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Keeping Agricultural Education Relevant for the 21st Century: Assessing the Perceptions of Local CTE Administration on STEM Skills Integration

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Abstract

As agricultural education propels itself into the 21st century, a focus on Science, Technology, Engineering, and Mathematics (STEM) education has been prioritized. While STEM integration has been held in high regard, many employers claim that students lack the necessary STEM-based skills to be successful in an entry-level position. In addition, STEM achievement of agricultural education students has not been consistent. This study aimed to ascertain the perceptions of Alabama and Georgia CTE administrators employed in school districts with agricultural education programs on the importance of integrating individual STEM skills into Agriculture, Food, and Natural Resource (AFNR) pathways. In this descriptive correlational study, 129 CTE administrators were emailed a survey through Qualtrics to rate 62 STEM-based AFNR standards using a five-point Likert-type scale. Results of the study suggested that most CTE administrators valued all assessed STEM-based AFNR standards as Very Important or Extremely Important. A mixed model was used to determine any statistical differences in importance ratings between Alabama and Georgia and among pathway scores. AFNR pathways with the highest importance ratings included the Animal Science Pathway, Plant Systems Pathway, and the Food Products and Processing Pathway. AFNR pathways with the lowest ratings included the Power, Structural, and Technical systems pathway and the Biotechnology pathway. No statistical differences were found between states, suggesting consistency between CTE administrators in these two states. These results suggested that CTE administrators value STEM and that agricultural educators should ensure STEM is integrated into their course curriculum.

Introduction/Review of Literature

For over 100 years, agricultural education has prepared students for the workforce (Friedel, 2011; Martinez, 2007). While vocational training comes in many forms, instilling students with

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skills in the areas of Science, Technology, Engineering, and Mathematics (STEM) has been increasingly prioritized over the last decade (Chumbley et al., 2015; Smith et al., 2015; Wang & Knoblach, 2020). This augmented focus on STEM has had significant implications on curriculum development in agricultural education (Kelly & Knowles, 2016; Swafford, 2018a).

The ideology that STEM should be integrated into agricultural education has been overwhelmingly accepted by teachers, preservice teachers, administrators, teacher educators, and industry leaders (Conner et al., 2017; Stubbs & Myers, 2016; Swafford, 2018b). Overall, teachers hold a positive perception of STEM integration and agree that STEM is an integral part of agricultural education (Smith et al., 2015; Stubbs & Myers, 2016). Even though teachers agree STEM integration is a critical aspect of agricultural education, many teachers report being unconfident in effectively integrating these subjects (Conner et al., 2017; Smith et al., 2015; Swafford, 2018a; Wang & Knobloch, 2020). Overall, teachers agree that science, technology, and mathematics are among the most critical subjects to integrate into agricultural education and their integration is necessary for programs to remain relevant in the 21st century (Stubbs & Myers, 2016). Coinciding, Conner et al. (2017) reported that preservice teachers believed that mathematics integration was a critical part of School-Based Agricultural Education (SBAE), although they felt ill-prepared in this area.

While the importance of STEM integration has been established, specific methods of integration into SBAE have not been well developed. Bybee (2010) described STEM integration as "the education community [embracing] a slogan without really taking the time to clarify what the term might mean when applied beyond a general label" (p. 30). The American Association for Agricultural Education (AAAE) has addressed this issue in the third priority area of the National Research Agenda, which is "Sufficient Scientific and Professional Workforce That Addresses the Challenges of the 21st Century" (Stripling & Ricketts, 2016, p. 29). The fifth priority research question in this research priority area is "What are effective models for STEM integration in school-based agricultural education curriculum?" (Stripling & Ricketts, 2016, p. 31). This research priority shows the need for further development of STEM integration models.

While STEM integration has been prioritized in SBAE (Swafford, 2018a), the results of incorporating STEM into agricultural education have been less than favorable (McKim et al., 2018; Wang & Knoblach, 2020). There have been mixed results regarding the STEM achievement of students enrolled in agricultural education (Chiasson & Burnett, 2001; Clark et al., 2013; McKim et al., 2018; Nolin & Parr, 2013; Plank, 2001; Theriot & Kotrlik, 2009). Some researchers have found that student achievement in science is significantly higher in students enrolled in SBAE (Chiasson & Burnett, 2001; Theriot & Kotrlik, 2009), while other studies have shown there is no difference (Clark et al., 2013) or that achievement is lower in SBAE students (McKim et al., 2018). Furthermore, research has shown that achievement in mathematics is higher among students enrolled in agricultural education (Nolin & Parr, 2013). Still, others suggest that differences in achievement in math are not statistically significant (Plank, 2001) or that achievement is lower in SBAE enrollees (McKim et al., 2018). Furthermore, students enrolled in agricultural education are often less motivated by self-determination and more motivated by grades to learn STEM concepts (Chumbley et al., 2015). These conclusions are troubling for agricultural educators, considering the importance placed on STEM education in today's educational environment.

In addition to student academic achievement, employers have found that students exiting secondary education do not possess the necessary skills in STEM (Chumbley et al., 2015; McGunagle & Zizka, 2020). According to McGunagle and Zizka (2020), “employability skills... are often under-estimated and under-trained in educational institutions, and, more specifically, in Science, Technology, Engineering, and Math (STEM) education” (p. 2). It has been purported that the skills gap between employees and their employer's expectations can be resolved through improved STEM education integration into Career and Technical Education (CTE; Brown et al., 2011; Kelly & Knowles, 2016; Scherer et al., 2019; Swafford, 2018a).

CTE is a broad term used to describe vocational-based courses in health occupations, business/marketing education, family and consumer science education, technical education, agricultural education, and so forth (ACTE, 2023). The purpose of CTE is to "prepare youth and adults for a wide range of high-wage, high-skill, high-demand careers" (ACTE, 2023, para 1). In many districts across the U.S., CTE administrators oversee these educational programs (Zirkle & Jeffery, 2017). While agricultural education is one component of Career and Technical Education (ACTE, 2023), CTE administrators often manage the distribution of federal and state funding, course and curriculum selections, program compliance, and other administrative duties for the agricultural education program (Zirkle & Jeffery, 2017). Throughout the U.S., 34 states do not require a certification specific to CTE administration and do not require CTE experience to supervise secondary CTE programs (Manley, 2012; Zirkle & Jeffery, 2017). Manley (2012) claims that "…strong administrators have extensive training and experience in CTE. This means they have been trained as a CTE teacher and have worked in CTE prior to becoming a CTE administrator" (p. 22). While CTE experience may be necessary to be a strong CTE administrator (Manley, 2012), many districts opt to hire individuals who do not have a CTE background in these critical roles (Manley, 2012; Zirkle & Jeffery, 2017). This pivotal influence on the agricultural education program from administrators who may not have prior experience in CTE, may impact CTE's effectiveness with STEM.

These concerning results from inconstancies in student academic success and recent graduates' lack of preparedness for the workforce will require agricultural education to develop specific methods of STEM integration further. Little research on STEM integration into SBAE has been conducted, and there is a lack of literature involving CTE administrators, specifically regarding CTE administrators' perceptions of the importance of STEM-based AFNR standards in the agricultural education curriculum. If agricultural education is going to meet the goal of preparing students for the workforce, educators will need to find modern and innovative ways to integrate STEM into their curriculum and ultimately instill these skills into students.

Purpose of the Study

The purpose of this study was to assess the perceptions of Alabama and Georgia CTE administrators with agricultural education in their districts on the importance of STEM integration into SBAE. The following research objectives were assessed:

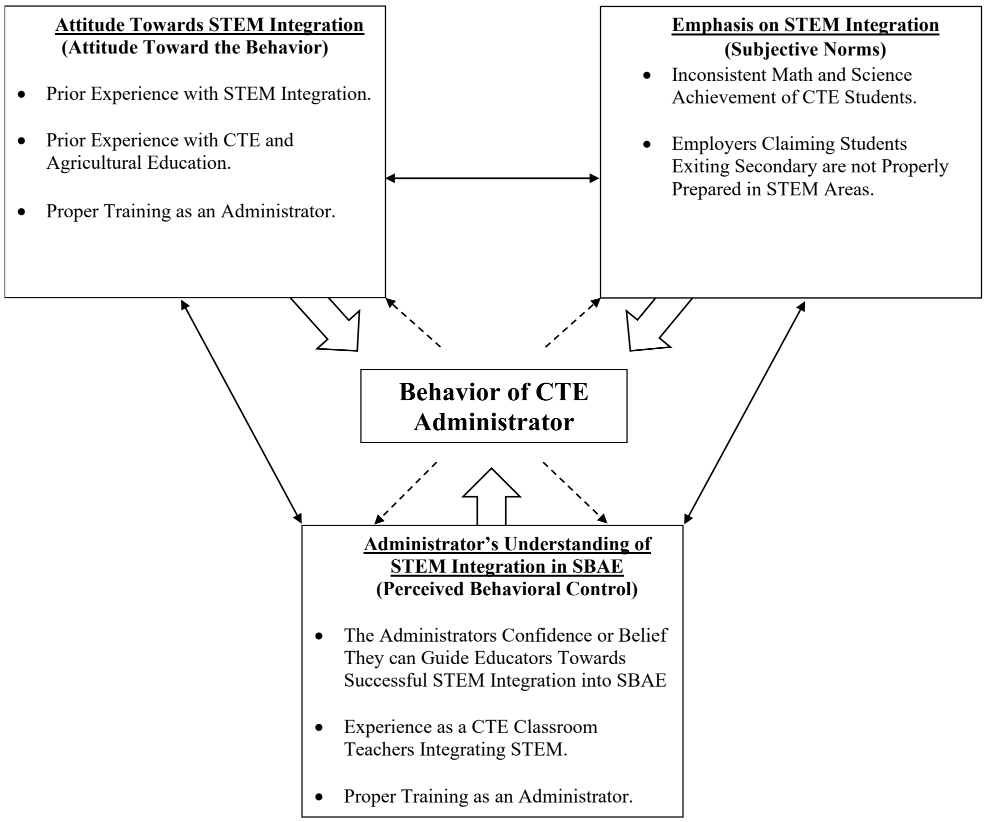
1. Determine the extent that Alabama and Georgia CTE administrators with agricultural education in their district regard the importance of STEM integration into the AFNR curriculum.
2. Assess any differences in perceptions between Alabama and Georgia CTE administrators with agricultural education in their district regarding AFNR pathways.

Theoretical Framework

The theoretical framework used to guide this study was Ajzen's (1991) Theory of Planned Behavior. Ajzen (1991) proposed that an individual's behavior is the result of a mixture of intentions, attitudes, and beliefs. A conceptual model was developed based on the theory of planned behavior (Figure 1; Ajzen, 1991).

Figure 1

Conceptual Model Adapted from the Theory of Planned Behavior.



Note. Adapted from Ajzen, 1991.

This theory considers the "subjective norms," the "perceived behavioral control," and "attitude toward the behavior" and how they evolve into intention and behavior (Ajzen, 1991, p. 179). Within the subjective norms, the theory of planned behavior outlines how injunctive and descriptive norms affect decision-making. Descriptive norms are an individual's perception of what is typical for most people, while injunctive norms are guided by morality. The subjective norms can be viewed as social pressures or social influences. In the context of this study, subjective norms influencing CTE administrators can be viewed as the educational system placing emphasis on STEM integration, research showing inconsistent academic math and science achievement of SBAE students, and industry reporting students' lack of preparedness in math and science as they enter the workforce.

This theory also recognizes the influences of self-efficacy and personal agency on perceived behavioral control. The perceived behavioral control is the individual's belief that they can accomplish the necessary task. In this study, CTE administrators understanding of STEM integration and agricultural education was the perceived behavioral control. This study aimed to ascertain CTE administrators' "attitudes toward the behavior." This theory uses the influence of affective and instrumental attitudes to delineate the effect of attitude on decision-making further. An affective attitude describes an individual's feeling towards a behavior, and an instrumental attitude describes an individual's assessment of the behavior's result.

One limitation of this study was that it only focused on attitudes and perceptions, but it could assist in determining CTE administrators' behavior toward STEM integration into agricultural education. Furthermore, this framework was selected because it "provides a useful conceptual framework for dealing with the complexities of human social behavior" (Ajzen, 1991, p. 206). If the attitudes and beliefs of CTE administrators regarding STEM integration are determined, the value placed toward SBAE programs and their structure can be evaluated.

Methods

Participants

The participants of this study were CTE administrators in Alabama (*N* = 137) and Georgia (*N* = 178) that offered agricultural education courses in their district. This study gained IRB approval from Mississippi State University in December 2020, and data collection for this study occurred during the Winter of 2021.

Instrumentation

A descriptive correlational research design was implemented to obtain the data needed for this study. The instrument utilized in the study was delivered through Qualtrics (web-based data collection) and consisted of two sections. The first section of the instrument assessed the perceptions of Alabama's and Georgia's CTE administrators that have agricultural education in their district on the integration of STEM skills education into agricultural education. This section of the instrument was developed to assess the participating CTE administrators' "attitude toward the behavior" (Ajzen, 1991, p. 1). The second section collected demographic data on the participating CTE administrators.

Statements regarding the perceptions of administrators on the integration of STEM skills education were taken from the Agriculture, Food, and Natural Resources (AFNR) standards crosswalk produced by The National Council for Agricultural Education (2015). These AFNR standards were cross walked with the Common Core Mathematics standards, Next Generation Science Standards, and the STEM section of the Green/Sustainability Knowledge and Skill Statements. These specific STEM-based AFNR standards were included in the instrument. The standards included in the instrument are listed in Table 3 by pathway, along with the percentage and frequency that CTE administrators ranked each standard as one of descriptors within the Likert scale. The standards have been abbreviated from their original form, but effort has been made to maintain the intent of the original statement. Each standard that assessed STEM skills utilized a Likert type scale that ranged from 1 = *Not Important at All*, 2 = *Somewhat Important*, 3 = *Moderately Important*, 4 = *Very Important*, to 5 = *Extremely Important*. Demographic data collected on each CTE administrator included gender, ethnicity, highest degree earned, CTE background, if agricultural education was offered in their district, years as a classroom teacher, total years in education, school system type, duty allocation, and school system size. If participants answered that agricultural education was not offered in their district, skip logic rerouted them directly to the demographic data, skipping all questions regarding STEM integration. The instrument was developed utilizing a matrix question for rating the STEM-based AFNR standards within each of the eight pathways and 14 additional questions to measure the participants' demographics. In addition, the beginning of the instrument included the consent to participant questions required by the Mississippi State University IRB.

Pilot Study

The researchers conducted a pilot study with CTE administrators throughout Mississippi (*n* = 33). Overall, the pilot study yielded a 73% response rate (*f* = 24). The researchers chose to conduct a pilot study to assess the validity and reliability of the instrument. To assess the instrument, a committee of four faculty members at Mississippi State University was formed to evaluate the instrument's content, face, and construct validity. In addition, the participants in the pilot study were asked to submit comments regarding the instrument's validity, readability, intent of the statements, text font, and other general formatting issues.

Instrument reliability can be a concern in survey research (Salkind, 2017). To address this concern, a Cronbach's alpha reliability test was used on each subsection of the instrument. The results of the Cronbach alpha analysis ranged from .859 to .945 in the pilot study. According to Ary et al. (2010), a reliability coefficient greater than .80 is considered an acceptable level of reliability. All sections of the instrument met this Cronbach's alpha threshold, suggesting there were no reliability issues.

Data Collection

A list of CTE administrators was collected using resources from the Alabama Department of Education, Georgia Department of Education, school system websites, and the Association for Career and Technical Administrators (ACTA) mailing list. In events where the CTE administrators' email could not be found, the researchers called seven school districts to inquire who manages CTE for that respective district. A spreadsheet of current CTE administrators from Alabama and Georgia was compiled, including the name of the administrator, the school system in which they are employed, and their email address. All CTE administrators were contacted through their employer's email address. This led to 137 emails being sent to Alabama CTE administrators and 178 emails being sent to Georgia CTE administrators for a total of (N = 315) email recipients.

A census of CTE administrators in each state was used to collect data. This method was implemented to alleviate any sampling bias (Bluman, 2004). To implement the census, every CTE administrator in each state was emailed the instrument and invited to participate in the study. On the completion of the instrument, a threshold of 100% was set and no partial responses were included in the analysis. According to Ramsey and Schafer (2012), a total of 30 responses are necessary for quality descriptive research. This study achieved a response rate of 41% (n = 129) overall.

In survey research, non-response bias is a concern. All CTE administrators in this study were emailed individually with an introduction letter in the email and a hyperlink to the instrument in Qualtrics. After the initial email was sent, a total of three reminders were sent in two to three-day intervals to stimulate responses (Dillman et al., 2014). A t-test was utilized to assess non-response bias by evaluating statistical differences between early respondents and late respondents (Lindner et al., 2001). To evaluate this, responses stimulated from the first email were considered early respondents, and responses stimulated from the three reminder emails were considered late respondents. Due to excluding CTE administrators who did not offer agricultural education in their district from rating the assessed AFNR standards, the analysis only included n = 102 responses with n = 47 viable responses being considered early respondents and n = 55 viable responses being considered late respondents. The construct scores for the eight AFNR pathways were used as the variables for the analysis. The Agribusiness Pathway $t(100)$ = 1.22, p = .23, Animal Science Pathway $t(100)$ = .79, p = .44, Biotechnology Pathway $t(100)$ = .59, p = .56, Environmental Services Pathway $t(100)$ = .68, p = .50, Food Products and Processing Pathway $t(100)$ = .07, p = .95, Natural Resources Pathway $t(100)$ = .07, p = .95, Plant Systems Pathway $t(100)$ = .48, p = .62, and the Power Structural and Technical Systems Pathway $t(100)$ = 2.04, p = .06 showed no statistical differences between early and late respondents, suggesting there were no issues with non-response bias (Table 1).

Table 1

Non-Response Bias t-test Results

AFNR Pathway	*t*	*p*
Agribusiness Pathway	1.22	.23
Animal Science Pathway	.79	.44
Biotechnology Pathway	.59	.56
Environmental Services Pathway	.68	.50
Food Products and Processing Pathway	.07	.95
Natural Resources Pathway	.72	.48
Plant Systems Pathway	.48	.62
Power Structural and Technical Systems	2.04	.06

Note. $\alpha = .05$ and $df = 100$

Analysis of the Data

To analyze research objective one, frequencies and percentages were used to describe the findings. Individual item responses were summarized descriptively by reporting the frequency and percentage of respondents rating each standard as one of the descriptors in the Likert scale. To compare states and pathways in objective two, AFNR pathway construct scores, obtained by averaging numeric values for items within the construct, were analyzed using a mixed model with fixed effects for state, pathway, and their interaction. These statistical tests allowed the researchers to assess the attitudes and beliefs of the CTE administrators (Ajzen, 1991). Because respondents provided scores for each pathway, researchers expected the pathway scores for respondents to be correlated. To account for these correlations and possible non-constant variance among pathways or between states, separate unstructured covariance matrices were fit for the two states. The Kenward-Roger method was used to compute denominator degrees of freedom. *Post hoc* means separation corresponding to significant effects was conducted using Tukey's multiple comparison method to control the experiment-wise error rates. Effect sizes were computed using Cohen's *d* (Cohen, 1988) for CTE administrators' perceptions of the integration of STEM-based AFNR standards. Pathway effect sizes were computed utilizing Dankel and Loenneke's (2021) recommendation to use the standard deviation of a change score in computing effect sizes for paired data; pairwise pathway effect sizes were computed using the mixed model estimate of the difference between two pathways divided by a model-based difference standard deviation estimate pooled across states.

Demographics of the Participants

Demographic information from CTE administrators in Alabama, Georgia, and the demographic totals are listed in Table 2. The average participating CTE administrator was a white female with a Specialist or Doctoral degree that had no background in CTE. In addition, the average participating CTE administrator had 13.05 years of teaching experience, 23.25 years of experience in education, worked in a school district that offered agricultural education courses, had 5,000 students or less in their school district, and their duties were majority CTE related.

Table 2

Personal Demographics of Participating CTE Administrators in Alabama and Georgia

		Alabama		Georgia		Total	
		f	%	*f*	%	*f*	%
Gender	Female	23	43.4	51	67.1	74	57.4
	Male	30	56.6	25	32.9	55	42.6
Ethnicity	White	44	83.0	63	82.9	107	82.9
	African American	8	15.1	13	17.1	21	16.3
	American/Alaskan Native	1	1.9	0	0.0	1	0.8
Highest Degree Earned	Bachelors	0	0.0	2	2.6	2	1.6
	Masters	15	28.3	10	13.2	25	19.4
	Specialist	21	39.6	42	55.3	63	48.8
	Doctoral	17	32.1	22	28.9	39	30.2
CTE Background	Agricultural Education	11	20.7	5	6.6	16	12.4
	Business Education	10	18.9	27	35.5	37	28.7
	Other Areas of CTE	1	1.9	10	5.3	11	8.6
	No Background in CTE	31	58.5	34	44.7	65	50.3
Years as a Teacher	0-5 Years	7	13.2	10	13.1	17	13.2
	6-10 Years	16	30.2	13	17.1	29	22.5
	11-15 Years	23	43.4	23	30.3	46	35.6
	16-25 Years	7	13.2	21	27.7	28	21.7
	25+ Years	0	0.0	9	11.8	9	7.0
School System Type	City School Systems	25	47.2	13	17.1	38	29.5
	County School System	28	52.8	63	82.9	91	70.5
Years in Education	0-5 Years	7	13.2	0	0.0	7	5.4
	6-10 Years	16	30.2	3	3.9	19	14.7
	11-15 Years	23	43.4	7	9.2	30	23.3
	16-20 Years	4	7.5	13	17.1	17	13.2
	21-25 Years	3	5.7	19	25.0	22	17.0
	25+ Years	0	0.0	34	44.8	34	26.4
Duty Allocation	Majority of Duties in CTE	36	67.9	56	73.7	92	71.3
	Majority Duties Not in CTE	17	32.1	20	26.3	37	28.7
School System Size	0-1,000 Students P-12	5	9.4	10	13.2	15	11.6
	1,000-3,000 Students P-12	16	30.2	25	32.9	41	31.8
	3,000-5,000 Students P-12	16	30.2	15	19.7	31	24.0
	5,000-9,000 Students P-12	8	15.1	9	11.9	17	13.2
	9,000-15,000 Students P-12	6	11.3	9	11.9	15	11.6
	15,000+ Students P-12	2	3.8	8	10.4	10	7.8
Agricultural Education	Offered	38	71.7	64	84.2	102	79.1
	Not Offered	15	28.3	12	15.8	27	20.9

Note. The demographics of all CTE administrators are included in the table, including administrators who did not offer agricultural education in their district. Alabama (n = 53), Georgia (n = 76), and Total (n = 129).

Research Objective One

Overall, the percentage of respondents rating each item as *Very Important* or *Extremely Important* ranged from 53.9% to 86.3% (Table 3).

Table 3

CTE Administrator Rating Distributions of AFNR STEM-Based Standards

AFNR Standards	*Not Important at All*	*Somewhat Important*	*Moderately Important*	*Very Important*	*Extremely Important*
Agribusiness Pathway					
Apply… economic principles…manage inputs and outputs...	2(2.0)	4(3.9)	24(23.5)	52(51.0)	20(19.6)
Apply accounting principles…track and audit AFNR transactions.	2(2.0)	7(6.9)	20(19.6)	49(48.0)	24(23.5)
Assemble, interpret, and analyze financial information…	2(2.0)	6(5.9)	24(23.5)	47(46.1)	23(22.5)
Develop… cash budgets to achieve AFNR business goals.	2(2.0)	6(5.9)	19(18.6)	52(51.0)	23(22.5)
Analyze…and manage credit budgets to achieve…business goals.	2(2.0)	5(5.0)	23(22.5)	49(48.0)	23(22.5)
Animal Science Pathway					
Assess and select animal production methods for… animal systems.	0(0.0)	1(1.0)	22(21.6)	49(48.0)	30(29.4)
Analyze and apply laws… to animal agriculture.	0(0.0)	4(3.9)	21(20.6)	50(49.0)	27(26.5)
Demonstrate management techniques that ensure animal welfare.	0(0.0)	0(0.0)	19(18.6)	47(46.1)	36(35.3)
Analyze… to ensure that animal products are safe for consumption	0(0.0)	2(2.0)	15(14.7)	42(41.2)	43(42.1)
Apply scientific principles to select and care for breeding animals.	0(0.0)	2(2.0)	19(18.6)	53(52.0)	28(27.4)
Design animal housing, equipment, and handling facilities…	0(0.0)	4(3.9)	23(22.5)	50(49.1)	25(24.5)
Apply principles of comparative anatomy and physiology…	1(1.0)	2(2.0)	24(23.5)	49(48.0)	26(25.5)
Select and train animals for specific purposes…	1(1.0)	7(6.9)	30(29.4)	45(44.1)	19(18.6)
Design programs to prevent animal diseases, parasites, etc.	1(1.0)	2(2.0)	21(20.6)	46(45.1)	32(31.3)
Design… methods to reduce the effects of animal production…	1(1.0)	2(2.0)	26(25.5)	50(49.0)	23(22.5)
Evaluate the effects of environmental conditions on animals…	1(1.0)	2(2.0)	20(19.5)	52(51.0)	27(26.5)
Biotechnology Pathway					
Apply…procedures for the safe handling…materials in a laboratory.	1(1.0)	4(3.9)	9(8.8)	43(42.2)	45(44.1)
Examine and perform scientific procedures using… in a laboratory.	2(2.0)	11(10.8)	26(25.5)	40(39.2)	23(22.5)
Apply biotechnology… to create… through gene engineering.	3(2.9)	13(12.7)	27(26.5)	39(38.3)	20(19.6)
Apply biotechnology… to enhance plant and animal care… production.	2(2.0)	9(8.8)	27(26.5)	44(43.1)	20(19.6)

AFNR Standards	*Not Important at All*	*Somewhat Important*	*Moderately Important*	*Very Important*	*Extremely Important*
Environmental Services Pathway					
Analyze laboratory and field samples…	2(2.0)	8(7.8)	15(14.7)	52(51.0)	25(24.5)
Interpret the impact of laws, agencies, policies, and practices…	2(2.0)	6(5.9)	20(19.6)	46(45.1)	28(27.4)
Apply meteorology principles to environmental service systems.	3(2.9)	8(7.8)	26(25.5)	47(46.1)	18(17.7)
Apply soil science and hydrology principles…	2(2.0)	4(3.9)	20(19.6)	46(45.1)	30(29.4)
Apply chemistry principles to environmental service systems.	2(2.0)	5(4.9)	23(22.5)	46(45.1)	26(25.5)
Apply microbiology principles…	2(2.0)	5(4.9)	21(20.6)	50(49.0)	24(23.5)
Apply ecology principles to environmental service systems.	2(2.0)	6(5.9)	18(17.6)	53(52.0)	23(22.5)
Use pollution control measures to maintain a safe facility…	2(2.0)	5(4.9)	15(14.7)	56(54.9)	24(23.5)
Manage safe disposal of all categories of solid waste…	1(1.0)	5(4.9)	13(12.7)	50(49.0)	33(32.4)
…ensure a safe supply of drinking water and… wastewater…	1(1.0)	4(3.9)	10(9.8)	49(48.0)	38(37.3)
Compare and contrast the impact of… energy sources….	2(2.0)	6(5.9)	19(18.6)	51(50.0)	24(23.5)
Use… tools to map land, facilities, and infrastructure….	1(1.0)	4(3.9)	20(19.6)	55(53.9)	22(21.6)
Perform assessments of environmental conditions…	1(1.0)	4(3.9)	20(19.6)	53(52.0)	24(23.5)
Food Products and Processing Pathway					
Implement…techniques to ensure safe and quality food products.	1(1.0)	4(3.9)	12(11.8)	42(41.2)	43(42.1)
Create food distribution plans to ensure safe delivery of food…	1(1.0)	4(3.9)	20(19.6)	47(46.1)	30(29.4)
Examine the scope of the food industry…	1(1.0)	5(4.9)	21(20.6)	49(48.0)	26(25.5)
Evaluate…changes and trends in the… industry…	1(1.0)	5(4.9)	20(19.6)	50(49.0)	26(25.5)
Identify… industry organizations and regulatory agencies…	1(1.0)	5(4.9)	24(23.5)	44(43.1)	28(27.5)
Natural Resources Pathway					
Apply methods of classification to examine… function in a... region	1(1.0)	4(3.9)	26(25.5)	48(47.1)	23(22.5)
Classify…natural resources…to enable protection, conservation…	1(1.0)	3(2.9)	21(20.6)	51(50.0)	26(25.5)
Apply…concepts and principles to atmospheric natural resource…	2(2.0)	4(3.9)	28(27.4)	46(45.1)	22(21.6)
Apply… concepts and principles to aquatic natural resource…	2(2.0)	4(3.9)	27(26.5)	46(45.1)	23(22.5)
Apply… concepts and principles to terrestrial natural resource...	2(2.0)	4(3.9)	27(26.5)	44(43.1)	25(24.5)
Apply… concepts and principles to living organisms in natural...	1(1.0)	4(3.9)	27(26.5)	44(43.1)	26(25.5)
Examine…laws and agencies related to natural resource…	1(1.0)	3(2.9)	27(26.5)	43(42.1)	28(27.5)
Assess the impact of human activities on… natural resources.	1(1.0)	3(2.9)	16(15.7)	52(51.0)	30(29.4)

AFNR Standards	*Not Important at All*	*Somewhat Important*	*Moderately Important*	*Very Important*	*Extremely Important*
Natural Resources Pathway					
Examine…how economics affects the use of natural resources.	1(1.0)	5(4.9)	21(20.6)	51(50.0)	24(23.5)
Communicate information…related to…natural resources.	1(1.0)	4(3.9)	26(25.5)	48(47.1)	23(22.5)
Sustainably produce, harvest…and use natural resource products.	1(1.0)	3(2.9)	20(19.6)	51(50.0)	27(26.5)
Demonstrate natural resource…techniques.	1(1.0)	4(3.9)	17(16.6)	53(52.0)	27(26.5)
Plant Systems Pathway					
Diagnose plant and wildlife diseases… and prevent their spread.	1(1.0)	4(3.9)	18(17.6)	55(54.0)	24(23.5)
Develop and implement a fertilization plan for specific plants/crops.	0(0.0)	4(3.9)	15(14.7)	52(51.0)	31(30.4)
Apply knowledge of plant anatomy…to activities… plant systems.	0(0.0)	3(2.9)	14(13.7)	52(51.0)	33(32.4)
Apply knowledge of plant physiology and energy conversion… systems.	0(0.0)	3(2.9)	19(18.6)	51(50.0)	29(28.5)
Apply principles and practices of sustainable agriculture… production.	0(0.0)	4(3.9)	13(12.7)	53(52.0)	32(31.4)
Create designs using plants.	2(2.0)	6(5.9)	39(38.2)	37(36.3)	18(17.6)
Power, Structural, and Technical Systems Pathway					
Apply…engineering principles to…energy sources…	2(2.0)	7(6.9)	24(23.5)	46(45.1)	23(22.5)
Apply… engineering principles to…mechanical systems…	1(1.0)	7(6.9)	29(28.4)	42(41.2)	23(22.5)
Apply electrical wiring principles in AFNR structures.	1(1.0)	9(8.8)	31(30.4)	40(39.2)	21(20.6)
Apply computer and other technologies to solve problems…	1(1.0)	5(5.9)	29(28.4)	45(44.1)	21(20.6)
Apply geospatial technologies to solve problems…	1(1.0)	7(6.9)	37(36.3)	38(37.3)	19(18.5)

Note. Standards have been abbreviated from their original form. The frequencies and percentages in the table are presented as *f*(%).

The only standard within the highly rated Animal Science pathway with fewer than 70% *Very Important* or *Extremely Important* ratings was "Select and train animals for specific purposes…". For the lower-rated Power Systems pathway, all items had fewer than 70% *Extremely* or *Very Important* ratings. For the Biotechnology pathway, three out of four standards had fewer than 63% *Extremely* or *Very Important* ratings. While Plant Systems was a highly rated pathway, "Create designs using plants." had only 53.9% *Extremely* or *Very Important* ratings.

Research Objective Two

Overall, pathways differed $F(7, 68.4) = 4.24$, $p < .001$, but the state main and pathway x state interaction effects were not significant $F(1, 88.1) = 1.33$, $p = 0.25$; and $F(7, 68.4) = 0.54$, $p = 0.80$, respectively ($\alpha = .05$). While Georgia estimates were consistently numerically higher than Alabama estimates, the effect sizes for individual pathways were relatively small (Cohen, 1988) with magnitudes between 0.09 and 0.29 (Table 4). Animal Science, Food Products and Processing, and the Plant Systems pathways were rated higher than the Biotechnology and Power, Structural, and Technical Systems pathways (Table 4).

Table 4

Descriptive Statistics and Cohen's d for State Effects and Model-Based Estimates and Standard Errors for the Pathway Main Effect.

	Alabama		Georgia		Pathway Main Effect		
Pathway	*M*	*SD*	*M*	*SD*	Cohen's *d*	Estimate	SE
Agribusiness	3.78	0.74	3.87	0.91	.11	3.83	.08
Animal Science	3.92	0.69	4.06	0.67	.21	3.99	.07
Biotechnology	3.65	0.79	3.90	0.89	.29	3.77	.08
Environmental Services	3.79	0.76	3.99	0.83	.24	3.89	.08
Food Products and Processing	3.95	0.69	4.02	0.86	.09	3.98	.08
Natural Resource Systems	3.80	0.70	3.98	0.81	.24	3.89	.08
Plant Systems	3.91	0.73	4.05	0.66	.21	3.98	.07
Power Structural and Technical	3.62	0.82	3.81	0.86	.22	3.72	.09

Note. 1 = *Not Important at All*, 2 = *Somewhat Important*, 3 = *Moderately Important*, 4 = *Very Important*, and 5 = *Extremely Important.* Cohen's *d* is interpreted as a small effect = .20, medium effect = 0.50, and a large effect = .80. Alabama ($n = 38$), Georgia ($n = 64$), Total ($n = 102$).

Estimated ratings for these three pathways roughly corresponded to the *Very Important* rating category. Even the Biotechnology ($M = 3.77$, $SD = 0.85$) and Power, Structural, and Technical Systems ($M = 3.72$, $SD = 0.84$) estimates corresponded to an average rating between *Moderately Important* and *Very Important*. Effect sizes for pathway differences had magnitudes that ranged from 0.01 to 0.43, with 11 of the 28 effect sizes being small or very small with magnitudes of 0.2 or lower (Cohen, 1988). Larger magnitude effect sizes included those for the Animal Science – Biotechnology (0.38), Animal Science – Power Systems (0.41), Biotechnology – Food Products and Processing (−0.43), Food Products and Processing – Power Systems (0.40), and Plant Systems – Power Systems (0.42) (Table 5) and fell short of the 0.50 threshold corresponding to a medium-sized effect.

Table 5

Pathway Effect Sizes for Path 1 – Path 2 Differences

	Pathway 2						
Pathway 1	*Animal Science*	*Biotechnology*	*Environmental Services*	*Food Products and Processing*	*Natural Resources*	*Plant Systems*	*Power Systems*
Agribusiness	0.25	0.07	-0.10	-0.25	-0.11	-0.21	0.16
Animal Science	-	0.38	0.20	0.01	0.23	0.02	0.41
Biotechnology	-	-	-0.27	-0.43	-0.25	-0.33	0.08
Environmental Services	-	-	-	-0.22	0.01	-0.16	0.28
Food Products and Processing	-	-	-	-	0.26	0.01	0.40
Natural Resources	-	-	-	-	-	-0.21	0.31
Plant Systems	-	-	-	-	-	-	0.42

Note. Effect size computed as mixed model pathway difference estimate divided by pooled difference standard deviation. Brown-Forsythe test did not detect different state variances for different variables. Cohen's *d* is interpreted as a small effect = .20, medium effect = 0.50, and a large effect = .80.

Discussions and Conclusions

This study aimed to ascertain the perceptions of Alabama and Georgia CTE administrators with agricultural education programs in their district on the importance of STEM integration into agricultural education. The demographics section of the instrument aimed to describe the characteristics of the participants. Noteworthy demographics were that the average CTE administrator was a white female with an educational specialist or doctoral degree and no teaching background in CTE. In addition, the average CTE administrator was employed in a county school system with less than 5,000 students that offered agricultural education and CTE encompassed the majority of their duties. Furthermore, the average CTE administrator had 13.05 years of teaching experience and 23.25 years of total experience in education. The fact that 50.8% of CTE administrators did not teach in the CTE classroom is concerning, considering the key role the CTE administrator plays in the quality of CTE programs offered under their guidance. Manley (2012) states

> There are plenty of examples of CTE administrators who taught history, science, math, or English prior to assuming their role as a CTE administrator. While these individuals may understand school policy, procedures, and politics, they may not fully understand the policy, procedures, and politics associated with maintaining and updating a CTE program or center (p. 19).

Overall, 34 states did not require a certification specific to CTE administration and do not require CTE experience to supervise secondary CTE programs (Zirkle & Jeffery, 2017). Due to the CTE administrator's pivotal role in program management, this lack of experience in CTE's leadership could stunt its effectiveness (Zirkle & Jeffery, 2017) and affect their perceptions of the integration of STEM into CTE. In this study, most of the administrators with a CTE background had experience in Business/Marketing Education and Agricultural Education.

The first research objective aimed to ascertain how CTE administrators valued the assessed STEM standards. More than half of CTE administrators ranked each AFNR STEM standard as *Very Important* or *Extremely Important*. The fact that most CTE administrators rated AFNR STEM standards as *Very Important* or higher illustrates the significance of STEM integration into agricultural education. If agricultural education is going to meet its longstanding goal of preparing students for the workforce and close the skills gap between secondary education students and industry needs, it is imperative that students possess STEM skills (Kelly & Knowles, 2016; Scherer et al., 2019; Swafford, 2018a). This finding provides further evidence that prioritizing STEM integration is necessary for agricultural education to continue to impact students and close the skills gap. Furthermore, the inclusion of STEM in the American Association for Agricultural Education (AAAE) research agenda further proves the necessity of STEM integration into SBAE (Stripling & Ricketts, 2016). The positive perception that CTE administrators hold on STEM integration into SBAE complements the previous findings from other studies (Conner et al., 2017; Stubbs & Myers, 2016; Swafford, 2018b).

Research objective two aimed to determine perceptions between selected state CTE administrators. Analysis of AFNR pathway scores did not find overall state main or state by pathway interaction effects, but there were differences among pathways. The Animal Science Pathway, the Food Products and Processing Pathway, and the Plant Systems Pathway were the three highest-rated AFNR pathways with nearly identical means; the Biotechnology Pathway and Power Structural and Technical Systems Pathway were the lowest-rated AFNR pathways. The Environmental Science Pathway, the Natural Resource Systems Pathway, the Agribusiness Pathway, and the Biotechnology Pathway were intermediate and did not differ significantly from any other pathway. With only 11.6% of assessed CTE administrators having taught SBAE, differences in perception may be the result of some administrator's lack of knowledge of agricultural education, causing them not to appreciate the importance of STEM skills within some pathways, or it may be some pathways have better alignment with STEM principles than others. In addition, CTE administrators often have a role in allocating state and federal funds, determining specific duties of the agricultural educator, and curriculum development/course selection (Manley, 2012; Zirkle & Jeffery, 2017). This pivotal role could cause even a small difference in their regard to the importance of STEM integration for different pathways to impact programs in lower-ranked pathways. In some specific situations, agricultural educators may need to advocate to their CTE administrator for the importance of their program's pathway to ensure adequate resources.

Results from this study coincide with the Theory of Planned Behavior that was used to guide this research (Ajzen, 1991). In this study, the "subjective norms" (Ajzen, 1991, p. 179) influencing CTE administrators can be attributed to the educational system's emphasis on STEM integration (Chumbley et al., 2015; Smith et al., 2015; Wang & Knoblach, 2020), research indicating inconsistent academic achievement in math and science (Chiasson & Burnett, 2001; Clark et al., 2013; McKim et al., 2018; Nolin & Parr, 2013; Plank, 2001; Theriot & Kotrlik, 2009), and industry reports of students' lack of preparedness in these subjects when entering the workforce (Kelly & Knowles, 2016; Scherer et al., 2019; Swafford, 2018a). CTE administrators/ comprehension of STEM integration and agricultural education signifies the "perceived behavioral control" (Ajzen, 1991, p. 179). This study aimed to assess the CTE administrator's "attitudes toward the behavior" (Ajzen, 1991, p. 179). This study found that CTE administrators positively perceive STEM integration into agricultural education. This positive outlook on STEM integration could assist in influencing CTE administrators' behavior toward agricultural education in a favorable manner.
Since the inception of agricultural education, providing a prepared workforce has been a pillar of its purpose (Symonds et al., 2011). In light of this longstanding purpose, many employers claim that education has not sufficiently instilled secondary students with STEM skills (McGunagle & Zizka, 2020). This issue is troubling for all educators, particularly CTE educators, because they have been tasked with ensuring that secondary students graduate with the necessary skills to enter the workforce successfully (McKim et al., 2018; Sharma, 2009). The positive perception of CTE administrators with agricultural education in their district on STEM integration into agricultural education is beneficial, considering the importance of STEM

in providing a prepared workforce. However, it is unclear whether employers' views of students' STEM skill deficiencies are associated with their pathways. This study found some differences in the importance CTE administrators ascribed to STEM skill standards for different pathways. In addition, this study also did not assess whether CTE administrator's perceived importance of STEM for the various pathways effects resource allocation or curriculum prioritization for the different pathways. Due to mixed results as to STEM achievement of SBAE students (Chiasson & Burnett, 2001; Clark et al., 2013; McKim et al., 2018; Theriot & Kotrlik, 2009) and gaps in understanding provided by existing research, it is important to continue this line of inquiry to provide a workforce meeting today's societal need.

Recommendations for Future Practice

Based on the perceptions of their CTE administrators, agricultural educators should focus their STEM integration efforts on all AFNR pathways to ensure student success in a STEM-integrated workforce to encourage a more favorable view in relation to previous findings (McKim et al., 2018; Wang & Knoblach, 2020). This positive perception of STEM integration into agricultural education held by CTE administrators with agricultural education in their district is consistent with data found in other research examining agricultural educators' perception of STEM integration (Stubbs & Myers, 2016). This congruency between agricultural educators and CTE administrators will help bolster the quality of STEM integration and, ultimately, the success of secondary graduates.

Furthermore, the finding that 50.3% of CTE administrators did not have a background in CTE is concerning. In most states, a certificate or degree in Educational Leadership/Administration is required to hold the position of CTE administrator. In most cases, experience in the CTE classroom is not a requirement (Zirkle & Jeffery, 2017). A recommendation for school systems would be to require CTE experience to hold the position of CTE administrator, especially in instances where the position requires a majority of CTE duties, which occurred 71.3% of the time.

Recommendations for Future Research

For future research inquiries, the following areas should be evaluated: 1) examining the perceptions of CTE administrators in other areas of the U.S. on the importance of STEM skills, 2) examining the perceptions of administrators in other areas besides CTE and SBAE (superintendents, principals, etc.) on STEM skills, 3) assessing the professional development needs of agricultural teachers to implement STEM integration into their classrooms, and 4) exploring differences in the perceptions of employers in each AFNR pathway on the necessity of STEM skills in employees.

Education in STEM areas is a need that has been acknowledged for decades in many venues. Since the launch of Sputnik in 1957, educators in the United States have been focused on engaging and educating youth in STEM-related areas to ensure future professionals are highly prepared (Edgar, 2012). Understanding the perceptions of administrators will help shape CTE programs as the educational system evolves.

Limitations

The findings of this study should not be generalized beyond the participating CTE Administrators in Alabama and Georgia because of the limited response rate (41%). An additional limitation of this study is the instrument. While the instrument was robust, it is unlikely that it evaluated every possible STEM concept that is important to integrate into agricultural education.

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