School-Based Agricultural Education Teachers' Current Level of STEM Integration

Authors

Christopher J. Eck
Oklahoma State University
Chris.eck@okstate.edu

Nathan A. Smith
Oklahoma State University
Nathan.smith@okstate.edu

Research Type: Quantitative
Research Priority Area: Teacher education and school-based ag education
Keywords: Human capital; School-based agricultural education; STEM integration

School-Based Agricultural Education Teachers' Current Level of STEM Integration

Agricultural careers require a higher level of STEM comprehension and application than ever before, and SBAE teachers have the opportunity to be at the forefront of preparing the next generation of this essential workforce. The need for SBAE to prepare students for college and career readiness is evident, but a gap in the research makes it difficult for teachers to integrate STEM curriculum in their agricultural classrooms. This study implemented human capital theory to undergird the research, as the purpose of this study was to determine the current level of STEM integration in SBAE classrooms in Oklahoma and South Carolina. An exploratory, non-experimental survey research study, undergirded by the human capital theory, aimed to reach SBAE teachers in Oklahoma and South Carolina. Science was the most commonly integrated STEM component, with 91% of participants reporting regular integration in their curriculum. Overall, SBAE teachers reported being most efficacious in science, followed by math, technology, and engineering. Although this study is limited to SBAE teachers in Oklahoma and South Carolina, teacher preparation programs should consider the findings of this study as a potential need in their state related to SBAE teachers' preparedness to integrate STEM. As this study was exploratory, additional research is essential to better support SBAE teachers.

Introduction

Science, technology, engineering, and math (STEM) preparedness is of growing concern across the United States (Bostic et al., 2020; Kuenzi et al., 2006), as students struggle to reach proficient levels in science and math (ACT, 2019; Wilmer, 2008). These current conditions beg the question, are teachers themselves prepared to teach STEM content within their curriculum (Hayes, 2017; Kuenzi et al., 2006)? School-based agricultural education (SBAE) is not exempt from this question, as McKim et al. (2017) illuminated the foundational connection of science across "all aspects of SBAE" (p. 107), providing practical application of the core content in the oldest science in the world (Ricketts et al., 2006). Additionally, science has been further emphasized in SBAE by the National Council for Agricultural Education (2012) as "a systematic program of instruction available to students desiring to learn about the science, business, technology of plant and animal production and/or about the environmental and natural resources systems" (para. 1).

Today's agricultural careers require a higher level of STEM comprehension and application than ever before (Stubbs & Myers, 2016). Agricultural education has been described as providing a seamless avenue for applying and integrating STEM concepts (Smith et al., 2015). Moreover, agricultural education programs have shown the capability to enhance achievement in science and mathematics (Chiasson & Burnett, 2001; Conroy & Walker, 2000; Parr et al., 2006; Ricketts et al., 2006; Stubbs & Myers, 2016). The body of literature is rich with examples pertaining to the integration of specific components of STEM integration within SBAE programs. Although, those focused on integrating all four components of STEM within SBAE programs are not as vast. Researchers' primary focus has been on the integration of science concepts into agricultural education curricula (Boone et al., 2006; Brister & Swortzel, 2009; Clark, 2013; Conroy et al., 2000; Johnson, 1996; Stripling & Roberts, 2012; Swafford, 2018a, 2018b; Thoron & Myers, 2012a, 2012b; Warnick et al., 2004; Whisenhunt et al., 2021). Over the past 30 years, numerous studies (Chiasson & Burnett, 2001; Ricketts et al., 2006) have confirmed and reinforced the value of illuminating science concepts within agricultural education classrooms on student performance and achievement outcomes. Students enrolled in agriscience courses consistently display higher science scores than students who are not (Haynes et al., 2012; Scales et al., 2009). Additionally, findings consistently show that SBAE teachers feel most efficacious in their ability to implement science concepts into their curriculum (Haynes et al., 2012; Johnson, 1996; Ricketts et al., 2006; Scales et al., 2009; Smith et al., 2015) followed by mathematics, but teachers often lack in the necessary confidence to implement elements of technology and engineering (Eck et al., 2021, Wang & Knobloch, 2020). But why? Do SBAE teachers perceive themselves to be more adequately prepared to teach concepts of biological and physical sciences due to their undergraduate coursework and teacher preparation program?

Perhaps this is the case, as SBAE teachers' prior educational experiences have been found to impact their perceptions of STEM integration (Stubbs & Myers, 2016). Trends within agricultural teacher education preparation programs are steeped in rigorous science-based coursework but lack the same rigor when it comes to advanced mathematics and/or engineering courses. "The lesser amount of engineering and mathematics integration described by the teachers suggested the two disciplines may need more attention from teacher educators and researchers" (Stubbs & Myers, 2016, p. 98). Stripling's and Roberts's (2012) study of Florida preservice agricultural education teachers reported that "[m]ore preservice teachers completed an intermediate mathematics course as their highest level of mathematics than basic or advanced mathematics in high school and/or college" (p. 118). Interestingly, the study identified a lack of competency in basic mathematics skills yet also revealed a high level of efficacy in their ability to teach mathematic concepts. Studies have shown (Parr et al., 2006; Shinn et al., 2003) when math-enhanced curricula are presented within the appropriate context (e.g., agricultural power and technology), they can improve students' comprehension and understanding of mathematical concepts within the agricultural education classroom. If preservice and in-service SBAE teachers feel efficacious teaching aspects of mathematics within their curriculum, why is there reluctance to implement mathematics within the SBAE classroom?

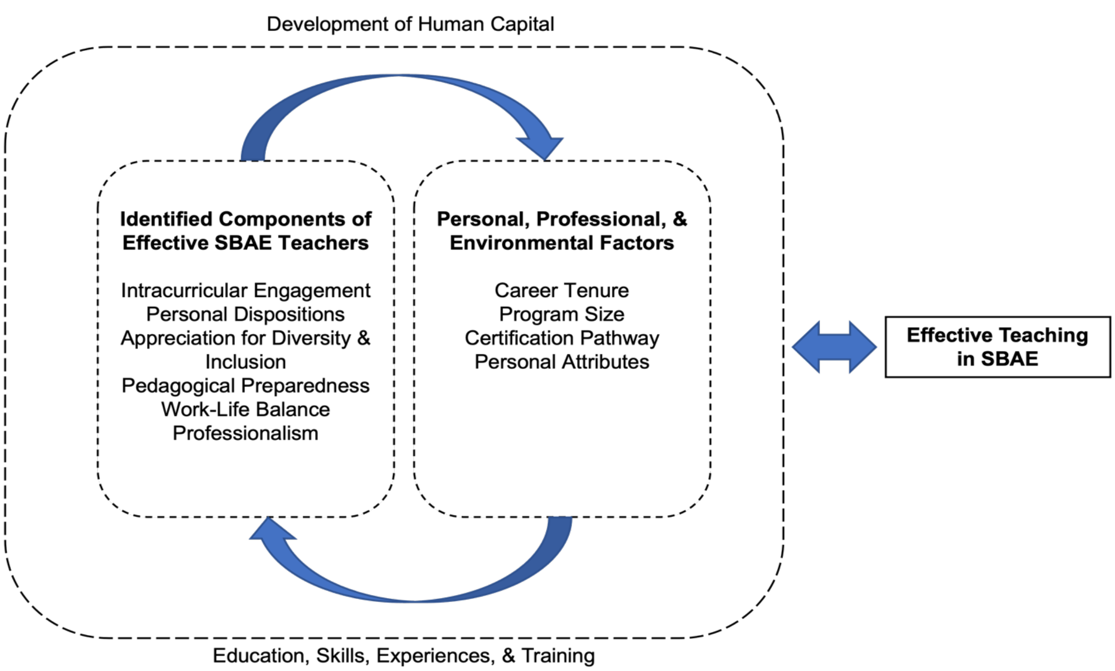
Despite positive attitudes toward the implementation of STEM concepts in agricultural education curriculum, barriers to integration have been identified by SBAE teachers across the nation (Haynes et al., 2012; Myers & Washburn, 2008; Thompson & Balschweid, 1999; Thompson & Balschweid, 2000; Warnick et al., 2004). Specifically, the lack of preservice and in-service professional development opportunities allowing SBAE teachers to enhance their core content knowledge in the areas of STEM was identified as a consistent barrier, inhibiting the integration of STEM concepts within the SBAE classroom (Haynes et al., 2012; Myers & Washburn, 2008; Thompson & Balschweid, 1999; Thompson & Balschweid, 2000; Warnick et al., 2004). Furthermore, the lack of funding and essential resources (Ricketts et al., 2006; Warnick et al., 2004) to integrate STEM concepts within SBAE programs and secondary education classrooms was also expressed. These barriers were coupled with a perceived lack of support from school administration, counselors, other classroom teachers, and community stakeholders regarding the integration of STEM concepts into agricultural education programs (Myers & Washburn 2008; Warnick et al., 2004), ultimately exacerbating the problem. The aforementioned barriers are a small representation of many others expressed throughout the literature pertaining to STEM integration in agricultural education. Therefore, to better facilitate the preparation of preservice SBAE teachers and meet the professional development needs of in-service teachers, an analysis of current in-service SBAE teacher perceptions of STEM integration within the SBAE classroom is essential.

Theoretical/Conceptual Framework

This study implemented human capital theory to undergird the research, as the study aimed to determine the current level of STEM integration and the self-efficacy of SBAE teachers. Specifically, the education, skills, experiences, and training (Becker, 1964; Little, 2003; Shultz, 1971; Smith, 2010; Smylie, 1996) an individual possess related to their profession are essential components of this study. Ultimately, an individual's human capital impacts their preparedness and competence in completing trade-specific tasks (Heckman, 2000), which in the case of this study is teaching SBAE. Eck et al. (2020) connected SBAE specific human capital development with effective teaching across a complete SBAE program (i.e., classroom/laboratory instruction, FFA advisement, and SAE supervision), identifying the connection between human capital development and effective teaching in SBAE. This connection is pivotal considering the positive impact self-efficacy has on a teacher's educational aspirations (Roy et al., 2018). Specifically, teachers who feel more efficacious have greater aspirations to improve their future human capital as an educator (Roy et al., 2018). Figure 1 depicts the development of SBAE specific human capital (i.e., the identified components of an effective SBAE teacher along with personal, professional, and environmental factors) with effective teaching in SBAE (Eck et al., 2020).

Figure 1

Conceptual Model of Effective Teaching for School-Based Agricultural Education Teachers (Eck et al., 2020)



Using the model developed by Eck et al. (2020) as a framework to better understand the current level of STEM integration put forth by SBAE teachers and their preparedness to do so helps to identify the gaps related to the specific human capital needed by SBAE teachers (Robinson & Baker, 2013) to be effective (Eck et al., 2021). As STEM integration has been identified as an integral part of a complete SBAE program (McKim et al., 2017; Ricketts et al., 2006). Therefore, it aligns with the necessary pedagogical preparedness to be an effective SBAE teacher, as identified in Figure 1. Furthermore, effective SBAE teachers impact the human capital (i.e., learning and development) of their students through the knowledge and skills taught and the personal dispositions exhibited (Smylie, 1996) throughout the complete SBAE program. This student-specific human capital development aligns with parents who ". . . want local educators to provide children with diplomas, if not specific job skills, that will ensure fruitful participation in the economy" (Sweetland, 1996, p. 356) and is furthered by industry leaders who believe educators should produce ". . . young people who are ready to function productively in a competitive workforce" (Sweetland, 1996, p. 356). Fortunately, Roberts and Ball (2009) discussed the potential for SBAE programs to meet the needs of both parents and industry professionals by developing both college and career readiness skills. Additional research is essential to further the human capital of SBAE teachers, ultimately impacting the necessary STEM workforce of the future.

Purpose and Objectives

While the barriers to STEM integration and teacher self-efficacy related to teaching STEM has been explored, and SBAE continues to aspire to prepare students for college and career readiness, a gap in the research specifically related to STEM integration in agricultural education exists (Stubbs & Myers, 2015). Therefore, this study aimed to determine the current level of STEM integration in SBAE classrooms in Oklahoma and South Carolina. Four research objectives guided this study:

1. Determine Oklahoma and South Carolina SBAE teachers' current level of STEM integration.
2. Identify the career clusters Oklahoma and South Carolina SBAE teachers integrate STEM.
3. Explain the components of STEM commonly integrated by SBAE teachers in Oklahoma and South Carolina.
4. Identify Oklahoma and South Carolina SBAE teachers' self-efficacy related to teaching STEM.

Methods and Procedures

This exploratory, non-experimental survey research study (Privitera, 2020) aimed to reach SBAE teachers in Oklahoma ($N = 467$) and South Carolina ($N = 153$) through a census approach. The two states were selected based on similarities related to current challenges facing education (Stanford, 2023), the historical significance of agriculture, and the focus on STEM in agricultural education (Oklahoma Department of Career and Technical Education, n.d.; South Carolina Department of Education, 2023). Therefore, individual emails requesting participation were sent to all SBAE teachers in Oklahoma and South Carolina. The survey research design implemented a 16-item questionnaire developed to determine the level of STEM integration currently in

SBAE programs in Oklahoma and South Carolina. Four questions were utilized for each of the four STEM components; for example, for science, SBAE teachers were asked (1) Do you regularly integrate science in their agricultural classes?; (2) What classes do you regularly integrate science in?; (3) What components related to science do you regularly integrate in the listed classes?; and (4) What is your current level of self-efficacy related to teaching science in agriculture? The same question structure (i.e., four questions with a change in STEM component) was implemented for technology, engineering, and math. Figure 2 outlines the questions used for math as an example, along with the sliding self-efficacy scale for each of the four STEM components.

Figure 2

STEM Integration in SBAE Instrument Example

STEM Integration in SBAE

Do you regularly integrate math in your agricultural classes?

○ Yes

○ No

What class/classes do you integrate math in?

____

What components related to math do you regularly integrate in your agricultural curriculum? (Please provide specifics/examples)

____

____

____

Why do you not integrate math in your agricultural classes?

____

Please indicate your level of self-efficacy (how prepared you feel to teach the concepts) considering each of the STEM components, where zero is no self-efficacy and 100 is very high self-efficacy related to teaching STEM in agriculture.

	0 10 20 30 40 50 60 70 80 90 100
Science	
Technology	
Engineering	
Math	

If respondents reported not integrating a component per question one, they were prompted to answer why. In addition to the 16 items, six demographic questions (i.e., gender, age, certification pathway, SBAE teaching experience, highest degree earned, and the number of teachers in the program) were implemented to describe the participants. Prior to distribution, the questionnaire was evaluated for face, construct, and content validity (Privitera, 2020) by two faculty members in agricultural education and one in the College of Education, who focuses on STEM teaching and learning. Given the exploratory nature of this study and the open-ended response questions in the survey questionnaire, validity was the primary focus in the survey development, followed by experimenter bias. The research team aimed to reduce all potential biases that unintentionally could influence participants' responses (Privitera, 2020). Finally, the survey questionnaire was pilot tested with 12 preservice SBAE teachers to further establish face and content validity. As the aim of the study was related to the current integration of in-service SBAE teachers, the pilot data was not used in past survey development. The questionnaire was distributed via individual email addresses to 153 SBAE teachers in South Carolina and 467 SBAE teachers in Oklahoma. A total of four points of contact (i.e., an initial email followed by three reminder invitations to participate) were utilized following the tailored design method to increase survey participation (Dillman et al., 2014).

Data collection resulted in 131 SBAE teachers responding to the online questionnaire after the initial participation invitation, 104 from Oklahoma and 27 from South Carolina, resulting in an overall response rate of 21.2%. The respondents were 65.2% male and 34.8% female, ranging from 22 to 66 years old. The majority (83.6%) of respondents were traditionally certified (i.e., agricultural education bachelor or master's degree with student teaching), 13.4% were alternatively certified i.e., A route to teacher certification that varies

> from short summer programs that place candidates in teaching assignments with full responsibility for students after a few weeks of training to those that offer one- or two year post-baccalaureate programs with ongoing support, integrated coursework, close mentoring, and supervision, (Darling-Hammond et al., 2002, p. 287)

and 3.0% were emergency certified (i.e., "a process whereby states grant temporary teaching certificates to individuals who do not meet the standard certification criteria. Emergency teaching certificates can only be granted in cases where no certified teacher can be found to fill a given position" (Childs, 2012, para.1). The SBAE teachers ranged from first year teachers to those with over 35 years of experience, ranging from 59.7% with bachelor's degrees to 38.8% with master's degrees, and one reporting to have a Ph.D. The majority of respondents (53.7%) were in single teacher programs, while 38.8% reported being in two teacher departments, and 7.5% were in three teacher programs.

Although the study only reached 21.2% (n = 131) of the target population, the demographics collected allowed the researchers to compare respondent's demographics to those of SBAE teachers in Oklahoma and South Carolina, of which the respondents were representative of the state populations based on the distribution of personal and professional characteristics (NAAE, 2022). To further address the limitation associated with a low response rate, following data collection, early (i.e., those responding following the first two contacts [n = 72]) and late respondents (i.e., those responding following the last two contacts [n = 59]) were compared based on the recommendations of Lindner et al. (2001). The comparison between the two groups resulted in no difference; therefore, the results of this study should be considered generalizable to the target audience of SBAE teachers in Oklahoma and South Carolina. Descriptive statistics were utilized to analyze the data using SPSS Version 25. Specifically, the first research objective evaluated frequencies and percentages, while research objectives two and three relied on frequencies, and the final research objective was analyzed using means and standard deviations.

Findings

Research Objective 1: Determine Oklahoma and South Carolina SBAE Teachers' Current Level of STEM Integration

When asked if they regularly integrate each of the STEM components (i.e., Science, Technology, Engineering, and Math) in their SBAE classroom, teachers most commonly integrated science, as 90.8% (*n* = 119) of respondents indicated they regularly incorporate science. Adversely, engineering was the least common STEM component incorporated, with only 33.6% (*n* = 44) integrating it in the SBAE classroom. Table 1 outlines the level of integration for each of the STEM components.

Table 1

Frequency of SBAE Teachers Integrating STEM Components (n = 131)

STEM Component	*f*	*%*
Science	119	90.8
Technology	76	58.0
Engineering	44	33.6
Math	66	50.4

Although many teachers identified integrating some STEM components, those who did not were asked why. When asked, SBAE teachers responded with "I am not a science teacher," "I am not familiar enough with the state science curriculum to make relevant connections," "STEM is not currently integrated into the curriculum I am using," or "I am not comfortable teaching these components ."Some respondents went on to say that teaching STEM "is someone else's job" or that "[they] would, but they do not know how."

Research Objective 2: Identify the Career Clusters Oklahoma and South Carolina SBAE Teachers Integrate STEM

To address the second research objective, individual courses were grouped by their identified career cluster specified by their state. SBAE in Oklahoma and South Carolina offers 29 different classes spanning seven career clusters, including agricultural communications, agribusiness and management, agricultural power, structures, and technology, animal science, food products and processing, natural resources and environmental science, and plant and soil science. In addition to the 29 classes, three additional classes are available as introductory agricultural courses not specific to a career cluster. Introductory Courses (i.e., introduction to agriculture, introduction to agriscience, Ag 1) had highest integration of science (*f* = 61) and technology (*f* = 22). While engineering was most commonly reported in Agricultural Power and Technology (*f* = 25). Math had the lowest reported level of integration, with Plant and Soil Science being the most common pathway, with five teachers reporting integration. The frequency of science, technology, engineering, and math integration for each pathway is outlined in Table 2.

Table 2

Cluster Specific STEM Integration for SBAE Teachers (n = 131)

Career Cluster	Science	*Technology*	*Engineering*	*Math*

Agribusiness	0	1	0	0
Agricultural Communications	0	16	0	0
Agricultural Power and Technology	13	10	25	2
Animal Science	32	10	1	1
Environmental Service Systems	0	0	0	0
Food Science	3	0	0	0
Introductory Courses	61	22	4	6
Natural Resource and Environmental Science	11	2	0	2
Plant and Soil Science	26	5	1	5

Research Objective 3: Explain the Components of STEM Commonly Integrated by SBAE Teachers in Oklahoma and South Carolina

The third research objective aimed to explain the specific topics addressed within agriculture related to each of the STEM components. When prompted to answer what components related to science they regularly integrated into their agricultural curriculum, participants commonly responded with genetics, anatomy, photosynthesis, plant and animal cells, animal reproduction, animal nutrition, and biology. Considering technology principles, SBAE teachers reported using computers, Google classroom, Canvas, Quizlet, iCEV, PowerPoint, Promethean boards, electronic record books, online curriculum, and computer software in general. A few teachers went past the technology integration for teaching and added the usage of CNC machines, drones, cameras, survey instruments, and pH testers. Engineering elicited responses, including reading blueprints, metal fabrication, construction, surveying, project design, and small engine repair. The final component of math demonstrated teachers making connections to feed rations, mixing fertilizer, record keeping, calculating area, measurement, calculating slope, and compiling a cost list of building materials. Table 3 outlines the 14 topic areas mentioned for science, 19 for technology, seven for engineering, 12 for math, and the corresponding frequency of participants who identified integrating that topic area.

Table 3

SBAE STEM Integration Topics Addressed by SBAE Teachers (n = 131)

STEM Component	Topic	*f*
Science	Genetics	21
	Anatomy	18
	Photosynthesis	14
	Plant Cells	13
	Animal Reproduction	11
	Animal Nutrition	10

STEM Component	Topic	*f*
	Biology	10
	Plant Classification	9
	Animal Cells	8
	Scientific Method	6
	Chemistry of Herbicides	5
	Plant Propagation	5
	Animal Processing	3
	Scientific Process of Welding	2
Technology	Google Classroom	26
	Online Curriculum/iCEV	18
	SMART/Promethean Boards	17
	Computers	15
	Computer Software	13
	Electronic Record Books/AET	11
	PowerPoint	10
	Quizlet	7
	CNC Machines	7
	Canvas	4
	Drones	4
	GPS	4
	Cameras	3
	Survey Instruments	3
	pH Testers	2
	YouTube	2
	Microscopes	1
	3-D Printers	1
	Virtual Reality	1
Engineering	Project Design	20
	Construction	18
	Reading Blueprints	17
	Metal Fabrication	16
	Surveying	10
	Small Engine Repair	10
	Irrigation Systems	5

STEM Component	Topic	*f*
Math	Feed Rations	23
	Measurement	23
	Record Keeping	20
	Fertilizer Calculations	18
	Cost Sheets	17
	EPDs	14
	Yield Percentages	14

STEM Component	Topic	*f*
	Average Daily Gain	13
	Calculating Area	9
	Calculating Slope	9
	Soil Triangle	8
	Ear Notching	2

Research Objective 4: Identify Oklahoma and South Carolina SBAE Teachers' Self-Efficacy Related to Teaching STEM

The final research objective asked SBAE teachers to report their level of self-efficacy related to teaching science, technology, engineering, and math from zero to 100, where zero was no self-efficacy, and 100 was very high self-efficacy. Respondents ranged from SBAE teachers integrating STEM for the first time to those who reported to have been integrating STEM for over 35 years. SBAE teachers in Oklahoma and South Carolina felt most efficacious in integrating science and least successful with engineering. Table 4 outlines the mean and standard deviation for teacher STEM self-efficacy for each component.

Table 4

SBAE Teacher STEM Self-Efficacy (n = 131)

STEM Component	Mean	*SD*
Science	78.20	15.73
Math	75.62	19.05
Technology	74.29	18.36
Engineering	53.07	25.95

Conclusions, Implications, and Recommendations

While this study was limited to SBAE teachers in Oklahoma and South Carolina who responded to the study *(n* = 131), their personal and professional characteristics were representative of those in their respective states. Science was the most commonly integrated STEM component, with 91% (*n* = 119) of participating SBAE teachers reporting they regularly integrate science into their curriculum. Similarly, science is the most regularly integrated STEM component with preservice SBAE teachers in multiple studies over the past 25 years (Boone et al., 2006; Brister & Swortzel, 2009; Clark, 2013; Conroy et al., 2000; Johnson, 1996; Stripling & Roberts, 2012; Swafford, 2018a, 2018b; Thoron & Myers, 2012a, 2012b; Warnick et al., 2004; Whisenhunt et al., 2021). Science being the dominant component further aligns with previous research referring to agriculture as the oldest science globally (Ricketts et al., 2006) and an applied science (Balschweid & Thompson, 2000). In the case of this study, science was followed by lower integration levels, with 58% (*n* = 76) integrating technology, 50% (*n* = 66) integrating math, and 34% (*n* = 44) integrating engineering.

These levels of STEM integration align with recent research related to technology and engineering integration in SBAE (Eck et al., 2021, Wang & Knobloch, 2020), which outlined a lack of concern for technology and engineering as STEM components. Although only 50% of the participants reported integrating math, the math enhanced curriculum in SBAE has significantly impacted secondary students' math performance (Parr et al., 2006). Therefore, it is essential to further understand SBAE teachers' level of STEM integration, including the courses for each component of STEM.

Introductory agricultural courses (i.e., eighth or ninth-grade ag, introduction to agriculture) were the most commonly reported cluster of integration for science, technology, and math. In contrast, engineering was most frequently integrated in agricultural power and technology courses. Although much of the reported integration aligns with the career clusters, others have little to no integration even though respondents reported teaching those courses. For example, no STEM integration was reported for environmental service systems, and only one SBAE teacher reported integrating STEM in agribusiness, which was in technology. Overall, technology was integrated across most career clusters of the STEM components.

Although technology was reported across most career clusters, the technology integration focused on classroom technologies, including computers, Google classroom, Canvas, Quizlet, iCEV, PowerPoint, Promethean boards, electronic record books, online curriculum, and computer software in general. Unfortunately, only a few SBAE teachers ($n = 3$) went past the technology integration for teaching and focused on integrating technology in agriculture, including the use of CNC machines, drones, cameras, survey instruments, and pH testers. Perhaps this is due to the nature of their training as they prepare to be certified teachers, focusing on teaching pedagogy and educational technologies? Additional research is warranted related to SBAE teachers' understanding of the STEM technology integration in agriculture, as it was integrated across the most career clusters, even though respondents' technology self-efficacy resulted in a mean score of 74.3.

Overall, SBAE teachers reported being most efficacious in science, followed by math, technology, and engineering. This corresponds with science also being the most integrated item reported in this study. In addition, many SBAE teacher preparation programs provide additional science emphasis or coursework in the undergraduate degree plans, as nearly 84% of respondents were traditionally certified. Although participants felt most efficacious in science, the mean score for self-efficacy in integrating science in agriculture was only 78.2. This *C* grade in science self-efficacy is concerning considering the vast body of literature focused on science integration in SBAE. Perhaps additional resources need to be developed for preservice and inservice SBAE teachers to further understand and develop skills related to STEM self-efficacy and integration.

Considering the current level of STEM integration reported by SBAE teachers in Oklahoma and South Carolina and their current level of self-efficacy to integrate STEM, we must consider how this impacts their human capital. Specifically the human capital undergirding this study focuses on career specific (Heckman, 2000) human capital (i.e., teaching SBAE) that ultimately leads to effective teaching in SBAE, according to Eck et al. (2020). This study's levels and depth of STEM integration highlight the need for purposeful professional development for in-service

SBAE teachers focusing on STEM integration in the classroom while simultaneously increasing STEM teaching self-efficacy. This supports the development of SBAE specific pedagogical preparedness (Eck et al., 2021) and better situates teachers to effectively integrate STEM, which has been identified as an integral part of a complete SBAE program (McKim et al., 2017; Ricketts et al., 2006).

Although this study was limited to SBAE teachers in Oklahoma and South Carolina, teacher preparation programs should consider the findings of this study as a potential need in their state related to SBAE teachers' preparedness to integrate STEM. Additionally, in-service teachers reported varying levels of STEM integration, leading to the need for a scaffold approach to professional development. This approach should consider each component of STEM (i.e., science, technology, engineering, and math) along with a career cluster focus (i.e., ag communications, agribusiness and management, agricultural power, structures, and technology, animal science, food products and processing, natural resources and environmental science, and plant and soil science), allowing teachers to determine the best fit for their current level of understanding and programmatic needs. Beyond developing preservice and inservice SBAE teachers, school, district, and state-level administrators should be made aware of the rigor and relevance within SBAE classrooms, as these teachers are not only making real-world connections that lead to viable STEM careers (Bostic et al., 2020; Kuenzi et al., 2006), but they are also making relevant connections to concepts taught in classes across campus. Effective SBAE teachers ready to integrate STEM in their classroom have the opportunity to address the current struggle students face (The Condition of College & Career Readiness, 2017; Wilmer, 2008) as they attempt to reach proficient levels in science and math. Perhaps additional support and value can be placed on SBAE teachers by administrators who are aware of the effort put forth by the teacher and the potential impact agricultural classes have on students.

As this study was exploratory, additional research is essential to better understand and support in-service and preservice SBAE teachers. Therefore, this study should be replicated in other states to determine the specific needs of teachers. Likewise, an adapted study should be implemented with preservice teachers to evaluate the impact of coursework in their teacher preparation program on their preparedness to effectively integrate STEM during their clinical teaching experience and beyond. Although SBAE teachers reported integrating STEM, it is essential to consider if they really are and, if so, how? Therefore, to further understand the STEM integration of SBAE teachers, a qualitative focus group interview should be conducted to explore the current integration and barriers associated with STEM integration across career clusters. Additionally, the evaluation of in-service SBAE teacher lesson plans or the observation of SBAE classes could further the understanding of the current level of STEM integration. As research on STEM integration is expanded, SBAE Stakeholders (i.e., school administrators, state agricultural education and FFA staff, SBAE teacher educators) will better grasp the need to support the development of purposeful STEM integration training for in-service and preservice SBAE teachers.

References

American College Testing (ACT). (2019). *The condition of college & career readiness 2019*. https://www.act.org/content/act/en/research/reports/act-publications/condition-of-college-and-career-readiness-2019.html

Balschweid, M. A., & Thompson, G. W. (2000). Agriculture and science integration: A pre-service prescription for contextual learning. *Journal of Agricultural Education, 41*(2), 36–45. https://doi.org/10.5032/jae.2000.02036

Becker, G. (1964). *Human capital: A theoretical and empirical analysis with special reference to education*. The University of Chicago Press.

Boone, H. N., Gartin, S. A., Boone, D. A., & Hughes, J. E. (2006). Modernizing the agricultural education curriculum: An analysis of agricultural education teachers' attitudes, knowledge, and understanding of biotechnology. *Journal of Agricultural Education, 47*(1), 78-89. https://doi.org/10.5032/jae.2006.01078

Bostic, J. D., Clark, Q. M., Vo, T., Esters, L. T., & Knobloch, N. A. (2020). A design process for developing agricultural life-science focused model electing activities. *School Science and Mathematics, 2020*(00), 1–12. https://doi.org/10.1111/ssm.12444

Brister, M. H., & Swortzel, K. A. (2009). A comparison of attitudes of agriscience teachers, counselors, and administrators toward science integration with student attitudes toward agriscience programs. Paper presented at the American Association for Agricultural for Agricultural Education Research Conference, Louisville, KY.

Chiasson, T. C., & Burnett, M. F. (2001). The influence of enrollment in agriscience courses on the science achievement of high school students. *Journal of Agricultural Education, 42*(1), 60-70. https://doi.org/10.5032.jae/2001/01061

Childs, B. (2012). *What is emergency teacher certification?* https://certificationmap.com/emergency–teacher–certification/

Clark, A. R. (2013). Effects of integrating mathematical concepts into an animal science curriculum (Master's thesis, Utah State University). http://digitalcommons.usu.edu/etd/1950/

Conroy, C. A., Dailey, A. L., & Shelley-Tolbert, C. A. (2000). The move to agriscience and its impact on teacher education in agriculture. *Journal of Agricultural Education, 41*(4), 51–61. https://doi.org/10.5032/jae.2000.04051

Conroy, C. A., & Walker, N. J. (2000). An examination of integration of academic and vocational subject matter in the aquaculture classroom. *Journal of Agricultural Education, 41*(2), 54-64. https://doi.org/10.5032/jae.2000.02054

Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education, 53*(4), 286–302. https://doi.org10.1177/0022487102053004002

Eck, C. J., Robinson, J. S., Cole, K. L., Terry Jr., R., & Ramsey, J. W. (2020). Validation of the effective teaching instrument for school-based agricultural education teachers. *Journal of Agricultural Education, 61*(4), 229–248. http://doi.org/10.5032/jae.2020.04229

Eck, C., Robinson, J. S., Cole, K., Terry, R, & Ramsey, J. (2021). Identifying the characteristics of effective school-based agricultural education teachers: A national census study. *Journal of Agricultural Education, 62*(3), 292-309. https://doi.org/10.5032/jae.2021.03292

Eck, C. J., Whisenhunt, J., Robinson, J. S., Neumann, K. L., Utley, J., & Gossen, D. (2021). How pre-service agricultural education teachers plan to integrate STEM competencies in their lessons. *NACTA Journal, 65*(1), 242–253. https://www.nactateachers.org/index.php/volume-65-november-2020-october-2021/3123-how-pre-service-agricultural-education-teachers-plan-to-integrate-stem-competencies-in-their-lessons

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). Wiley.

Hayes, S. (2017). Preparation matters most in STEM (Issue brief). ACT. http://www.act.org/content/dam/act/unsecured/documents/R1647-preparation-matters-in-stem-2017-05.pdf

Haynes, J. C., Robinson, J. S., Edwards, M. C., & Key, J. P. (2012). Assessing the effect of using a science-enhanced curriculum to improve agriculture students' science scores: A causal comparative study. *Journal of Agricultural Education, 53*(2), 15–27. https://doi.org/10.5032/jae.2012.02015

Heckman, J. L. (2000). Invest in the very young. Ounce of Prevention Fund. http://www.ounceofprevention.org/downloads/publications/Heckman.pdf

Johnson, D. M. (1996). Science credit for agriculture: Perceived support, preferred implementation methods, and teacher science course work. *Journal of Agricultural Education, 37*(1), 22–30. https://doi.org/10.5032/jae.1996.01022

Kuenzi, J. J., Matthews, C. M., & Mangan, B. F. (2006*). Science, technology, engineering, and mathematics (STEM) education issues and legislative options*. Congressional Research Report. Congressional Research Service. https://apps.dtic.mil/dtic/tr/fulltext/u2/a474889.pdf

Lindner, J. R., Murphy, T. H., & Briers, G. E. (2001). Handling nonresponse in social science research. *Journal of Agricultural Education, 42*(4), 43–53.

https://doi.org/10.5032/jae.2001.04043

Little, A. W. (2003, December). Motivating learning and the development of human capital. *British Association for International and Comparative Education, 33*(4), 437–452.

McKim, A. J., Velez, J. J., Lambert, M. D., & Balshweid, M. A. (2017). A philosophical review of science and society within agricultural education. *Journal of Agricultural Education, 58*(2), 98–110. https://doi.org/10.5032/jae.2017.02098

Myers, B. E., & Washburn, S. G. (2008). Integrating science in the agriculture curriculum: Agriculture teacher perceptions of the opportunities, barriers, and impact on student enrollment. *Journal of Agricultural Education, 49*(2), 27–37. https://doi.org/10.5032/jae.2008.02027

National Association of Agricultural Educators (NAAE). (2022). *Agricultural Education supply and demand*. Author. https://www.naae.org/teachag/supplyanddemand.cfm#sd

National Council for Agricultural Education. (2012). *About agricultural education*. Author. https://www.ffa.org/thecouncil/aboutus

Oklahoma Department of Career and Technical Education. (n.d.). *Agricultural education*. Author. https://oklahoma.gov/careertech/educators/agricultural-education.html

Parr, B. A., Edwards, M. C., & Leising, J. G. (2006). Effects of a math-enhanced curriculum and instructional approach on the mathematics achievement of an agricultural power and technology students: An experimental study. *Journal of Agricultural Education,47*(3), 81–93. https://doi.org/10.5032/jae.2006.03081

Privitera, G. J. (2020). *Research methods for the behavioral sciences* (3rd ed.). SAGE.

Ricketts, J. C., Duncan, D. W., & Peake, J. B. (2006). Science achievement of high school students in complete programs of agriscience education. *Journal of Agricultural Education, 47*(2), 48–55. https://doi.org/10.5032/jae.2006.02048

Roberts, T. G., & Ball, A. L. (2009). Secondary agricultural science as a content and context for teaching. *Journal of Agricultural Education, 50*(1), 81–91. https://doi.org/10.5032/jae.2009.01081

Robinson, J. S., & Baker, M. A. (2013). The effect of human capital on principals' decisions to interview candidates in agricultural education: Implications for pre-service teachers. *Journal of Agricultural Education, 54*(1), 139–152. https://doi.org/10.5032/jae.2013.01139

Roy, S., Morton, M, & Bhattacharya, S. (2018). Hidden human capital: Self-efficacy, aspirations and achievements of adolescent and young women in India. *World Development, 111*, 161–180. https://doi.org/10.1016/j.worlddev.2018.07.002

Scales, J., Terry Jr, R., & Torres, R. M. (2009). Are teachers ready to integrate science concepts into secondary agriculture programs? *Journal of Agricultural Education, 50*(2), 102–113. https://doi.org/10.5032/jae.2009.02102

Shinn, G. C., Briers, G. E., Christiansen, J. E., Edwards, M. C., Harlin, J. F., & Lawver, D. E., (2003). *Improving student achievement in mathematics: An important role for secondary agricultural education in the 21st century.* Monograph, National Council for Agricultural Education. https://doi.org/10.1.1.130.5829

Shultz, T. W. (1971). *Investment in human capital: The role of education and of research*. The Free Press.

Smith, E. (2010). Sector-specific human capital and the distribution of earnings. *Journal of Human Capital, 4*(1), 35–61. https://doi.org/10.1086/655467

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective practices in STEM integration: Describing teacher perceptions and instructional method use. *Journal of Agricultural Education, 56*(4), 182–201. https://doi.org/10.5032/jae.2015.04183

Smylie, M. A. (1996). From bureaucratic control to building human capital: The importance of teaching learning in education reform. *Educational Researcher, 25*(9), 9–11. https://doi.org/10.2307/1177152

South Carolina Department of Education. (2023). *About*. Author. https://ed.sc.gov/about/

Stanford, L. (2023). *The state of rural schools, in charts: Funding, graduation rates, performance, and more*. Education Week. https://www.edweek.org/leadership/the-state-of-rural-schools-in-charts-funding-graduation-rates-performance-and-more/2023/11

Stripling, C. T., & Ricketts, J. C. (2016). Research priority 3: Sufficient scientific and professional workforce that addresses the challenges of the 21st century. In T. G. Roberts, A. Harder, M. T. Brashears (Eds.), *American Association for Agricultural Education national research agenda: 2016-2020* (pp. 29-36). Department of Agricultural Education and Communication.

Stripling, C. T., & Roberts, T. G. (2012). Florida pre-service agricultural education teachers' mathematics ability and efficacy. *Journal of Agricultural Education, 53*(1), 109-122. https://doi.org/10.5032/jae.2012.01109

Stubbs, E. A., & Myers, B. E. (2016). Part of what we do: Teacher preparation of STEM integration. *Journal of Agricultural Education, 57*(3), 87-100. https://doi.org/10.5032/jae.2016.03087

Stubbs, E. A., & Myers, B. E. (2015). Multiple case study of STEM in school-based agricultural education. *Journal of Agricultural Education, 56*(2), 188–203.

https://doi.org/10.5032/jae.2015.02188

Swafford, M. (2018a). STEM education at the nexus of the 3-circle model. *Journal of Agricultural Education, 59*(1), 297–315. https://doi.org/10.5032/jae.2018.01297

Swafford, M. (2018b). The state of the profession: STEM in agricultural education. *Journal of Agricultural Education, 59*(4), 315–333. https://doi.org/10.5032/jae.2018.04315

Sweetland, S. R. (1996). Human capital theory: Foundations of a field of inquiry. *Review of Educational Research, 66*(3), 341–359. https://www.jstor.org/stable/1170527?seq=1#metadata_info_tab_contents

Thompson, G. W., & Balschweid, M. M. (1999). Attitudes of Oregon agricultural science and technology teachers toward integrating science. *Journal of Agricultural Education, 40*(2), 21–29. https://doi.org/10.5032/jae.1999.02021

Thompson, G. W., & Balschweid, M. M. (2000). Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs. *Journal of Agricultural Education, 41*(2), 73–80. https://doi.org/10.5032/jae.2000.02073

Thompson, G. W., & Warnick, B. K. (2007). Integrating science into the agricultural education curriculum: Do science and agriculture teachers agree? *Journal of Agricultural Education, 48*(3), 1–12. https://doi.org/10.5032/jae.2007.03001

Thoron, A. C., & Myers, B. E. (2012a). Effects of inquiry–based agriscience instruction and subject matter–based instruction on student argumentation skills. *Journal of Agricultural Education, 53*(2), 58–69. https://doi.org/10.5032/jae.2012.02058

Thoron, A. C., & Myers, B. E. (2012b). Effects of inquiry–based agriscience instruction on student scientific reasoning. *Journal of Agricultural Education, 53*(4), 156–170. https://doi.org/10.5032/jae.2012.04156

Wang, H.-H., & Knobloch, N. A. (2020). Pre-service educators' beliefs and practices of teaching STEM through agriculture, food, and natural resources. *Journal of Agricultural Education*, *61*(2), 57–76. https://doi.org/10.5032/jae.2020.02057

Warnick, B. K., Thompson, G. W., & Gummer, E. S. (2004). Perceptions of science teachers regarding the integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 45*(1), 62–73. https://doi.org/10.5032/jae.2004.02073

Whisenhunt, J., Eck, C. J., Robinson, J. S., Cole, K. L., Key, J., R., & Ramsey, J. W. (2021). How the duration of a student teaching internship impacts the overall quality of interns' lesson plans: A comparison of two formats. *Journal of Southern Agricultural Education Research*, *71*. http://jsaer.org/2021/04/08/how-programmatic-changes-impact-the- lesson-plan-quality-of-student-teaching-interns-a-comparison-of-two-formats/

Wilmer, E. (2008). Student support services for the underprepared student. *Inquiry, 13*(1), 5–19. https://files.eric.ed.gov/fulltext/EJ833908.pdf