extend STEM learning as well as motivations for students to engage in STEM learning.

Our final conclusion relates to the nature of engineering within exemplary STEM lessons. While some respondents articulated difficulty finding ways to teach engineering within agriculture, others noted successful student outcomes related to engineering during their exemplary STEM lessons. These findings suggest agricultural education holds the potential for developing engineering knowledge and skills; however, teacher self-efficacy may be a limiting factor. Prior research that illuminates more teacher self-confidence in teaching science and mathematics components of STEM (Smith et al., 2015) supports this finding. Therefore, we recommend the discipline consider opportunities to enhance teacher confidence within engineering education. Specific considerations should include expanding engineering education requirements in preservice agriculture teacher education, intentional teacher professional development related to engineering education, and development of engineering-based agricultural curriculum ready for teacher implementation.

This study addressed a gap in the literature related to the instructional approaches used by agricultural educators to teach STEM (Scherer et al., 2019). In doing so, this research provides a foundation upon which to structure future research and interventions to support agricultural educators teaching STEM. Specifically, future work should acknowledge the importance of teacher perspectives regarding STEM; support STEM learning in agriculture by strengthening program facilities, curriculum structure, and application of STEM learning to FFA and SAE opportunities; and foreground diverse, meaningful student outcomes in agriculture, STEM, and general employability skills.

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