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Beyond Content Knowledge: Inquiry-Based Learning and Preservice Teachers' Perceived Ability to Incorporate STEM and AFNR Concepts

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Abstract

Integrating science, technology, engineering, and math (STEM) into classroom activities is a recurring and increasingly important topic. School-based agricultural education (SBAE) has historically been a relevant platform to integrate STEM concepts since it has strong ties to STEM industries, including horticulture, animal science, mechanization, and more. This non-experimental, exploratory research design aimed to determine the impact of a semester-long undergraduate inquiry-based laboratory teaching methods course on preservice SBAE teachers' (N = 27) self-efficacy related to integrating STEM and AFNR concepts at Oklahoma State University. Evaluating efficacy scores revealed a positive relationship between course participation and teaching efficacy for Integrate Learning Objectives, Integrate STEM Concepts and Content, Evaluate Learning Outcomes, Facilitate Inquiry-Based Instruction, and Integrate AFNR Standards. As preservice teachers lack the contextual knowledge of a classroom, exposure to intentional and explicit explanations of the modeled teaching strategies and their classroom applications could have benefitted the students' efficacy scores. Recommendations for future research include evaluating the impact of a semester-long inquiry-based class in agricultural education using different CASE curriculum certifications. In addition, a longitudinal look into the impact of this course on teaching self-efficacy during the student teaching experience and into the first three years of teaching SBAE is warranted.

Introduction/Literature Review

Integrating science, technology, engineering, and math (STEM) into classroom activities is a recurring and increasingly important topic (Gao et al., 2020). The United States Department of Labor predicted occupations in STEM will increase by 10.8% over the next decade, with a decrease in the number of individuals aged 16 to 34 entering the workforce over the same period (Machovex, 2023). With the rising demand for these skills in the workforce, there is a stringent focus on integrating STEM concepts into core disciplines (Gao et al., 2020). Unfortunately, Shernoff et al. (2017) reported that teachers face significant challenges with STEM integration, including a lack of resources, student motivation, and teacher understanding. Additionally, an overwhelming number of teachers reported the need for more direct instruction during professional development workshops focused on bridging STEM concepts through problem-solving and teamwork (Shernoff et al., 2017).

These unique challenges suggest a two-fold priority for teacher education programs in STEM. "The first is to strengthen teachers' content knowledge and classroom management skills needed to efficiently

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run integrated STEM lessons. The second is to prepare teachers with pedagogical practices that encourage students to collaborate, deal productively with failure, and persevere" (Shernoff et al., 2017, p. 13).

School-based agricultural education (SBAE) has historically been a relevant platform to integrate STEM concepts since it has strong ties to STEM industries, including horticulture, animal science, mechanization, and more (Phipps & Osborne, 1988). SBAE teachers reported that integrating STEM concepts into their classes increased students' motivation, interest, and level of achievement in their core classes (Stubbs & Myers, 2016). Other SBAE teachers expressed their self-motivation behind an integrated approach by saying they view agriculture as an applied science and believe it should have science integrated into the content (Washburn & Myers, 2010). However, some SBAE teachers are concerned that integrating STEM into their classes could decrease the "fun" aspect of an elective course, thereby decreasing program enrollment (Baker et al., 2015; Stubbs & Myers, 2016).

Even though individual SBAE teachers reported they perceived agricultural education as a natural avenue for STEM integration (Washburn & Myers, 2010), research has identified that teachers may not be integrating STEM concepts as well as they think (Scherer et al., 2019). Researchers examined articles covering the topic of STEM in agriculture, food, and natural resources (AFNR) to determine the actual state of STEM in AFNR content. They found that 33% of articles highlighted science as the only STEM subject integrated, with no studies focusing on technology or engineering (Scherer et al., 2019). Similarly, Hendrix et al. (2024) found teachers' highest personal teaching efficacy in STEM to be science and their lowest to be engineering. SBAE teachers reported being confident in answering students' engineering questions but possessed a low confidence level in effectively teaching engineering concepts (Hendrix et al., 2024). The authors suggested this could be due to a lack of complete understanding of the engineering field. SBAE teachers reported they are continually improving their science and technology teaching practices, and the authors recommended further professional development is needed (Hendrix et al., 2024).

While educators commonly attend professional development sessions throughout their careers, Roberts et al. (2020) found SBAE teachers do not benefit from generic professional development. Instead, they recommended tailoring sessions to the teachers' specific needs. Educators' professional development needs are influenced by many factors, including career stage, certification route, and personal teaching efficacy (Dossett et al., 2019; Haynes & Stripling, 2014; Roberts et al., 2020; Wood et al., 2024). Early career teachers reported a need for professional development focused on content knowledge (Roberts et al., 2020). In addition, both traditionally and alternatively certified teachers reported content knowledge and curriculum development as a top need from professional development (Wood et al., 2024). However, Wood et al. (2024) found less than 30% of teachers reported professional development as a source of knowledge that had impacted their ability to teach effectively. When looking at STEM content knowledge, specifically math, teachers reported a moderate personal math teaching efficacy but stated teaching math concepts in an agricultural context as a professional development need (Dossett et al., 2019; Haynes & Stripling, 2014). With these ideas in mind, it is no wonder that a multitude of research recommends preservice teacher preparation programs focus on content knowledge and pedagogical methodologies (Baker et al., 2015; Hendrix et al., 2024; Scherer et al., 2019; Stubbs & Myers, 2016).

One professional development opportunity for SBAE teachers is Curriculum for Agricultural Science Education (CASE) Institutes (CASE, n.d.). CASE's mission is "to design industry-leading, inquiry-based curriculum and teacher education to create lifelong learners and prepare students for the future of agriculture" (CASE, n.d., para. 2). Inquiry-based learning is closely related to the more familiar problem-based learning (Parr & Edwards, 2004). Both methodologies strive to create and facilitate students' critical thinking and problem-solving skills (Parr & Edwards, 2004). Gerber et al. (1997) found students who received inquiry-based instruction possessed higher scientific reasoning abilities than those who did not. This supports Minner et al. (2010), who stated being actively involved in the investigative process, including hands-on experiences, can increase conceptual science learning. Still, "the success of inquiry-based learning in SBAE programs ultimately rests upon the agriculture teachers who teach and effectively incorporate this type of instruction into their curriculum" (Wells et al., 2015, p. 176). To help teachers more easily incorporate inquiry-based instruction, CASE (n.d.) provides a sequenced, ready-to-execute agricultural curriculum that upholds core content standards.

Many universities partnered with CASE to provide inservice teachers in their state curriculum training and support as they implement the CASE curriculum (CASE, n.d.). However, as of 2024, only four universities offer CASE training specifically to preservice teachers (J. Russell, personal communication, September 26, 2024) even though research showed increased content knowledge among preservice teachers who completed a CASE institute after student teaching (Tummons et al., 2020). Yet, they also reported some participants did not understand the mechanics of implementing inquiry-based teaching in their classrooms (Tummons et al., 2020). Wells et al. (2019) recommended preservice teachers receive substantial exposure to CASE through a preservice institute or a different avenue before student teaching. This supports Tummons et al. (2019), who stated, "… it is critical preservice teachers attend specially designed CASE institute to ensure their unique developmental needs are met" (p. 302).

Despite the clear benefits of integrating STEM into SBAE, there remains a gap in the effective implementation of these concepts. This gap is often attributed to the lack of comprehensive training and resources available to teachers. As noted by Scherer et al. (2019), while science is frequently integrated, technology and engineering are often neglected. This imbalance highlights the need for a more holistic approach to STEM education within SBAE programs.

Moreover, the role of professional development in bridging this gap cannot be overstated. Tailored professional development programs that address the specific needs of SBAE teachers are crucial (Sewell, 2024). These programs should not only focus on content knowledge but also on practical strategies for integrating STEM concepts into the curriculum. As Roberts et al. (2020) suggested, professional development should be customized to the career stage and certification route of the teachers to maximize its effectiveness.

Finally, the importance of preservice teacher preparation cannot be ignored. Providing preservice teachers with robust training in STEM integration through programs like CASE can significantly enhance their teaching efficacy. As Tummons et al. (2020) highlighted, preservice teachers who undergo CASE training demonstrate increased content knowledge and are better equipped to implement inquiry-based learning in their classrooms. Therefore, expanding access to CASE training for preservice teachers is a critical step towards improving STEM education in SBAE.

Purpose/Objectives

This study aimed to determine the impact of a semester-long undergraduate inquiry-based laboratory teaching methods course on preservice SBAE teachers' self-efficacy related to integrating STEM and Agricultural, Food, and Natural Resources (AFNR) concepts at Oklahoma State University. This course is required before student teaching, aiming to prepare SBAE preservice teachers with the content knowledge and pedagogy to integrate CASE curriculum during student teaching and beyond. Successful completion of the course results in lifetime CASE AFNR certification and curriculum access for preservice teachers. To achieve this aim, three research objectives guided this inquiry:

1. Determine the impact of a semester-long preservice inquiry-based training course on preservice SBAE students' teaching efficacy.
2. Examine the effect of a semester-long inquiry-based course on SBAE preservice teachers' perceived ability to incorporate STEM and AFNR concepts into their instruction.

3. Compare teaching efficacy scores between male and female SBAE students enrolled in a semester-long inquiry-based training course.

Theoretical Framework

Albert Bandura's Theory of Self-Efficacy guided this study. This theory defines self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (Bandura & Wessels, 1997, p. 1). These beliefs influence a person's thoughts, feelings, behaviors, and motivations (Bandura & Wessels, 1997). "A strong sense of efficacy enhances human accomplishment and personal well-being in many ways" (Bandura & Wessels, 1997, p. 1). Bandura notes that highly efficacious individuals will have more endurance in challenging tasks and can bounce back from setbacks quicker than those with low self-efficacy (Bandura & Wessels, 1997). Additionally, efficacious people tend to see complex tasks as learning opportunities, while people with low self-efficacy avoid challenging tasks and see failures as a personal deficit (Bandura & Wessels, 1997). Individuals can form or improve their efficacy by having mastery experiences, experiences provided by social models, social persuasion, and reducing stress reactions (Bandura & Wessels, 1997).

Self-efficacy among men and women in STEM is a widely researched topic (Sakellariou & Fang, 2021). While many factors develop self-efficacy, literature has linked STEM self-efficacy development to culture and gender stereotypes (Sakellariou & Fang, 2021). Dicke et al. (2019) found females who ascribed to traditional gender role beliefs had lower educational and STEM attainment than males who believed the opposite. Furthermore, Blažev et al. (2017) found the assumption that STEM subjects are more suitable for boys to be prevalent among Croatian primary students. Beilock et al. (2010) found the more a female student's beliefs aligned with typical gender stereotypes, the lower their self-efficacy in STEM subjects. One way to combat low self-efficacy among females is to increase the number of female STEM teachers in elementary and secondary schools (Beilock et al., 2010; Stearns et al., 2016). Stearns et al. (2016) found white girls whose high school had a higher percentage of female math and science teachers were likelier to choose a STEM major. In addition, female teachers must also be efficacious in their subject area to make a positive impact (Beilock et al., 2010). Research revealed female elementary students' math achievement was linked to the level of confidence their female teacher portrayed (Beilock et al., 2010). Interestingly, the male students' math achievement was unaffected by their female teacher's confidence. The authors suggested witnessing a female teacher's low efficacy regarding math pushed the female students to confirm their gender beliefs about math (Beilock et al., 2010).

In education, "teacher self-efficacy is an important component of teacher effectiveness that influences teacher behavior and student motivation" (Kelley et al., 2020, p. 2). This is especially true regarding STEM concepts. A 2023 survey by the Department of Industry, Science, and Resources (2024) revealed male teachers reported higher efficacy in teaching STEM and connecting content to STEM careers than their female counterparts. This was true across every STEM subject. However, the survey revealed only 39% of secondary STEM teachers were confident in their ability to effectively explain STEM careers (Department of Industry, Science, and Resources, 2024). This is troubling because a teacher lacking confidence in teaching STEM may limit student STEM exposure (Kelley et al., 2020). Bray-Clark and Bates (2003) suggested to combat low teacher efficacy, professional development should be designed with the central tenet of developing self-efficacy.

School-based agricultural education (SBAE) is one avenue for STEM integration (Phipps & Osborne, 1988). Hendrix et al. (2024) found most teachers reported being most efficacious in science. Still, there seems to be a disparity between teachers' self-reported efficacy level and implementation of STEM concepts (DeCoito & Myszkal, 2018). SBAE teachers reported low efficacy in integrating biology standards into their plant and animal science classes (Chumbley et al., 2019). This is concerning as McKim and Velez (2015) found science teaching efficacy significantly predicts career commitment for early career SBAE teachers. Fortunately, efficacy increases as a teacher gains years of experience (Putman, 2012). McKim and Velez (2015) said if the teacher has more years of teaching experience, they will inevitably have more mastery experiences. Preservice teachers do not have the benefit of years in the classroom, and thus, they gain mastery experiences through preservice coursework (Sheehan & Moore, 2019).

Implementing intentional mastery experiences and/or vicarious experiences in preservice coursework can positively affect the students' teaching efficacy (Sheehan & Moore, 2019). Stair et al. (2012) suggested the addition of specialized experiences in preservice coursework would allow preservice teachers to increase their confidence in their abilities early on in their teacher preparation program. By intentionally building the students' efficacy early in the program toward low-level tasks such as writing a lesson plan or time management (Paulsen et al., 2015), the students can focus on learning teaching strategies and content knowledge later in their programs (Stair et al., 2012). This is crucial as Snider et al. (2021) found student teachers were not prepared to teach content from all eight AFNR pathways.

Figure 1

Curriculum Framework of the National AFNR Content Standards

Note. From "National AFNR Content Standards," by the National Council for Agricultural Education, 2015, https://thecouncil.ffa.org/afnr/.

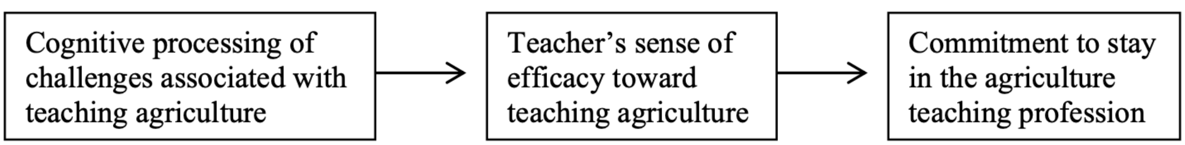
The authors recommended addressing this concern by enhancing coursework and learning experiences during the teacher preparation program (Snider et al., 2021). One way to increase AFNR understanding is by participation in CASE professional development since it is designed to "promote common understanding of agricultural concepts by aligning the lessons to the national Agricultural, Food, and Natural Resources (AFNR) Standards and Next Generation Standards" (Bird & Rice, 2021, p. 262). While preservice teachers experience growth in content knowledge and understanding from attending a CASE institute, they struggle with contextual understanding to apply the principles taught (Tummons et al., 2020). Thus, preservice teachers should attend CASE trainings designed for their developmental stage (Tummons et al., 2020).

Bandura and Wessels (1997) described four ways to improve or develop self-efficacy. The first is having mastery experiences, meaning the more times a person completes a task, the more they believe they can complete it (Bandura & Wessels, 1997). In this study, preservice teachers participated in inquiry-based learning three times a week for 16 weeks. During this time, they gained mastery experiences by going to the local high school and teaching an inquiry-based lesson. Bandura and Wessels (1997) also suggested increasing efficacy through modeling, which is when someone witnesses someone else successfully complete a task. In this course, students were constantly exposed to modeling behavior by the professor while participating in student-centered inquiry-based learning. In addition, students had time to brainstorm and ask questions about how they could implement inquiry-based learning during student teaching and eventually in their classrooms. The third- and fourth-ways Bandura and Wessels (1997) said to increase efficacy are social persuasion and stress reduction. During this 16-week course, the students were in a supportive environment where they could practice inquiry-based instruction. Allowing them time to practice with a supportive group of faculty and peers reduced the stress and adverse reactions caused by the uncertainty of their ability to use inquiry-based instruction.

In addition, McKim and Velez (2015) developed a model that connects self-efficacy to the challenges associated with teaching SBAE and commitment to remain in the profession (see Figure 2). This becomes increasingly important considering the increasing complexity and challenges associated with teaching SBAE (Baker et al., 2015; Dossett et al., 2019; Haynes & Stripling, 2014; Hendrix et al., 2024; Roberts et al., 2020; Scherer et al., 2019; Shernoff et al., 2017; Stubbs & Myers, 2016; Wood et al., 2024).

Figure 2

Conceptual Model Illustrating the Relationship Between Perceived Challenges, Self-Efficacy, and Career Commitment



Note. From "Exploring the Relationship between Self-Efficacy and Career Commitment among Early Career Agriculture Teachers," by McKim, A. J., and Velez, J. J., 2015, *Journal of Agricultural Education*, *56*(1), 129. https://doi.org/10.5032/jae.2015.01127.

While this model (McKim & Velez, 2015) focuses on in-service teachers, this study aims to determine the impact within a pre-service teacher preparation program. Therefore, the development of cognitive processes to overcome future challenges is paramount. The development of self-efficacy to overcome known challenges at the pre-service level could improve commitment to the teaching profession.

Methods

Course Structure

In the fall of 2024, Oklahoma State University offered the Inquiry-Based Instruction in Agricultural Education course as a required AGED major-specific pedagogical content knowledge course. The instructor implemented CASE AFNR curriculum as the foundation for this course. The course met three times a week for a total of four contact hours per week. The sequence of instruction was based on the CASE AFNR detailed course description (see Table 1). The students received a lab notebook, which contained all the lab worksheets needed for the semester. The students were encouraged to keep thorough records so they could use the notebook as a guide for their teaching when they begin in their classrooms.

Table 1

Fall 2024 Inquiry Based Instruction in Agricultural Education Course Sequence of Instruction

Unit Name	Number of Course Contact Hours per Unit
Unit 1: The Circles of Agricultural Education	4
Unit 2: Communicating Today	1
CASE Foundations[a]	2
Unit 3: The Science of Agriculture	7
Unit 4: Natural Resources	13.5
Unit 5: Plants and Animals	13.5
Unit 6: Agricultural Power and Technology	13
Implementing CASE During Student Teaching	2
Working with Administrators about CASE	.5
Purchasing Materials for CASE	.5
Unit 7: Looking Ahead[a]	3
Developing a Sequence of Instruction[a]	1
Teaching Experiences	4

Note. The sequence of instruction was based on CASE AFNR detailed course outline; [a] = online module.

The first part of the class period was when the instructor modeled implementing the curriculum in a high school classroom type setting. For every lesson, the instructor taught it as they would in a high school classroom, including an introduction to the lesson, direct instruction, a learning activity, and a reflection and closure. The students engaged in inquiry-based activities as if they were in a SBAE classroom. This component of the course provided the modeling component of self-efficacy for the students (Bandura & Wessels, 1997).

The second part of the class period consisted of guided discussions on implementing the content in high school classrooms. The instructor led the students in open conversations regarding sourcing materials, modifications to the curriculum, concerns over implementing the material, and innovative uses for the curriculum. The students recorded their notes from these discussions in their lab notebooks. This component of the course provided students with the opportunity to reduce their stress reactions and experience social persuasion from their peers and instructor, both of which are needed to increase self-efficacy (Bandura & Wessels, 1997).

In addition to in-class work, the students participated in teaching experiences at the local high school. The students selected one lesson to teach to a class of high school students enrolled in the local SBAE program. The preservice teachers were assigned to a random class period, which ranged from 50 minutes to 90 minutes in length. They were required to submit a lesson plan and materials list to the instructor in advance for feedback. A faculty member or a graduate student with SBAE teaching experience observed the preservice teachers' teaching experiences. After their lesson, the preservice teachers engaged in a reflexive evaluation of their lesson with their assigned observer. The teaching experiences allowed the preservice teachers to gain mastery experiences, which is a crucial component of self-efficacy (Bandura & Wessels, 1997).

Preservice CASE integration varies from university to university, at Oklahoma State University all agricultural education majors complete the Inquiry-Based Instruction in Agricultural Education course and receive CASE AFNR certification for successful course completion using an integrated model. The cost for certification is $500 per student (CASE, 2025), which is covered through an annual gift to the Oklahoma State University Agricultural Education Program, aimed to improve STEM preparedness and career longevity of SBAE teachers.

Data Collection

This non-experimental, exploratory research design (Privitera, 2017) aimed to determine the impact of a semester-long undergraduate inquiry-based laboratory teaching methods course on preservice SBAE teachers' (N = 27) self-efficacy related to integrating STEM and AFNR concepts at Oklahoma State University. This design was chosen to explore the changes in self-efficacy over time without manipulating any variables, aligning with the study's objective to observe natural variations in self-efficacy.

"This course [was] designed to prepare future school-based agricultural education teachers for teaching inquiry-based science, technology, engineering, and math (STEM) curriculum. This course aims to unpack the Agriculture, Food, and Natural Resources (AFNR) curriculum developed by the Curriculum for Agricultural Science Education (CASE)" (Eck, 2024, p. 1). To address the research objectives, data was collected at three points throughout the semester: the first day of class (i.e., Week 1), midway through the semester (i.e., Week 7), and the end of the semester (i.e., Week 15).

The sample consisted of 27 undergraduate agricultural education majors enrolled in the course at Oklahoma State University. Twenty-five of the students were in the semester before their student teaching experience, while the other two students were two semesters away from student teaching. The sample included 22 females and 5 males. This convenience sample was chosen due to the accessibility of the participants and their relevance to the study.

Data collection resulted in a 100% response rate (N = 27) at the first and last points of data collection (i.e., Week 1 and Week 15). The second data collection point (i.e., Week 7) resulted in a 92.6% response rate (n = 25), as two students were absent during data collection. While the entire population of interest participated in this study, the study is limited by the 27 students enrolled in the Inquiry-Based Instruction in Agricultural Education course at Oklahoma State University. Findings and conclusions should be considered based on this limiting factor.

Data were collected in-person using printed survey questionnaires adapted from Wang and Knobloch (2018). The original instrument's validity and reliability were established in previous studies, and minor modifications were made to fit the context of this study. Students self-reported their preparedness on six identified tasks using a four-point Likert-type scale (i.e., 1 = not prepared; 2 = somewhat prepared; 3 = prepared; 4 = very prepared). Specifically, students were asked to identify their preparedness to integrate learning objectives, integrate STEM concepts and content, evaluate learning outcomes, facilitate inquiry-based instruction, integrate AFNR content standards, and engage students in critical thinking.

The surveys were administered during class sessions to ensure a controlled environment and consistency in data collection procedures. Participants were informed about the study's purpose, and their consent was obtained before participation. Measures were taken to ensure confidentiality, including anonymizing the data and securely storing the survey responses.

Data were entered into Microsoft Excel by the lead researcher and then moved to SPSS Version 29 for data analysis. Descriptive statistics (i.e., mean and standard deviation) were used to summarize the data, while paired samples t-tests and crosstabs analysis were employed to address the proposed research objectives. Eta squared (η^2) was utilized to determine effect size (small = .01; medium = .06; large = .14; Cohen & Cohen, 1983). These statistical methods were chosen to compare self-efficacy scores at different points in time and to explore relationships between variables.

Oklahoma State University Institutional Review Board approved this study prior to data collection, ensuring that all procedures adhered to ethical guidelines for research involving human subjects.

Findings

The first objective sought to determine the impact of a semester-long inquiry-based teaching methods course on preservice students' teaching efficacy. A survey was administered in the first week of the course (i.e., point one) before direct instruction. The students reported the least amount of efficacy for *Integrate STEM Concepts and Content* (*M* = 2.1, *SD* = .53) and the highest efficacy for *Engage Students in Critical Thinking* (*M* = 2.92, *SD* = .86). After seven weeks of participating in the course, the students were administered the survey again (i.e., point two). Students reported their lowest efficacy in *Engage Students in Critical Thinking* (*M* = 3.08, *SD* = .57 and the highest efficacy in *Evaluate Learning Outcomes* (*M* = 3.40, *SD* = .65). The students were administered the survey again after 15 weeks of the course (i.e., point three). The lowest efficacy was for *Integrate STEM Concepts and Content* (*M* = 3.04, *SD* = .59). The highest efficacy was for *Integrate AFNR Content and Standards* (*M* = 3.59, *SD* = .50). An ANOVA test revealed a statistically significant ($p < .05$) increase in efficacy across all constructs except *Engage Students in Critical Thinking* (see Table 2). Furthermore, a large effect size ($\eta^2 = .14$) (Cohen & Cohen, 1983) was noted for *Integrate Learning Objectives, Integrate STEM Concepts and Content, Facilitate Inquiry Based Instruction, and Integrate AFNR Content Standards*. A medium effect size ($\eta^2 = .06$; Cohen & Cohen, 1983) was reported for *Evaluate Learning Outcomes and Engage Students in Critical Thinking.*

Objective two sought to evaluate the effect of a semester-long inquiry-based course on preservice teachers' efficacy in integrating STEM and AFNR concepts into their instruction. Point one mean score for *Integrate STEM Concepts and Content* was 2.12 (*SD* = .53) and *Integrate AFNR Content Standards* received a mean of 2.48 (*SD* = .92). Point three revealed a statistically significant increase ($p < .05$) and a large effect size ($\eta^2 = .14$; Cohen & Cohen, 1983) in the students' teaching efficacy for *Integrate STEM Concepts and Content* (*M* = 3.04, *SD* = .59). There was also a significant increase ($p < .05$) as well as a large effect size ($\eta^2 = .14$; Cohen & Cohen, 1983) in teaching efficacy for *Integrate AFNR Content Standards* (M = 3.59, *SD* = .50) (see Table 2).

Table 2

Preservice Teachers' Efficacy Scores for Identified Tasks

Identified Tasks	Point	*M*	*SD*	*f*	*p*	η^2
Integrate Learning Objectives	1	2.80	.70	6.00	.004	.14
	2	3.20	.58			
	3	3.41	.64			
Integrate STEM Concepts and Content	1	2.12	.53	25.82	<.001	.41
	2	3.08	.57			
	3	3.04	.59			
Evaluate Learning Outcomes	1	2.88	.67	4.32	.017	.10
	2	3.40	.65			
	3	3.22	.75			
Facilitate Inquiry-Based Instruction	1	2.32	.63	22.86	<.001	.38
	2	3.28	.46			
	3	3.37	.74			
Integrate AFNR Content Standards	1	2.48	.92	18.94	<.001	.33
	2	3.36	.64			
	3	3.59	.50			
Engage Students in Critical Thinking	1	2.92	.86	2.30	.11	.06
	2	3.08	.57			
	3	3.33	.62			

Note. 1 = Not Prepared, 2 = Somewhat Prepared, 3 = Prepared 4 = Very Prepared.

A comparison between the male (*n* = 5) and female (*n* = 22) students enrolled in the course revealed the females' highest reported efficacy for point one was *Evaluate Learning Outcomes* (*M* = 2.95, *SD* = .58). While males reported their highest efficacy in *Engage Students in Critical Thinking* (*M* = 3.40, *SD* = .89). Both groups' lowest reported efficacy for point one was *Integrate STEM Concepts and Content* (see Table 3). Point two data revealed the most significant increase in both female and male mean scores was for *Integrate STEM Concepts and Content,* which increased by .91 and 1.25 points, respectively. However, female students reported being most efficacious in *Evaluate Learning Outcomes* (*M* = 3.38, *SD* = .67). Males were most efficacious in *Integrate AFNR Content Standards* (*M* = 3.75, *SD* = .50). At the conclusion of the course *Integrate AFNR Content Standards* was the task both males (*M*= 3.40, *SD* = .55) and females (*M* = 3.64, *SD* = .49) reported being most efficacious. Point three revealed female students experienced the most significant increase in efficacy for *Facilitate Inquiry Based Instruction* which increased by 1.18 points compared to their initial scores. The male students reported the biggest increase in efficacy for *Integrate AFNR Content Standards* with a 1.0-point jump in scores compared to point one.

Table 3

Efficacy Scores for Identified Tasks for Male and Female Students

		Male		Female	
Identified Tasks	Point	*M*	*SD*	*M*	*SD*
Integrate Learning Objectives	1	2.75	.50	2.82	.73
	2	2.75	.50	3.29	.56
	3	3.20	.84	3.45	.60
Integrate STEM Concepts and Content	1	2.00	.71	2.14	.47
	2	3.25	.57	3.05	.50
	3	2.80	.84	3.10	.53
Evaluate Learning Outcomes	1	2.40	.89	2.95	.58
	2	3.25	.96	3.38	.67
	3	3.00	.71	3.27	.77
Facilitate Inquiry Based Instruction	1	2.60	.55	2.27	.63
	2	3.50	.58	3.24	.44
	3	3.00	1.22	3.45	.60
Integrate AFNR Content Standards	1	2.40	1.14	2.50	.86
	2	3.75	.50	3.29	.64
	3	3.40	.55	3.64	.49
Engage Students in Critical Thinking	1	3.40	.89	2.82	.85
	2	3.25	.50	3.00	.63
	3	3.20	.84	3.36	.58

Note. 1 = Not Prepared, 2 = Somewhat Prepared, 3 = Prepared 4 = Very Prepared.

Conclusions, Implications, and Recommendations

Evaluating efficacy scores revealed a positive relationship between course participation and teaching efficacy for *Integrate Learning Objectives, Integrate STEM Concepts and Content, Evaluate Learning Outcomes, Facilitate Inquiry-Based Instruction, and Integrate AFNR Standards*. Initially, both male and female students reported being somewhat prepared to complete tasks associated with agricultural education instruction. However, after 15 weeks in the course, students reported being prepared. Perhaps this was caused by continuous exposure to effective modeling of inquiry-based instruction as supported by the theory of self-efficacy (Bandura & Wessels, 1997). Additionally, allowing students to gain mastery experiences by practicing inquiry-based learning could have significantly impacted the student's teaching efficacy (Bandura & Wessels, 1997). While efficacy scores for *Engage Students in Critical Thinking* did increase, it was not statistically significant. Perhaps this was due to prior agricultural education courses adequately preparing students to perform this task. After 15 weeks of this course, efficacy scores increased across all constructs, with five of the six tasks being statistically significant. This increase could result from adding specialized coursework into the teacher preparation program which provided additional mastery and vicarious experiences (Bandura & Wessels, 1994; Sheehan & Moore, 2019; Stair et al., 2012).

Considering the challenges faced by SBAE teachers in effectively incorporating STEM concepts (Shernoff et al., 2017), the need to improve STEM education through targeted preservice training is essential. Specifically, the emphasis on mastery experiences and modeling within the preservice coursework is crucial. These elements not only enhanced self-efficacy within this study but also provided preservice teachers with practical, hands-on experiences that were essential for effective teaching (Eck et al., 2020). Considering the incorporation of these strategies, future research should evaluate the impact of such coursework on the development of confident future SBAE teachers who are well-equipped to integrate STEM concepts into their curriculum.

The aim to increase self-efficacy (Bandura & Wessels, 1994; Sheehan & Moore, 2019) resulted in the establishment of a supportive environment during the 16-week course, which was a key factor in reducing stress and building confidence among preservice teachers. This aspect of the study underscores the importance of creating a nurturing and encouraging learning atmosphere, which is vital for the development of self-efficacy. By fostering such an environment, it is recommended that preservice teacher preparation faculty help SBAE teacher aspirants to face the challenges of the classroom with resilience and confidence.

While the conclusion of this study is limited to Oklahoma preservice teachers, other teacher preparation programs should consider adding specialized coursework to better prepare students for the reality of teaching SBAE integrated with STEM concepts, as the demand for such continues to rise (Gao et al., 2020). This becomes increasingly important given the challenges that SBAE teachers have been identified as facing (Shernoff et al., 2017).

Over the length of the course, students' efficacy scores for *Integrate STEM Concepts and Content* and *Integrate AFNR Content Standards* increased significantly. Initially, students reported being somewhat prepared for both tasks. However, after the course students reported being prepared for both tasks. This could be due to the repeated exposure of modeling techniques implemented in this course (Bandura & Wessels, 1997). As preservice teachers lack the contextual knowledge of a classroom, exposure to intentional and explicit explanations of the modeled teaching strategies and their classroom applications could have benefitted the students' efficacy scores. Another explanation for the increase in efficacy is the nature of the CASE curriculum, as it focuses on increasing the understanding of AFNR and STEM content. Perhaps, CASE curriculum is a practical resource for integrating STEM and AFNR concepts within the agricultural education classroom for preservice and early-career teachers.

The male and female students initially reported similar efficacy scores for all tasks. However, female students reported higher efficacy after the course than male students for every task. Both groups reported their lowest efficacy score for *Integrate STEM Concepts and Content,* with males being somewhat prepared and females being prepared. This highlights a need for better explanations of the breadth of STEM concepts, as past research indicates teachers may not grasp the full depth and breadth of all STEM subjects (Hendrix et al., 2024). Both groups of students reported being most efficacious in *Integrate AFNR Content Standards*. Training in the AFNR CASE course likely had the most significant impact on this score as this curriculum focuses on the broad reach of the AFNR content standards. Perhaps CASE curriculum is an effective avenue for increasing preservice teachers' AFNR content knowledge and their teaching efficacy.

Recommendations for future research include evaluating the impact of a semester-long inquiry-based class in agricultural education using different CASE curriculum certifications (i.e., plant science, animal science, food science, etc.). In addition, a longitudinal look into the impact of this course on teaching self-efficacy during the student teaching experience and into the first three years of teaching SBAE is warranted. Teacher educators should consider the findings of this study as they work to make curriculum revisions and plan for impactful learning experiences for SBAE teacher aspirants. The model of self-efficacy development (McKim & Velez, 2015) and the potential impact on career commitment should be further considered within pre-service teacher preparation using a longitudinal design to determine the effects of coursework designed to prepare teacher aspirants for successful SBAE careers.

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