Journal of Agricultural Education, 59(4), 315-333
https://doi.org/10.5032/jae.2018.04315

The State of the Profession: STEM in Agricultural Education

Marshall Swafford[1]

Abstract

Recently, the agricultural education profession has advocated its relationship with STEM education. Agricultural education has been identified as an effective context to support the components of STEM through analysis of data from student and teacher attitudes and results of experiments and quasi-experiments. However little attention has been paid to the attitudes and behaviors of agricultural education faculty. Therefore, the purpose of this research study was to describe the attitudes and self-identified STEM supportive behaviors of agricultural education faculty (n = 112). Generally, agricultural education faculty held positive attitudes toward STEM in agricultural education programs. However, differences existed between land-grant and non-land-grant faculty as well as faculty holding STEM appointments and those without. Agricultural education faculty engaged in teaching and programming behaviors which support STEM in agricultural education but, differences between STEM-appointed faculty and non-STEM appointed faculty were found. Recommendations were made to encourage teacher educators to facilitate partnerships with faculty at other institutions to maximize the impact of the profession on student learning in STEM and agricultural education. Future research should be conducted to identify promising practices which engage non-STEM appointed faculty in STEM supportive behaviors and research.

Keywords: agricultural education, STEM education, teacher education

Introduction and Theoretical Framework

Before Dr. Judith Ramaley introduced *STEM* to the lexicon in 2002 (J. Ramaley, personal communication, July 3, 2018), its elements, science, technology, engineering, and mathematics, to varying degrees, had been integral components of school-based agricultural education (SBAE) for over 100 years (Hillison, 1996). Stimulated by the passage of the Hatch Act of 1887, the Office of the Experimental Stations made a call to transfer new knowledge created at the experiment stations to the classroom (Moore, 1988), which led to the development and use of integrated curriculum by the early 1900's (Hillison, 1996). Yet, while Hillison (1996) noted by the mid 1900's the focus of secondary agricultural education programs had transitioned from scientific agricultural data dissemination to vocational training, the scientific foundation never disappeared.

By the early 1980's, education, and by extension agricultural education, in the United States was at a crossroads. The report, *A Nation at Risk* revealed Americans performed poorly in science (National Commission on Excellence in Education, 1983). In response, the National Commission on Secondary Vocational Education encouraged schools to teach basic academic skills in vocational courses, but did not suggest the methods or models by which integration could be accomplished (National Commission on Secondary Vocational Education, 1984; Stecher et al., 1994). In 1988, the National Research Council identified integrated agricultural education as a

[1] Marshall Swafford is an Assistant Professor of Agricultural Education in the Department of Family and Consumer Sciences & Agriculture at Eastern New Mexico University, 1500 South Avenue K, Station 11, Portales, NM 88130, marshall.swafford@enmu.edu.

potential solution to address nationwide concerns over inadequate science education (Wilson & Curry, 2011) however, in the report *Understanding Agriculture: New Directions for Education*, agricultural education programs were identified as outdated and based on production agriculture (NRC, 1988). To address both issues simultaneously, the National Research Council recommended revising existing agricultural education curriculum to include the application of physical and biological science concepts (NRC, 1988).

Today, for the second time in 35 years, education finds itself at a crossroads. The United States' ability to maintain global competitiveness within STEM hinges on a fully developed economy with workers possessing STEM knowledge and skills to drive innovation and economic growth (Carnevale, Smith, & Melton, 2011; Rothwell, 2013). Yet, the number of students pursuing STEM careers still lags behind demand both in the United States and internationally (Rothwell, 2014; U. S. Department of Labor, 2009). To compound the issue, U.S. students are routinely ranked outside of the top 20 in science and math literacy (Desilver, 2017). These findings have compelled researchers and stakeholders to, once again, call upon the profession to assist the United States in meeting its scientific and professional workforce needs (Stripling & Ricketts, 2016).

Agricultural education has been identified as a means to address the national workforce needs due to its status as an effective context to facilitate science and mathematics achievement and thus, STEM education (Boone, Gartin, Boone, & Hughes, 2006; Brister & Swortzel, 2009; Clark, 2013; Conroy, Dailey, & Shelley-Tolbert, 2000; Haynes, Robinson, Edwards, & Key, 2012; Johnson, 1996; Myers & Thompson, 2006; Myers & Washburn, 2008; Parr, Edwards & Leising, 2006, 2009; Ricketts, Duncan, & Peake, 2006; Scales, Terry, & Torres, 2009; Shinn et al., 2003; Swafford, 2018; Thompson & Balschweid, 1999; 2000; Thoron & Myers; 2012a, 2012b; Warnick, Thompson, & Gummer, 2004). In addition to science and mathematics, agricultural education can be an effective context to teach technology and engineering (Stubbs & Myers, 2016; Swafford, 2018).

Components of the agricultural education model have also been identified as effective contexts to promote workforce skills. Smith and Rayfield (2016) reported when students participate in the Supervised Agricultural Experience (SAE) program within the agricultural education model, they are engaged in an environment which supports the development of skills needed for contemporary employment. Bunshaft et al. (2015) further noted the experiential nature of the SAE program inherently promotes needed workforce competencies including, personal qualities and academic and higher-order thinking skills. Participation in Career Development Events, found within the leadership component of the model, not only expose students to scenarios which support workforce employability skills but, require participants to apply STEM content knowledge (Lundry, Ramsey, Edwards, & Robinson, 2015; Stubbs & Myers, 2016; Swafford, 2018).

The evolution of STEM in agricultural education has prompted researchers to explore the attitudes and perceptions of students toward this concept. Students conveyed favorable perceptions of agriculture when it was used as a context to teach biology and reported a better understanding of biological science concepts when they were taught in a contextualized approach (Balschweid, 2002; 2003). Additionally, students indicated that mathematics taught contextualized in agriculture improved their attitudes toward learning mathematics (Conroy & Walker, 2000). Likewise, Thoron and Burleson (2014) reported findings that suggested when students are taught using inquiry-based methods, they form more favorable attitudes toward science which, as Sandoval and Harven (2011) pointed out, increases student motivation to learn the subject matter. On the other hand, Chumbley, Haynes, and Stofer (2015) noted when taught through an agricultural STEM emphasis, students primary motivation to learn science was driven by their desire to earn a high grade.

Secondary agricultural education teachers' attitudes and perceptions toward STEM have also been investigated by researchers. Teachers have conveyed confidence in their abilities to integrate science concepts in their courses (Scales, Terry, & Torres, 2009) and argued that embedding science instruction in agriculture is a more effective method to increase science test scores than standalone science courses (Myers & Dyer, 2006; Ricketts, Duncan, & Peake, 2006). Smith, Rayfield, and McKim (2015) found generally high ratings among teachers toward the importance of integrating STEM concepts in agricultural education. However, the importance varied among the components of STEM with female teachers perceiving technology to be less important than their male counterparts. Stubbs and Myers (2016) also explored the range of attitudes and perceptions among agriculture teachers toward STEM. They reported teachers viewed STEM as inseparable from the agriculture curriculum and that integration was naturally occurring. However, teachers were concerned that too much STEM integration could have a negative impact on student interest in agriculture or diminish rapport with their students (Stubbs & Myers, 2016).

Teacher perceptions and the methods they employ to teach STEM are influenced by their own educational experiences (Stubbs & Myers, 2016). In a study of the methods used to integrate STEM, Smith, Rayfield, and McKim (2015) found over 90% of agriculture teachers received formal training to teach using experiments. These same teachers also perceived experimentation as a highly effective method to integrate STEM yet, were only moderately confident in their abilities to implement it in the classroom and reported only using it 6% of the time. On the other hand, teachers were more confident using and devoted more time to lecture, but conceded it was less effective than experimentation (Smith, Rayfield, & McKim, 2015). Agriculture teachers have indicated preservice teachers should be taught how to utilize curriculum in which STEM is emphasized (Myers, Thoron, & Thompson, 2009) but, have cautioned that preparation programs must balance these concepts and pedagogical course requirements (Stubbs & Myers, 2016).

Although clear evidence exists documenting agriculture student and teacher attitudes and perceptions toward STEM education, little research has been conducted which has explored views held by agricultural education faculty. Among non-agricultural education faculty, Breiner, Harkness, Johnson, and Koehler (2012) indicated faculty attitudes and perceptions toward STEM are primarily driven by the role it played in their personal lives. These same researchers also found that despite faculty identifying their appointment as STEM-related or non-related attitudes and perceptions toward STEM were mixed. Employment responsibilities and expectations based upon university land-grant status may also influence faculty attitudes. Lane and Casey (1989) reported agriculture faculty at non-land-grant (NLG) colleges of agriculture are more likely to be employed on a 100% teaching appointment, with teaching loads reaching 18 credit hours per semester, with no release time provided to conduct research or seek external funding to support research interests. To meet research expectations, it was noted that land-grant (LG) faculty are more likely provided reduced course loads to promote research activities (Lane & Casey, 1989). Furthermore, Lane and Casey pointed out LG faculty are also eligible to pursue external funds which are unavailable to faculty at NLG institutions (e.g. Hatch Act funds). Duncan (2017) illustrated this point by noting the USDA has a yearly funding budget of approximately $850 million specifically earmarked for capacity-building at LG universities and $5 million devoted to NLG institutions. Duncan further noted, through competitive grant programs, for which both LG and NLG institutions are eligible, the USDA also budgets an additional $700 million per year but, as Lane and Casey pointed out, NLG colleges of agriculture may not have the institutional or faculty capacity to secure funding or manage large-scale projects.

The goal of this study was to explore agricultural education faculty teaching behaviors and attitudes toward STEM in agricultural education programs. The theory of planned behavior served as the theoretical foundation for this study (Ajzen, 1991). This theory is routinely used to understand human behavior and has been used within agricultural education to explore the attitudes and beliefs of students (Osborne & Dyer, 2000; Thompson Jr. & Russell, 1993), preservice teachers (Thoron & Myers, 2010), and inservice teachers (McKim, Lambert, Sorenson, & Velez, 2015).

The theory of planned behavior was selected as it "provides a useful conceptual framework for dealing with the complexities of human social behavior" (Ajzen, 1991, p. 206). Furthermore, this theory provides a means of understanding individuals' decisions to act and can allow for the development of programs to meet targeted academic needs (Murphrey, Lane, Harlin, & Cherry, 2016). Ajzen and Fishbein (2005) suggested that an individual's behavior is a result of the combination of beliefs, attitudes, and intentions. Ajzen (1991) posited intentions precede behavior and presented a model that depicts the influences on intention (Figure 1). Ajzen (2006) explained that individuals act on behavioral decisions based upon one's attitude toward the behavior (what one thinks the outcomes of the behavior will be), subjective norms (what other people think about the behavior), and perceived behavioral control (what one understands about the factors that facilitate or discourage the behavior).

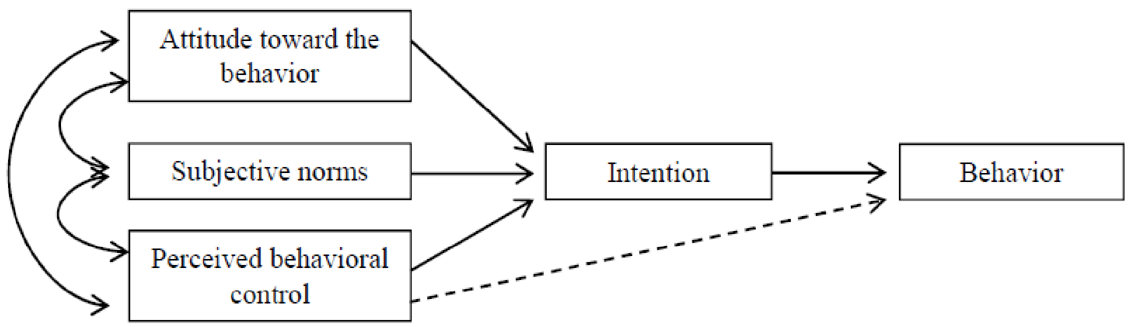

Figure 1. Theory of planned behavior (Ajzen, 1991).

Purpose and Objectives

The purpose of this research was to describe agricultural teacher education faculty attitudes toward STEM education in teacher preparation programs and their teaching behaviors which support integrated STEM teaching in secondary agricultural education programs. With the impetus of the *Standards for School-Based Agricultural Education Teacher Preparation Programs* (AAAE, 2017) to produce graduates who can highlight STEM concepts in lesson plan construction and implement experiential education and inquiry-based learning, research into teacher preparation faculty perceptions related to the implementation of these standards addresses National Research Agenda Priority Area 3: "Sufficient Scientific and Professional Workforce That Addresses the Challenges of the 21st Century" (Stripling & Roberts, 2016, p. 29). In order to accomplish the purpose of this research, four objectives were developed. These research objectives were:

1. Describe agricultural education faculty attitudes toward STEM in agricultural education programs;
2. Describe the differences in STEM attitudes of agricultural education faculty attitudes by institution type and appointment focus.
3. Describe agricultural education faculty teaching behaviors which support integrated STEM education.
4. Describe the differences in STEM teaching behaviors of agricultural education faculty by institution type and appointment focus.

Instrumentation

To fulfill the objectives of the study, a three-section online survey instrument was developed. Section one of the instrument asked teachers to report their attitudes toward STEM as it relates to agricultural education teacher preparation programs. The second section of the instrument asked teachers to identify their behaviors related to integrated STEM teaching and programming within their teacher preparation program. Data from sections 1 and 2 were captured using a Visual Analog Scale (VAS) with answer options ranging from 1-5 at .10 intervals. A VAS allows survey respondents to move a slider along a continuum to match their beliefs to a point on a scale where Likert-type scales use radio buttons (Gay, Leal, Ruth, Lamm, & Rumble, 2015). Visual Analog Scales have been used to collect attitudinal data from extension education professionals (Gay et al., 2015) and provide data that more accurately reflects the population (Malmsheimer & Germain, 2002). The third section of the instrument asked faculty to identify demographic characteristics including age, gender, years of experience as an SBAE teacher and teacher educator, rank, and teacher preparation courses taught. Faculty were also asked if their appointment included a STEM-related focus in teaching or research. Data from this question was later used to categorize faculty as either STEM or Non-STEM.

Prior to conducting the study, the instrument was examined by a panel of agricultural education faculty who were not included in the study for face and content validity. To ensure reliability, the instrument was piloted to 16 agricultural education faculty. Section 1 was developed by the researcher and consisted of six items in VAS form. Scores from the pilot responses were consolidated into the following response continuum: 1.00 – 1.49 (Strongly Disagree), 1.50 – 2.49 (Disagree), 2.50 – 3.49 (Neutral), 3.50 – 4.49 (Agree), and 4.50 – 5.00 (Strongly Agree). Reliability was for this scale was established at $\alpha = 0.80$. Section 2 consisted of eight items and was developed by the researcher and based upon the *Principal Leadership for STEM (P-STEM) Survey* (Friday Institute for Educational Innovation, 2014). The eight items included two constructs, STEM teaching (three items) and STEM programming (five items). Pilot responses yielded construct reliability coefficients of $\alpha = .91$ for items related to STEM teaching and $\alpha = .90$ for items related to STEM programming. Post-hoc reliability for all sections was calculated at $\alpha = .81$ for section 1, $\alpha = .91$ for STEM teaching, and $\alpha = .91$ for STEM programming. Nunnally (1978) reported a Cronbach's α of .70 or greater is adequate in the initial stages of instrument development. Therefore, the instrument was deemed to have appropriate levels of reliability to meet the objectives of this study.

Methods

The objectives of this study were accomplished through descriptive survey methods. Agricultural education teacher preparation faculty (N = 176) throughout the United States served as the population and were identified through a search of all institutions reported to house agricultural teacher education programs (Swortzel, 2016). From the population, 112 useable responses were collected, for a 63.3% response rate (45.2% Non-Land-Grant; 81.4% Land-Grant). Following procedures outlined by Dillman, Smyth, and Christian (2009), respondents were contacted through a pre-survey notification, followed by an email including a unique link to the online survey. Three follow-up letters were sent by email. Non-response error was controlled by comparing early and late responders (Lindner, Murphy, & Briers, 2001). No significant differences were found between those who completed the survey prior to the first reminder ($n = 66$), and those completing the survey following the reminder email ($n = 46$). Data were analyzed using *SPSS v. 25*, and was described using percentages, means, medians, modes, and standard deviations. Differences were assessed using independent samples t-tests with an alpha level of .05 set *a priori* to determine statistical significance. Additionally, Cohen's d statistic was calculated to determine the practical significance of the independent samples *t*-tests and was interpreted as *small* (0.20), *medium* (0.50), and *large* (0.80) effects (Kotrlik, Williams, & Jabor, 2011).

Subject Demographics

The makeup of the respondents was 73.2 % male ($n = 82$), and 22.3% female ($n = 25$) (five respondents chose not to respond) with a mean age of 45 years ($SD = 11.25$). The typical faculty taught 2.9 (SD = 1.65) teacher preparation courses per year, had been a teacher educator for 11.8 years ($SD = 9.52$) and taught SBAE for 6.8 years ($SD = 5.31$) prior to their current role. Thirty-six (32.1%) identified their faculty rank as professor, 30 (26.8%) as associate professor, 31 (27.7%) as assistant professor, and 13 (11.6%) as instructor/lecturer. Additionally, 45 (40.2%) reported being employed on a STEM appointment and 54 (48.2%) indicated they had published or presented STEM-related research.

Findings

Objective 1 sought to determine the attitudes of agricultural education faculty toward STEM in agricultural education programs. Results (Table 1) indicated over 90% of agricultural education faculty agreed or strongly agreed that undergraduates should be provided instruction on how to implement experiential teaching (94.6%) and highlight STEM concepts in course curriculum (95.6%). However, attitudes toward increasing STEM-based course requirements were mixed with only 55.4% of faculty agreeing or strongly agreeing.

Table 1

Agricultural Education Faculty Attitudes toward STEM (n = 112)

Contemporary school-based agricultural education teacher preparation programs should…	SD	D	N	A	SA
	%	%	%	%	%
Provide instruction for undergraduates on how to implement experiential teaching techniques.	0.0	0.9	4.5	12.5	82.1
Provide instruction for undergraduates on how to highlight STEM concepts in course curriculum.	0.0	0.9	3.6	42.9	52.7
Illustrate the relationship between STEM and the 3-cirlce model of agricultural education	0.0	3.6	11.6	42.9	42.0
Place less emphasis on STEM education in agricultural education.[a]	0.0	2.7	11.6	47.3	38.4
Place student teachers with cooperating teachers who highlight STEM during instruction.	0.0	2.7	17.0	54.5	25.9
Increase STEM-based course requirements for undergraduates.	2.7	6.3	35.7	42.0	13.4

Note. [a] reverse scored. Mean = 4.17; SD = 0.50

Objective 2 was to describe the differences of agricultural education faculty toward STEM by institution type and appointment focus. Institutions were categorized by Land-Grant (LG) or Non-Land-Grant (NLG) and appointments were categorized as STEM-focused (STEM) and Non-STEM (NSTEM). Figure 2 illustrates the attitudes of LG and NLG faculty toward STEM in teacher preparation programs. Results of an independent samples *t*-test (Table 2) revealed a statistically significant difference (p = .001; d = 0.10) in the overall mean attitude score between the two groups.

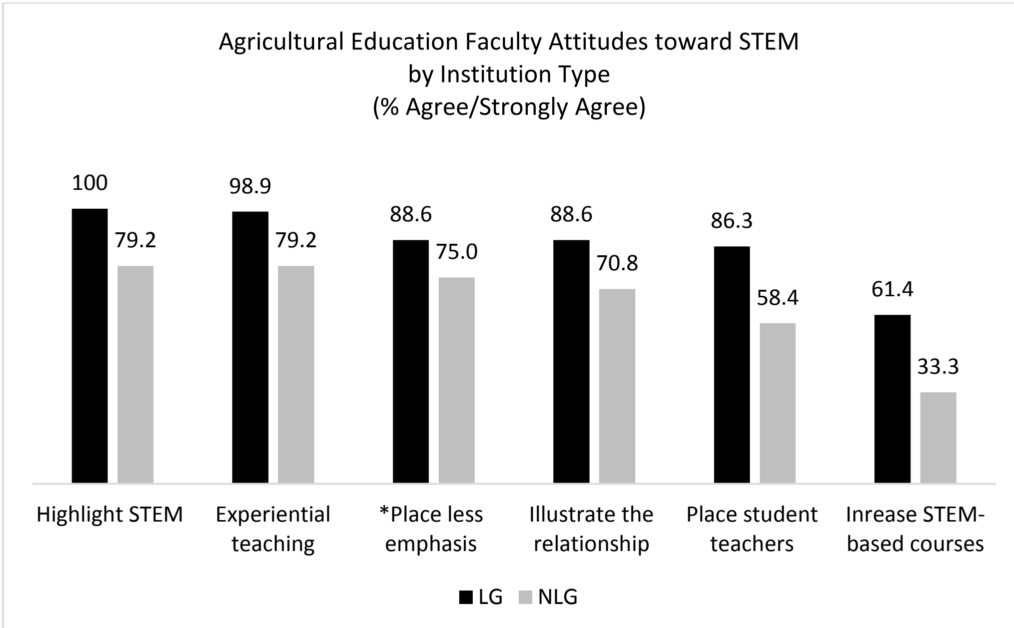

Figure 2. * = reverse scored. LG, *n*=88; NLG, *n*=24

Table 2

Agricultural Education Faculty Mean Attitude Scores toward STEM by Institution Type (LG, n=88; NLG, n=24)

Institution	*M*	*SD*	*t*	*p*	*Cohen's d*
LG	4.25	0.48	3.46	0.001	0.10
NLG	3.87	0.43			

Figure 3, illustrates the attitudes of STEM and NSTEM faculty toward STEM in teacher preparation programs. Results of an independent samples *t*-test (Table 3) revealed a statistically significant difference (p = .001; d = 0.12) in the overall mean attitude score between the two groups.

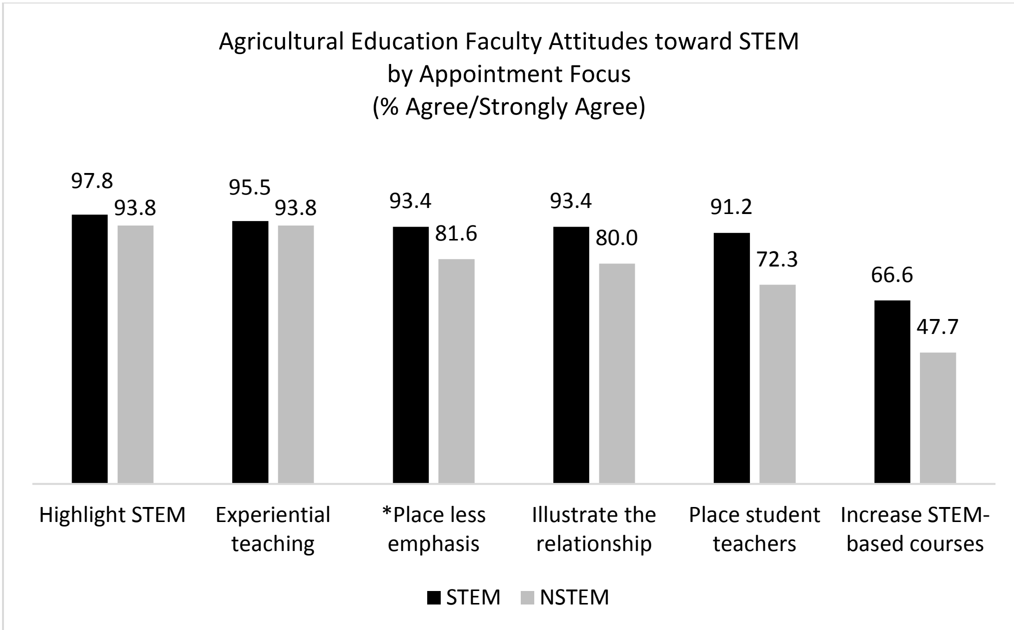

Figure 3. * = reverse scored. STEM, *n*=45; NSTEM, *n*=67

Table 3

Agricultural Education Faculty Mean Attitude Scores toward STEM by Appointment Focus (STEM, n=45; NSTEM, n=67)

Appointment	*M*	*SD*	*t*	*p*	*Cohen's d*
STEM	4.37	0.45	3.90	<0.001	0.12
NSTEM	4.03	0.47			

Objective 3 sought to describe agricultural education faculty teaching behaviors which support integrated STEM education. Over 80% of the faculty agreed or strongly agreed they modeled inquiry-based teaching methods (87.5%) and taught preservice teachers how to integrate STEM concepts into their teaching (80.3%). On the other hand, fewer than 50% of the faculty agreed or strongly agreed that they maintain partnerships with STEM industries (48.2%) or used an action plan to implement STEM into their programs (30.4%). These results are displayed in Table 4.

Table 4

Integrated STEM Education Behaviors of Agricultural Education Faculty (n=112)

Regarding STEM in the teacher education program, I…	SD	D	N	A	SA
	%	%	%	%	%
STEM Teaching					
Model inquiry-based teaching for the preservice teachers.	0.0	6.3	6.3	46.4	41.1
Teach preservice teachers how to integrate STEM concepts into their teaching.	3.6	6.3	9.8	44.6	35.7
Have articulated a vision for STEM education in agricultural education.	1.8	7.1	17.9	50.9	22.3
STEM Programming					
Include preservice teachers in decisions about measuring their success in STEM teaching.	3.6	8.0	27.7	33.9	26.8
Implement practices to increase participation of underrepresented students in STEM education.	1.8	7.1	17.9	50.9	22.3
Request feedback from inservice teachers on the progress of STEM education in agricultural education.	5.4	16.1	27.7	40.2	10.7
Maintain strategic partnerships with STEM industries.	5.4	25.9	20.5	40.2	8.0
Use an action plan to implement STEM education in agricultural education.	17.9	30.4	21.4	25.9	4.5

Note. STEM Teaching: Mean = 3.97; SD = 0.73; STEM Programming: Mean = 3.16; SD = 0.79

Overall STEM Behaviors: Mean = 3.46; SD = 0.69

The purpose of objective four was to describe the differences in STEM teaching behaviors of agricultural education faculty by institution type and appointment focus. As found in Figure 4, over 80% of LG faculty agreed or strongly agreed they model inquiry-based teaching methods (88.7%) and teach preservice teachers how to integrate STEM concepts (82.9%). Regarding STEM programming, less than one-third of LG (30.6%) and NLG (29.2%) faculty agreed or strongly agreed they use an action to implement STEM education in agricultural education.

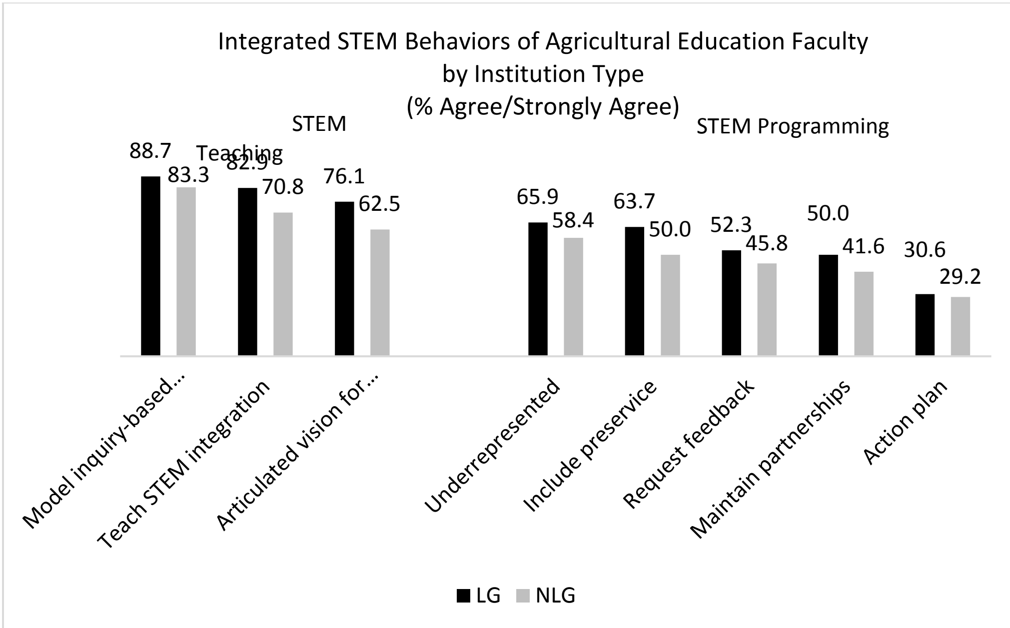

Figure 4. LG, *n*=88; NLG, *n*=24

As found in Table 5, the LG faculty overall mean score for STEM education in agricultural education behaviors was 3.47 (*SD* = 0.68), 3.99 (*SD* = 0.75) was the mean score for the STEM teaching behaviors construct, and the mean score for the STEM programming construct was 3.16 (*SD* = 0.77). For NLG faculty the mean scores were 3.42 (*SD* = 0.73) for overall behaviors, 3.86 (*SD* = 0.64) for STEM teaching, and 3.15 (*SD* = 0.88) for STEM programming. Results of an independent samples *t*-test revealed no significant differences between LG and NLG faculty.

Table 5

Integrated STEM Behavior Mean Scores of Agricultural Education Faculty by Institution Type (LG, n=88; NLG, n=24)

Construct	*M*	*SD*	*t*	*p*	*Cohen's d*
STEM Teaching					
LG	3.99	0.75	0.79	0.43	0.01
NLG	3.86	0.64			
STEM Programming					
LG	3.16	0.77	0.07	0.95	0.00
NLG	3.15	0.88			
Overall Behaviors					
LG	3.47	0.68	0.36	0.73	0.00
NLG	3.42	0.73			

As found in Figure 5, over 90% of LG faculty agreed or strongly agreed they teach preservice teachers how to integrate STEM concepts (97.8%) and model inquiry-based teaching methods (93.0%). Regarding STEM programming, less than one-third of NSTEM faculty agreed or strongly agreed they include preservice teachers in decisions about measuring their success in STEM teaching (31.4%) or use an action to implement STEM education in agricultural education (20.9%).

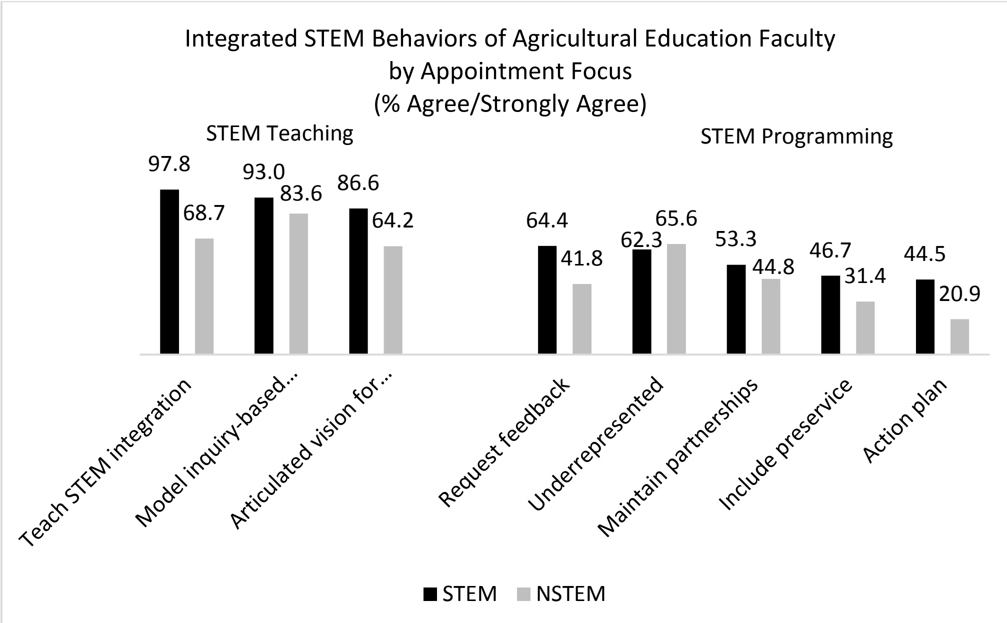

Figure 5. STEM, *n*=45; Non-STEM, *n*=67

As found in Table 6, the STEM faculty overall mean score for STEM education in agricultural education behaviors was 3.76 (*SD* = 0.60), 4.37 (*SD* = 0.52) was the mean score for the STEM teaching behaviors construct, and the mean score for the STEM programming construct was 3.39 (*SD* = 0.77). For NSTEM faculty, the mean scores were 3.25 (*SD* = 0.68) for overall behaviors, 3.68 (*SD* = 0.73) for STEM teaching, and 2.99 (*SD* = 0.78) for STEM programming. Results of an independent samples t-test revealed significant differences between the groups on the overall mean score, STEM teaching, and STEM programming (small effect size).

Table 6

Integrated STEM Behavior Mean Scores of Agricultural Education Faculty by Appointment Focus (STEM, n=45; NSTEM, n=67)

Construct	*M*	*SD*	*t*	*p*	*Cohen's d*
STEM Teaching					
STEM	4.37	0.52	5.42	<0.001	0.21
NSTEM	3.68	0.73			
STEM Programming					
STEM	3.39	0.77	2.67	0.009	0.06
NSTEM	2.99	0.78			
Overall Behaviors					
STEM	3.76	0.60	4.03	<0.001	0.13
NSTEM	3.25	0.68			

Conclusions

Overall, agricultural education faculty held positive attitudes toward STEM in teacher preparation programs and more often than not, engaged in teaching and programmatic behaviors which support an integrated approach to STEM teaching and learning. Regarding teaching practices specifically, it is worth noting that nearly 95% of all teacher educators agreed that teacher preparation programs should provide instruction for undergraduates about how to highlight STEM in their curriculum and implement experiential teaching techniques. Support for STEM education is further illustrated by the 85% of faculty who disagreed that agricultural education programs should place less emphasis on STEM.

A majority of the faculty held generally positive attitudes toward STEM but, differences did exist. Faculty employed at NLG institutions tended to be less positive toward placing student teachers with cooperating teachers who highlighted STEM in their instruction. This attitude may be influenced by the regional roles or constraints of NLG universities and, therefore, teacher educators at these institutions may not have an adequate supply of cooperating teachers who highlight STEM in their instruction with whom student teachers could be placed. Additionally, NLG faculty were less likely to agree that STEM-based course requirements should be increased. Perhaps these faculty tend to agree with the teacher attitudes identified by Stubbs and Myers (2016) that teacher preparation programs must find a balance between STEM and pedagogical course requirements. Of particular note was the difference between the groups regarding the responsibility of preparation programs to teach undergraduates how to highlight STEM and implement experiential teaching. Over 98% of LG faculty agreed with these statements yet, less than 80% of NLG faculty noted this agreement. The *American Association for Agricultural Education (AAAE)* established standards for school-based agricultural education teacher preparation programs which note preservice teachers graduating from this programs should be prepared to highlight STEM and implement experiential teaching practices (AAAE, 2017). As these standards are to be used as a guide by teacher educators, it is concerning that one in five teacher preparation faculty at NLG institutions have no opinion or a negative attitude toward implementing practices which are promoted by the profession.

Differences in attitudes also existed among faculty based upon their appointment focus. Breiner et al (2012) pointed out faculty attitudes toward STEM were mixed, despite a STEM or non-STEM appointment. Upon analyzing the data from this study, similar conclusions were drawn. Faculty who did not identify a STEM appointment tended to be more neutral than STEM-appointment faculty in their attitudes toward the relationship between STEM and the 3-circle model of agricultural education, placing student teachers with STEM-highlighting cooperative teachers, and increasing STEM-based course requirements. On the other hand, these faculty held similar attitudes regarding the responsibility of teacher educators to prepare their students to enter the classroom ready to highlight STEM and implement experiential teaching techniques. Breiner et al also noted that faculty attitudes are also driven by the role STEM plays in their lives. Perhaps NSTEM faculty are more passionate about teaching students than manipulating course requirements and placing student teachers.

A large majority of the faculty reported modeling inquiry-based teaching and teaching their students how to integrate STEM into their own teaching. Inquiry-based teaching has been reported as an effective technique to engage secondary students in STEM (Thoron & Burleson, 2014). Furthermore, teaching preservice teachers how to highlight STEM is a pedagogical content standard identified in the *Standards for School-Based Agricultural Education Teacher Preparation Programs* (AAAE, 2017). Teacher educators also maintain open dialogue with their students and inservice teachers by involving them in the evaluation process of teaching and learning and the progress of STEM education in agricultural education. Open dialogue with inservice teachers ensures that teacher educators are aware of their professional needs in order to provide or improve professional development or preservice training when needed (Swafford & Hagler, 2018).

Despite attitude differences among LG and NLG faculty, they tended to be more similar regarding their integrated STEM behaviors. This similarity may stem from the shared belief that teacher educators at all institutions have the charge of adequately preparing their students to enter the profession regardless of their university affiliation.

The conclusions drawn from the findings regarding the integrated STEM behaviors among faculty with and without STEM appointments are consistent with Ajzen's (1991) assertion that attitudes influence behaviors. STEM-appointed faculty held more positive attitudes toward STEM in agricultural education and more often modeled inquiry-based teaching, taught preservice teachers how to integrate STEM while working under an articulated vision for STEM education. STEM faculty were more engaged with their students concerning their success in STEM teaching and sought feedback from inservice teachers regarding the progress of STEM education in SBAE programs. Over one-third of NSTEM faculty did not maintain partnerships with STEM industries. As their appointments are not specifically tied to STEM, it could reasonably be concluded that these faculty may not engage in this behavior as they do not see it as germane to their role as a teacher educator. This belief may also be a contributing factor in the decision of over half of these faculty not utilizing an action plan to implement STEM in their programs.

Recommendations for Practice

Although, from a broad prospective, teacher educators generally hold positive attitudes toward STEM in agricultural education, differences existed among the behaviors in which teacher educators engaged. Therefore, it is recommended that a sense of cooperation and collaboration be maintained throughout the profession regardless of faculty university affiliation or appointment focus. Teacher educators should use the opportunities provided by professional organizations to network and share teaching ideas to better inform the profession of effective strategies which support STEM and agricultural education.

As research drives innovation in teaching, it is recommended that faculty who have the institutional capacity to secure and manage external funding seek to collaborate with faculty from other universities and industry organizations to provide opportunities to support regional or nation-wide working groups to create a synergy to address the workforce needs to which the profession has been charged. Additionally, faculty from non-land-grant institutions are encouraged to partner with land-grant universities to provide experiential teaching and learning experiences for their students which may be unavailable on their campuses.

It is further recommended that faculty remain engaged with inservice SBAE teachers. Active engagement with this group ensures that teacher educators are provided the current knowledge needed to adequately prepare preservice teachers for the rigors of the contemporary profession. Furthermore, as inservice teachers often look to teacher educators to meet their professional needs, engagement with this group will provide the insight required for the creation and implementation of effective professional development.

It is imperative that teacher educators not lose sight of the professional mission to promote and support agriculture through agricultural education. The future of the profession, the agriculture industry, and national prosperity rely on an adequately prepared workforce with knowledge and skills grounded in both agriculture and STEM principles. As the profession moves forward, it is recommended that the integration of STEM in agricultural education programs remain metered and deliberate in a balanced approach with decisions based on sound educational theory that transcend both agriculture and STEM to the betterment of students. When developing curriculum or preparing preservice teachers how to incorporate STEM, teacher educators are encouraged to bear in mind that all aspects of STEM need not be included in every lesson or unit plan and that these concepts should be incorporated or highlighted when possible and practical. As the profession seeks to balance STEM and agricultural education, the sentiments of Dr. Judith Ramaley may serve as a guide, "the core disciplines of science and mathematics between them support technology and engineering" (J. Ramaley, personal communication, July 3, 2018).

Recommendations for Research

To further improve integrated STEM and agricultural education, it is recommended that researchers continue to investigate the most promising practices by which these areas can be taught to secondary students without forfeiting teaching quality in both areas. Furthermore, it is recommended that future research focus on establishing the most effective methods to incorporate STEM into agricultural education programs without sacrificing the time and experiences required to adequately prepare preservice teachers to enter the profession. Additionally, it is recommended that those faculty with research interests focused on professional development conduct examinations with inservice teachers to establish the most effective strategies to encourage experienced teachers to implement integrated STEM/agricultural education into their programs without creating *AgriSTEM fatigue*.

The decisions to engage in teaching and programming behaviors which support STEM in agricultural education were significantly different among those faculty with STEM-appointments and those without. Future research should be conducted to assess the factors which persuade or dissuade faculty from engaging in those behaviors. If, in fact, a STEM appointment is the primary driver influencing agricultural education faculty decisions to support STEM in agricultural education, research should be conducted to determine what strategies can be used to assist non-STEM appointment faculty in supporting STEM integration without impacting negatively their students, career, and the profession. Additional research should be conducted to determine the influence faculty attitudes toward STEM and their teaching behaviors have on the decisions of school-based agricultural education teachers decisions to teach and integrate STEM in their classrooms.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211. doi: 10.1016/0749-5978(91)90020-T

Ajzen, I. (2006). *Behavioral interventions based on the theory of planned behavior.* Amherst, MA: University of Massachusetts System. Retrieved from http://www.people.umass.edu/aizen/pdf/tpb.intervention.pdf

Ajzen, I., & Fishbein, M. (2005). The influence of attitudes on behavior. In D. Albarracin, B. T. Johnson, & M. P. Zanna (Eds.), *The handbook of attitudes* (pp. 173-221). New York, NY: Lawrence Erlbaum Associates.

American Association for Agricultural Education. (2017). *2017-2020 Standards for school-based agricultural education teacher preparation programs.* Approved at the May 2017 National AAAE Conference, San Luis Obispo, CA.

Balschweid, M. A. (2002). Teaching biology using agriculture as the context: Perceptions of high school students. *Journal of Agricultural Education*, *43*(2), 56–67. doi: 10.5032/jae.2002.02056

Balschweid, M. A. (2003). *Science can be fun? A look at student attitudes towards science after completing a year–long biology course taught using agriculture as the context.* Proceedings of the 30th Annual National Agriculture Education Research Conference, Orlando, Florida, 277–288. Retrieved from http://aaaeonline.org/allconferences.php

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. doi: 10.5032/jae.2006.01078

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*(1), 3-11. doi: 11.1111/j.1949-8594.2011.00109.x

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 Education Research Conference, Louisville, KY.

Bunshaft, A., Boyington, D., Curtis-Fisk, J., Edwards, T., Gerstein, A., & Jacobson, C. (2015). *Focus on employability skills points to experiential learning.* A publication by STEMconnector's STEM Innovation Task Force.

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM state-level analysis: Science, technology, engineering, mathematics.* Washington, DC: Georgetown University Center on Education and the Workforce.

Chumbley, S. B., Haynes, J. C., & Stofer, K. A. (2015). A measure of students' motivation to learn science through agricultural STEM Emphasis. *Journal of Agricultural Education. 56*(4), 107-122. doi: 10.5032/jae.2015.04107

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

Cohen. J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

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. doi: 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. doi: 10.5032/jae.2000.02054

Desilver, D. (2017). *U.S. students' academic achievement still lags that of their peers in many other countries.* Washington, DC: Pew Research Center.

Duncan, R. (2017). *Importance of agricultural research: Non-land-grant colleges of agriculture.* Hearing before the U.S. House of Representatives Agriculture Committee.

Friday Institute for Educational Innovation (2014). *Principal Leadership for STEM survey.* Raleigh, NC: Author.

Gay, K. D., Leal, A., Ruth, T. K., Lamm, A. J., & rumble, J. N. (2015). Comparing the use of visual analog scales and Likert-type scales in international agricultural extension education surveys. *Journal of International Agricultural and Extension Education 21*(2), 37-51. doi: 10.5191/jiaee.2015.22203

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. doi: 10.5032/jae.2012.02015

Hillison, J. (1996). The origins of agriscience: or where did all that scientific agriculture come from? *Journal of Agricultural Education, 37*(4), 8–13. doi: 10.5032/jae.1996.04008

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. doi: 10.5032/jae.1996.01022

Kotrlik, J. W., Williams, H. A., & Jabor, M. K. (2011). Reporting and interpreting effect size in quantitative agricultural education research. *Journal of Agricultural Education, 52*(1), 132-142. doi: 10.5032/jae.2011.01132

Lane, R. A., & Casey, J. E. (1989). Faculty assignments at non-land grant universities. *NACTA Journal, 33*(4), 14-16.

Lindner, J., Murphy, T., Briers, G. (2001). Handling nonresponse in social science research. Journal of Agricultural Education, 42(4), 43-53.

Lundry, J., Ramsey, J. W., Edwards, M. C., & Robinson, J. S. (2015). Benefits of career development events as perceived by school-based, agricultural education teachers. *Journal of Agricultural Education, 56*(1). 43-57. doi: 10.5032/jae.2015.01043

Malmsheimer, R. W., & Germain, R., H. (2002). Needs assessment surveys: Do they predict attendance at continuing education workshops? *Journal of Extension, 40*(4). Retrieved from http://www.joe.org/joe/2002august/a4.php

McKim, A. J., Lambert, M. D., Sorenson, T J., & Velez, J. (2015). Examining the Common Core State Standards in agricultural education. Journal of Agricultural Education 56(3), 134-145. doi: 10.5032/jae.2015.03134

Moore, G. E. (1988). The Involvement of the agricultural experiment stations in secondary vocational agricultural, 1887–1917. *Agricultural History, 62*(2), 154–166.

Murphrey Pesl, T., Lane, K., Harlin, J., & Cherry, A. L. (2016). An examination of pre-service agricultural science teachers' interest and participation in international experiences: Motivations and barriers. *Journal of Agricultural Education, 57*(1), 12-29. doi: 10.5032/jae.2016.01012

Myers, B. E., & Thompson, G. W. (2006). Integrating academics into agriculture programs: A delphi study to determine perceptions of the national agriscience teacher ambassador academy participants. *Journal of Agricultural Education, 47*(4), 77-88. doi: 10.5032/jae.2006.04044

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. doi: 10.5032/jae.2008.02027

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: U.S. Department of Education.

National Commission on Secondary Vocational Education. (1984). *The unfinished agenda: The role of vocational education in high school*. Cincinnati, OH: Ohio State University, The National Center for Research in Vocational Education.

National Research Council. (1988). *Understanding agriculture: New directions for education.* Washington, D.C.: National Academy Press.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Osborne, E. W., & Dyer, J. E. (2000). Attitudes of Illinois agriscience students and their parents toward agriculture and agricultural education programs. *Journal of Agricultural Education, 41(*3), 50-59. doi: 10.5032/jae.2000.03050

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

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. doi: 10.5032/jae.2006.02048

Rothwell, J. (2013). *The hidden STEM economy.* Washington DC: Bookings Institution.

Rothwell, J. (2014). *Still searching: Job vacancies and STEM skills.* Washington, DC: Brookings Institution.

Sandoval, W. A. & Harven, A. M. (2011). Urban middle school students' perceptions of the value and difficulty of inquiry. *Journal of Science Education & Technology, 20*(1), 95-109.

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. doi: 10.5032/jae.2009.02102

Shinn, G.C., Briers, G.E., Christiansen, J.E., Edwards, M.C., Harlin, J.F., Lawver, D.E., et al. (2003). *Improving student achievement in mathematics: An important role for secondary agricultural education in the 21st century.* Monograph, National Council for Agricultural Education. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary doi: 10.1.1.130.5829

Smith, K. L. (2015). *A quasi-experimental examination of the effects of cognitive sequencing on STEM concept integration in agricultural education* (Unpublished doctoral dissertation). Texas A & M University, College Station, TX.

Smith, K. L., & Rayfield, J. (2016). An early historical examination of the educational intent of Supervised Agricultural Experiences (SAEs) and project-based learning in agricultural education. *Journal of Agricultural Education*, *57*(2), 146-160. doi: 10.5032/jae.2016.02146

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective practices in STEM integration: Describing teacher perception and instruction use. *Journal of Agricultural Education, 54*(4). doi: 10.5032/jae.2015.04

Stetcher, B. M., Hanser, L. M., Hallmark, B., Rahn, M. L., Levesque, K., Hoachlander, E. G.,... Klein,S. G. (1994). *Improving Perkins II performance measures and standards: Lessons from early implementers in four states*. Berkley, CA: National Center for Research in Vocational Education.

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). Gainesville, FL: Department of Agricultural Education and Communication.

Stubbs, E. A., & Myers, B. E. (2016). Part of what we do: Teacher perceptions of STEM Successful STEM Education in K-12 Schools. *Journal of Agricultural Education, 57*(3), 87-100. doi: 10.5032/jae.2016.03087

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

Swafford, M., & Hagler, P. (2018). Beginning SBAE teachers' metal fabrication knowledge needs: Implications for teacher preparation. *Journal of Agricultural Education, 59(*1), 287-296. https://doi.org/10.5032/jae.2018.01287

Swortzel, K. A. (2016). *American Association for Agricultural Education 2015-2016 Faculty Salary Report.* A report prepared for the American Association for Agricultural Education.

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. doi: 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. doi: 10.5032/jae.2000.02073

Thompson Jr., J. C., & Russell, E. B. (1993). Beliefs and intentions of counselors, parents, and students regarding agriculture as a career choice. *Journal of Agricultural Education, 34*(4), 55-63. doi: 10.5032/jae.1993.04055

Thoron, A. C., & Burleson, S. E. (2014). Students' perceptions of agriscience when taught through inquiry-based instruction. *Journal of Agricultural Education, 55*(1), 66-75. doi: 10.5032/jae.2014.01066

Thoron, A. C., & Myers, B. E. (2010). Perceptions of preservice teachers toward integrating science into school–based agricultural education curriculum. *Journal of Agricultural Education, 51*(2), 70–80. doi: 10.5032/jae.2010.02070

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. doi: 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. doi: 10.5032/jae.2012.04156

United States Department of Labor. Bureau of Labor Statistics. (2009). *Women in the labor force: A databook* (Report 1018). Washington, DC: United States Department of Labor.

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. doi: 10.5032/jae.2004.02073

Wilson, E. B., & Curry Jr., K. W. (2011). Outcomes of integrated agriscience processes: A synthesis of research. *Journal of Agricultural education, 52*(3), 136-147. doi: 10.5032/jae.2011.03136