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Effective Practices in STEM Integration: Describing Teacher Perceptions and Instructional Method Use

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Abstract

Career and Technical Education (CTE), including agricultural education, has been suggested as a platform for delivering Science, Technology, Education, and Mathematics (STEM) content in secondary classrooms (Stone, 2011). The purpose of this descriptive study was to describe agriculture teachers' perceptions and confidence levels for integrating the four STEM disciplines in agricultural education courses, along with perceptions and use of instructional methods for STEM integration. A stratified random sample (n =280) was drawn from agriculture teachers in three states (N =1,049), one state representing each of the American Association for Agricultural Education regions. Overall, teachers perceived each of the four components of STEM integration as important. Teachers had high levels of confidence in integrating science and mathematics, and reported lower confidence levels for technology and engineering. Although teachers reported spending most of their teaching time in lecture (M = 23.46; SD = 15.34) and ranked lecture first in overall confidence, lecture ranked seventh out of ten in effectiveness for student learning. Differences existed between gender and confidence integrating engineering, and perceptions of instructional method effectiveness. Results of this study suggest stakeholder examination of instructional methods which are most effective at integrating STEM concepts, and investigate how to increase teacher confidence with effective instructional methods for STEM concepts.

Keywords: STEM; teacher perceptions; teacher confidence; agricultural education; instructional methods

Science, Technology, Engineering, and Mathematics (STEM) education has been a part of the culture of education in the United States since the National Science Foundation (NSF) coined the term in the early 2000s (Duggar, 2010). Educational regulations have begun to dictate STEM integration through mandated testing (Myers & Dyer, 2004). Concerns have arisen that many students, including at-risk and low achievers, have difficulty understanding STEM concepts when taught in standalone courses (Boaler, 1998; Kieran, 1992; Woodward & Montague, 2002). Researchers have pointed to the abstract nature of STEM concepts as a possible barrier to gaining STEM understanding for all students (Stone, 2011; Woodward & Montague, 2002).

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Career and Technical Education (CTE) courses, including agricultural education, have been considered a viable platform for teaching STEM concepts, because these courses deliver abstract concepts in an applied context, which is shown to increase student understanding (Clark, Parr, Peake, & Flanders, 2012; Stone, 2011). To prepare agriculture students who are ready to meet the scientific professional workforce of the 21st century, as indicated as by research priority three of the American Association for Agricultural Education (AAAE), agricultural education should promote the learning and retention of STEM concepts, using effective teaching methods to facilitate student understanding (Doerfert, 2011).

Teacher attitudes and perceptions of STEM concepts have been examined related to specific STEM disciplines in agricultural education. Many studies have been conducted to investigate the integration of science in agriculture courses (Boone, Gartin, Boone, & Hughes, 2006; Brister & Swortzel, 2009; Clark, et al., 2012; Conroy, Dailey, & Shelley-Tolbert, 2000; Haynes, Robinson, Edwards, & Key, 2012; Johnson, 1996; Myers & Thompson, 2006; Myers & Washburn, 2008; Ricketts, Duncan, & Peake, 2006; Scales, Terry, & Torres, 2009; Thompson & Balschweid, 1999; Thompson & Balschweid, 2000; Thoron & Myers; 2012a, 2012b; Warnick, Thompson, & Gummer, 2004). Results of these studies highlighted the notion that agriculture teachers believe agriculture is an effective delivery method for science (Brister & Swortzel, 2009); agriculture teachers are confident in their ability to integrate science concepts (Scales, Terry & Torres, 2009; Thompson & Balschweid, 2000), and agriculture classes are often more effective at increasing student science scores than standalone science courses (Clark, et al. 2012; Myers & Dyer, 2006; Ricketts, et al., 2006).

Mathematics as a component of STEM education in agriculture classes has also been examined (Clark, 2013; Parr, Edwards & Leising, 2006, 2009; Shinn et al., 2003; Stripling & Roberts, 2012). Parr, Edwards, and Leising (2006) found students who engaged in a math integrated agricultural power and technology class scored higher on a postsecondary math placement test. In contrast, Clark (2013) found students who completed a math-enhanced unit in an animal science course showed no improvement in overall math test or self-efficacy scores.

With the exception of biotechnology, which is widely considered a science concept (Pisano, 2006), minimal research has been conducted related to integration of technology in agriculture courses. Dexter, Doering, and Ridel (2006), proposed models for integration of technology content in high school agriculture courses. The study was limited to curriculum development, rather than teacher perceptions and beliefs. A review of available literature yielded no obvious research related to agriculture teachers' perceptions or efficacy related to integrating engineering within secondary agriculture courses.

The educational literature supports increased focus on STEM concepts, although there are differing views on the instructional methods for teaching those concepts. In a 2007 report, the United States Department of Education Academic Competitiveness Council concluded that "despite decades of significant federal investment in science and math education, there is a general dearth of evidence of effective practices in STEM education" (p. 3). To more effectively integrate STEM concepts into all secondary classes, including agricultural science courses, quality research into effective practices must be conducted (Stone, 2011).

Effective instruction in STEM concepts relies on the use of effective instructional methods. Instructional methods can be defined as the specific techniques used to present educational content (Cronbach & Snow, 1981). Researchers have concluded that instructional methods are one of the largest determinants of student attention, learning, and retention (Marzano, Pickering & Pollock, 2001; Reigeluth, 2013; Sallee, Edgar, & Johnson, 2013). Lecture is the instructional method found to be used most frequently in general education, followed by cooperative learning and discussion (Wilen, Ishler, Hutchinson, & Kindsvatter, 2000).

In agricultural education, certain instructional methods have been examined with regard to student performance (Boone, 1990; Dyer & Osbourne, 1996a, 1996b; Parr & Edwards, 2004; Thoron & Myers, 2012a, 2012b). Much of the analysis of instructional methods in secondary agriculture courses has been related to the effectiveness of inquiry-based and problem-solving approaches to content delivery (Boone, 1990; Parr & Edwards, 2004; Thoron & Burleson, 2014; Washburn & Myers, 2010). Although the effectiveness of these instructional methods has been addressed, a comprehensive review of agricultural education-related literature revealed a gap in the knowledge base related to the instructional methods agriculture teachers are currently using to address student learning objectives. In addition, little is known related to agricultural educator perceptions of instructional method effectiveness.

Teacher perceptions are a factor likely to influence their confidence and effectiveness teaching those concepts (Darling-Hammond & Bransford, 2005). To understand which teaching methods are most likely to effectuate student learning in STEM areas, it is important to first examine the methods that agricultural educators are currently using to instruct. Finding a pairing between instructional method use and confidence in STEM areas could allow the profession to determine future research related to STEM learning in agricultural education courses. Understanding how agriculture teachers perceive their ability to integrate STEM concepts, and which instructional methods are being used in secondary agricultural science classrooms, from a holistic standpoint, will enable researchers to better determine which STEM integration methods warrant additional research.

Theoretical Framework

To understand how agriculture teachers might better use instructional methods to increase student performance in STEM topics, it is important to examine how individual teacher appraisal is related to both STEM integration and use of instructional methods. The multi-faceted decisions that teachers make in selecting instructional methods to use when integrating STEM concepts in to agricultural education courses require an understanding of how teachers personally relate to their teaching environment and the content. For this reason, social cognitive theory (Bandura, 1986), as illustrated in Figure 1, served as the theory guiding this study. The multi-dimensional interaction between all three factors of social cognitive theory (Bandura, 2002) provided a foundation for the examination of agriculture teacher selection of instructional methods to integrate STEM concepts in agriculture courses.

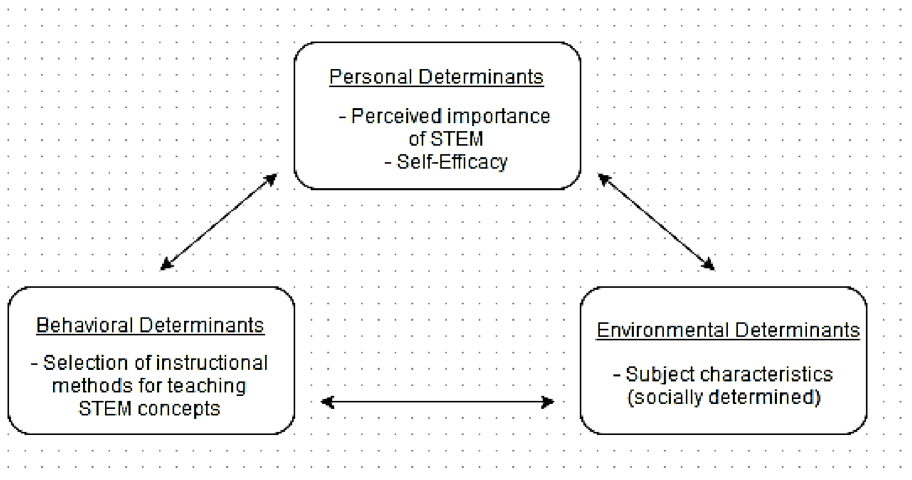

Figure 1. Model of social cognitive theory as related to examination of teacher STEM integration (Adapted from Bandura, 2002)

Bandura (1986) noted that humans are self-regulating and self-organizing. Bandura (1986) described human functioning as the interaction between personal, environmental, and behavioral factors. For the purposes of examining teacher perceptions of STEM and instructional methods, the desired behavioral outcome would be the successful use of instructional methods to teach STEM concepts.

Personal factors included in social cognitive theory include outcome expectations and self-efficacy. Bandura (1997) described self-efficacy as a person's "beliefs about their capabilities to produce designated levels of performance" (p. 1). According to Bandura's (1986) explanation of social cognitive theory, those with higher levels of self-efficacy are more confident in their ability to overcome challenges and endure setbacks within a given subject, and that those with more confidence in their control over the situation are more likely to effectuate a desirable outcome. Following Bandura's (1986) theory, teachers with greater levels of self-efficacy related to STEM integration should be more likely to see themselves successfully implementing science, technology, engineering, and/or mathematics in their agriculture courses. In addition, teachers who have greater levels of self-efficacy using a given instructional method would be more likely to successfully use that method to effectuate student learning.

Based on the framework of social cognitive theory, environmental determinants also contribute to the successful integration of STEM concepts. Bandura (1997) explained that environmental determinants are likely to play a role in cognition and outcome behavior. Type of certification, gender, and length of teaching career are all factors in which each individual interacts with their peers influencing their social environment. The social environment affects outcome behavior related to confidence in integrating STEM concepts and preferential use of instructional methods. Examining the relationship between the noted environmental factors may provide useful insight into the role that environment plays in STEM integration perception or preference for instructional method among agriculture teachers.

By understanding teacher perceptions of the integration of STEM concepts through the lens of social cognitive theory (Bandura, 1986), further steps can be taken to examine how the interaction between instructional method and STEM integration can be strengthened to create more effective STEM integration in all agriculture courses.

Purpose and Objectives

The purpose of this study was to describe agriculture teacher perceptions regarding integration of science, technology, engineering and mathematics in agriculture courses, and identify use and confidence in various instructional methods in agriculture courses.

To meet the purpose of this study, research was conducted with the following objectives:

1. Describe agriculture teacher perceptions of integrating science, technology, engineering, and mathematics components in agriculture courses
2. Determine if differences existed between social environmental determinants *(gender, type of certification, length of teaching career*) and perceptions of integrating STEM components in agriculture courses
3. Describe agriculture teachers perceptions of instructional methods including preparatory experience, amount of use, confidence in using, and rankings of effectiveness
4. Determine if differences exist between social environmental determinants *(gender, type of certification, length of teaching career)*and preference for using specific instructional methods

Instrumentation

To fulfill the objectives of this study, we developed a three-section online survey instrument. Section one of the instrument asked teachers to report their perception of the importance of each of the STEM areas, and their confidence in integrating each of the STEM areas on a five-point, summated-rated scale. The second section of the instrument asked teachers to select descriptors of their demographic characteristics including age, gender, length of teaching, and type of certification. The third section of the instrument asked teachers to consider their training in, use of, and perception of ten specific instructional methods. The ten instructional methods selected for incorporation in this study were taken from Newcomb, McCracken, Warmbrod, and Whittington (2004).

Descriptions of each of the instructional methods were included for clarification at the beginning of the third section, and are shown in Table 1. The third section included an item asking which instructional methods teachers received pre-service training in, what percentage of their classroom instruction was spent in each instructional method, and two rank order items: one asking teachers to rank the ten instructional methods in order of their confidence using the method, and one item asking respondents to rank the instructional methods in order of how effectively they believed the method increased student learning.

Table 1

Definitions of Instructional Methods (Adapted from Newcomb, et al., 2004)

Instructional Method	Definition
Cooperative Learning	Learner-centered instruction in which groups of 3-5 students work together on a well-defined learning task
Demonstration	Teacher led instruction of hands-on skills or activities
Discussion	Two-way communication about a pre-defined topic conducted with entire class or smaller groups of students
Experiments	Students using the scientific method to form hypothesis, test theory, and formulate conclusions on a given topic
Field Trips	Students taken away from traditional classroom setting for real-world experience in a content area
Guest Speakers	Guests with particular expertise are brought in to instruct about a specific concept or topic
Independent Study	Students are engaged in self-directed in learning of a topic specific to their interests
Lecture	Teacher led instruction for disseminating information, may be guided through multimedia presentation
Role Play (Skits)	Class participants play or portray a given role to illustrate concept
Supervised Study	Given a well-defined question or prompt, students use resource materials to find answers for themselves

Prior to conducting the study, the instrument was examined by a panel of experts in agricultural education, including secondary agriculture teachers who were not included in the study and university faculty in agricultural education for content and face validity. To ensure reliability, the instrument was piloted to 78 secondary agriculture teachers in four states ([States]) based on AAAE region, including two states in the Western region, one state in the North Central region, and one state in the Southern region. States and number of pilot participants were selected to mirror the stratification of the three states included in the study population.

Pilot responses to five-point, rating-scaled items were used to calculate reliability coefficients by construct, resulting in $\alpha = 0.70$ for scaled items related to perceived importance, and $\alpha = 0.74$ for scaled items related to teacher confidence STEM. Post-hoc reliability for the constructs was calculated at $\alpha = 0.79$ and $\alpha = 0.75$. According to Nunnally (1978), a Cronbach's α of .70 or greater is sufficient 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. Agriculture teachers from [three States] (N = 1,049) were purposively selected as the population for this research, one state representing each of the American Association for Agricultural Education (AAAE) regions. A stratified random sample of n = 280 agriculture teachers ([State], (n = 135); [State], (n = 112); and [State], (n = 33)) were selected from the population to complete the instrument and take part in the research study. From the sample, 127 useable responses were collected, for a 45.4% response rate. To test whether the number of responses received from each state had an uneven influence, number of responses were compared between states using a Chi Square test. Results indicated there were no differences ($p \geq .05$) by state, which supported the decision that no state had a weighted influence on findings.

The *Tailored Design Method* (Dillman, Smyth, & Christian, 2009) procedures were followed to maximize response rate. Respondents were contacted through a pre-survey notification by email, followed by an email including a unique link to the online survey. Two follow-up/thank you letters were sent by email. To control for non-response error, personal contact was made to obtain responses from non-responders (n = 23). Analyzing these responses yielded no significant differences from the responders. As an additional measure of control, early and late responders were compared (Linder, Murphy, & Briers 2001). No significant differences were found between those who completed the survey prior to the first reminder (n = 44), and those completing the survey following the reminder email (n = 81).

Although the previously noted steps were taken to ensure a methodologically sound approach to this study, several limitations and assumptions existed. To accurately assess agriculture teacher use of instructional methods, it was assumed that respondents identified the instructional methods with the definitions as listed in the instrument. The lack of a universally accepted list of instructional methods was a limitation to this study. In addition, although data from more than 125 agriculture teachers were included in the analysis, the relatively low response rate of this study leave a suggestion of caution in widespread generalization of the findings. Data were collected from the online survey hosting site, and analyzed using IBM™ SPSS® Version 20.

Subject Characteristics

Demographic characteristics of respondents are described in Table 2. The makeup of the respondent group was 55.6% male (n = 70), and 44.4% female (n = 56). Mean age of respondents was 35.4 years (SD = 9.83). Related to certification type, 91.3% (n = 116) of respondents reported being certified through a traditional university teacher education program and 8.66% (n = 11) of respondents obtained certification through an alternative or emergency certification program with an average of 9.96 (SD = 9.34) years of teaching experience. To further describe length of teaching, respondents were categorized by length of teaching into three categories; beginning (0 – 5 years of experience), early career (6 – 10 years of experience), veteran teachers (11 or more years of experience)

Table 2

Subject Characteristics

Characteristic	*f*	%	*M*	*SD*	*Min.*	*Max.*
Gender						
Male	70	55.56				
Female	56	44.44				
Age			35.45	9.83	22	64
Type of Certification						
Traditional	116	91.34				
Alternative/Emergency	11	8.66				
Years of Teaching Experience			9.96	9.34	0	41
Teaching Experience by Category						
Beginning Teachers (0 – 5 years)	50	39.37				
Mid-Career Teachers (6 – 10 years)	29	22.83				
Veteran Teachers (11 or more years)	45	35.44				
Not Reported	3	2.36				

Findings

To describe agriculture teachers' perceptions of each of the four components of STEM education, we asked respondents to rate the importance of integrating each STEM concept into agriculture courses, using a five-point rating-scale; greater mean values indicated greater perceived importance. Means and standard deviations for teacher responses related to STEM importance were reported in Table 3.

Table 3

Teacher Perceptions of the Importance of Integrating STEM Concepts

STEM Component	*M*	*SD*
Science	4.70	0.56
Technology	4.48	0.67
Engineering	3.86	0.94
Mathematics	4.44	0.67
Grand Mean	4.38	0.57

Note. Bipolar scale: 1 = Not Important, 5 = Very Important

Science (M = 4.70, SD = 0.56) was the STEM component perceived to be most important, based on mean score, followed by technology (M = 4.48, SD = 0.67) and mathematics (M = 4.44, SD = 0.67). Engineering had the lowest associated mean importance score (M = 3.86) and the most dispersion of scores (SD = 0.94). Overall, respondents indicated high importance ($M > 3.8$) of each of the four STEM concepts.

Respondents were also asked to indicate their confidence in integrating each of the STEM concepts using a five-point rating-scale; greater mean values indicated greater perceived confidence. A summary of respondents reported confidence in STEM concept integration were reported in Table 4. On average, agriculture teachers were confident in their ability to in integrating STEM concepts. Teachers believed they were most confident in integrating science concepts (M = 4.28, SD = 0.88) and least confident in integrating engineering concepts (M = 2.89, SD = 1.20).

Table 4

Teacher Confidence in Integrating STEM Concepts

STEM Component	*M*	*SD*
Science	4.28	0.88
Technology	3.89	0.84
Engineering	2.89	1.20
Mathematics	3.77	1.00
Grand Mean	3.72	0.75

Note. Bipolar scale: 1 = Not Confident, 5 = Very Confident

Before we tested if differences existed between gender for ratings of importance and confidence, we calculated bivariate correlations between teacher confidence and perceived importance items. Pearson product-moment correlation coefficients for teachers' perceptions of the importance of integrating STEM concepts ranged from .38 to .59, and teachers' confidence in integrating STEM concepts ranged from .37 to .48, which indicated weak to strong positive bivariate relationships (Newton & Rudestam, 1999). Therefore, we used multivariate analysis of variance (MANOVA) to compare mean perceptions of importance of integrating STEM concepts scores (DVs) and confidence in integrating STEM concepts scores (DVs) by gender (IV). We chose to interpret MANOVA results using the Hotelling's trace statistic (T^2) because "the Hotelling's T^2 is robust in the two-group situation when sample sizes are equal" (Field, 2009, p. 604).

Box's test of equality of covariance was significant (p = .009) for our comparison of perceptions of importance of integrating STEM concepts scores by gender, which is an indicator that the assumption of equality of covariance was violated (Field, 2009). Therefore, the results of this analysis can only be interpreted based on the robustness of Hotelling's T^2 test. Based on the results of the MANOVA, we determined significant differences existed in mean perceptions of importance of integrating STEM concepts scores, based on gender; T^2 = .160; F (4, 118) = 4.731; p = .001; η_p^2 = .138; 1 – β = .945).

Box's test of equality of covariance was not significant (p = .062) for our comparison of perceptions of confidence in integrating STEM concepts scores by gender, which was an indicator that the assumption of equality of covariance was not violated (Field, 2009). Significant differences existed among mean perceptions of confidence in integrating STEM concepts scores, based on gender; T^2 = .295; F (4, 118) = 8.703; $p <$ .001; η_p2 = .228; 1 – β = .999).

After identifying the significant MANOVAs, a subsequent univariate Analysis of Variance (ANOVA) was carried out on each of the dependent variables (see Table 5). A Bonferroni correction (adjusted significance value ≤ .021) was applied to each of the subsequent ANOVAs to protect against inflated Type I error (Field, 2009). Based on the results of the univariate ANOVAs, significant differences (by gender) existed in the perceived importance of integrating technology concepts with females indicating lower importance, and teachers' confidence in integrating engineering concepts, with females indicating lower confidence.

Table 5

Univariate ANOVAs as a follow up to significant MANOVA

Scale	*df*	*SS*	*MS*	*F*	*p*	η^2	1 - β
Importance of integrating science concepts							
Between	1	1.61	1.61	5.308	.023	.042	.628
Error	121	0.30					
Importance of integrating technology concepts**							
Between	1	2.44	2.44	5.656	.019	.045	.655
Error	121	0.43					
Importance of integrating engineering concepts							
Between	1	0.38	0.38	.424	.516	.003	.099
Error	121	0.90					
Importance of integrating mathematics concepts							
Between	1	2.03	2.03	4.696	.032	.037	.575
Error	121	0.43					
Confidence in integrating science concepts							
Between	1	0.12	0.12	0.16	.693	.001	.068
Error	121	94.92					
Confidence in integrating technology concepts							
Between	1	0.04	0.03	0.06	.816	.000	.056
Error	121	85.59					
Confidence in integrating engineering concepts**							
Between	1	32.79	32.79	27.63	.000	.186	.999
Error	121	143.62					
Confidence in integrating mathematics concepts							
Between	1	4.92	4.92	5.10	.026	.040	.611
Error	121	116.71					

Note. ** Indicates significant results ($p \leq .021$)

Comparing the small number of alternative/emergency certified teachers ($n = 11$) to traditionally certified teachers ($n = 116$) could not be achieved through parametric analysis. The Mann-Whitney *U* test is an acceptable nonparametric test for differences with small sample sizes (Howell, 2012), and was determined to be the appropriate tool for analyzing differences in certification type. Comparisons yielded no significant differences ($p \leq 0.05$) between type of certification and STEM perceptions.

A one-way ANOVA was used to compare perceptions of STEM integration by teaching experience. Length of teaching experience (categories) was used as the IV and perceptions of STEM integration were used as the DVs. The objectives of this research called for differences based on length of teaching category to be determined for two different factors, perceptions of STEM integration, and confidence in integrating. As two ANOVA analyses were run from this data set, significance levels were adjusted to prevent Type I error, per the suggestion of Howell (2012). When variance was compared between the four categories related to length of teaching career and perceptions of STEM concepts, no significant differences were observed.

To address research objective three, we asked respondents to indicate which of the ten instructional methods they had received formal training in during their teacher preparation program. Frequencies and percentages of respondents indicating they had received training for each method were shown in Table 6. All respondents reported receiving formal training in cooperative learning; whereas, close to one-half (56%) of respondents reported formal training in supervised study. In an open-ended response item, respondents also listed inquiry-based (*n* = 12), case study (*n* = 9), and problem-solving approach (*n* = 8) as instructional methods in which respondents had received formal training.

Table 6

Training Received by Instructional Method (n = 127)

Instructional Method	*f*	%
Cooperative Learning	127	100.0
Discussion	124	97.6
Role Playing	123	96.9
Experiments	118	92.9
Guest Speakers	103	81.1
Field Trips	95	76.0
Independent Study	77	61.1
Lecture	85	67.5
Supervised Study	70	56.0

A summary of the percentage amounts of instructional time spent in each of the instructional methods reported by respondents, was noted in Table 7. Lecture was found to be the most frequently used instructional method (*M* = 23.62, *SD* = 15.01), and respondents reported spending the least percentage of their class time using role playing (*M* = 2.23, *SD* = 4.36).

Table 7

Percent of Class Time Reportedly Devoted to Each Instructional Method (n = 127)

Instructional Method	*M*	*SD*
Lecture	23.62	15.01
Demonstration	15.79	9.08
Cooperative Learning	14.63	11.30
Discussion	14.53	8.49
Supervised Study	8.46	9.08
Independent Study	7.54	7.36
Experiments	6.30	5.32
Field Trips	3.69	3.85
Guest Speakers	2.70	2.64
Role Playing	2.23	4.36
Grand Mean	9.98	2.10

Note. Mean time spent in each method was calculated from self-reported percent of time devoted to each method

Agriculture teachers also ranked each of the instructional methods from 1 – 10, in order of their confidence using them. Means of overall ranking were calculated and are reported in Table 8. Lower mean scores show a higher confidence ranking. Respondents reported feeling most confident using lecture (*M* = 2.47, *SD* = 2.07) and demonstration (*M* = 3.12, *SD* = 1.84) to deliver instruction, and least confident using role playing (*M* = 8.55, *SD* = 1.84) and guest speakers (*M* = 7.05, *SD* = 2.20).

Table 8

Agriculture Teacher Confidence Ranking by Instructional Method (n = 127)

Instructional Method	*M*	*SD*
Lecture	2.36	2.07
Demonstration	3.12	1.84
Discussion	3.82	2.21
Cooperative Learning	4.83	2.50
Supervised Study	5.94	2.37
Experiments	5.98	2.42
Independent Study	6.54	2.46
Field Trips	6.70	2.37
Guest Speakers	7.05	2.20
Role Playing	8.55	1.84
Grand Mean	0.00	0.00

Note. Rating scores were summated from individual rankings on a 1 to 10 scale of confidence. Lower ranking scores indicate higher confidence.

To determine respondent perceptions of effectiveness of instructional method, respondents ranked the methods in order from most effective to least effective. Mean scores of effectiveness are shown in Table 9, with lower rankings equating to higher overall ranking. Demonstration (M = 2.96, SD = 2.04) and Experiments (M = 3.75, SD = 2.52) were the instructional methods ranked as most effective, using guest speakers (M = 6.91, SD = 2.36) and role playing (M = 7.27, SD = 2.31) fell to the bottom of the list of perceived effectiveness.

Table 9

Agriculture Teacher Ranking of Perceived Instructional Method Effectiveness (n = 127)

Instructional Method	*M*	*SD*
Demonstration	2.96	2.04
Experiments	3.75	2.52
Cooperative Learning	4.58	2.92
Discussion	4.96	2.21
Field Trips	5.05	2.53
Supervised Study	6.23	2.81
Lecture	6.47	2.82
Independent Study	6.82	2.62
Guest Speakers	6.91	2.36
Role Playing	7.27	2.32

Determining identifying relationships between behavioral determinants and instructional method perceptions involved analyzing differences in gender, length of teaching, and type of certification. To determine relationships based on gender, an independent samples *t*-test was used with the same adjusted significance level as determining differences in STEM confidence and importance (Howell, 2012), resulting in a significant alpha level of $\alpha = .002$. This analysis yielded two significant differences. Differences in gender occurred with regard to the perceived effectiveness of role playing ($p = .001$) and supervised study ($p = .001$). A medium effect size was found (Cohen, 1988), calculated at $d = 0.60$ for role playing and $d = -0.61$ for supervised study. The differences in positive and negative values allowed us to determine which assigned group was exhibiting a higher ranking. Results indicated female respondents ranked role playing higher in effectiveness, and male respondents ranked supervised study higher in effectiveness.

The examination of differences in certification type was completed through a Mann-Whitney *U* test. No significant differences were found related to type of certification and use or perceptions of instructional methods. Differences between length of teaching category and instructional method preferences were analyzed with a one-way ANOVA. No significant differences were found between length of teaching categories and ranking of confidence or effectiveness of instructional methods.

Conclusions and Implications

Overall, agriculture teacher ratings of the importance of integrating STEM concepts were high, supporting the notion that agriculture teachers are aware of shifts in educational structure mandating integration of STEM concepts (Myers & Dyer, 2004). It is comforting to know that teachers are likely to view STEM integration as a critical component of the responsibilities of an agricultural educator. Although importance was generally high, it is worth noting that female agriculture teachers perceived technology to be less important than their male colleagues. This difference may have increased implications for our profession as more and more female agriculture teachers enter the teaching field.

Confidence ratings of ability to integrate concepts varied by content area. It is important to note that high confidence does not always equate to high ability (Bandura, 1997). Scales, Terry, & Torres (2009), found that even though agriculture teachers rated their ability in integrating science high, they were not technically competent on a test of science knowledge. Examining teacher knowledge related to all four STEM concepts is recommended, and could reveal levels of competence vastly different from levels of confidence.

The highest confidence level was reported in science. Science efficacy scores may be high due to the historical influence of science concepts being embedded within agriculture courses (Hillison, 1996). This study allows us to conclude that science and agriculture remain the most closely intertwined concepts in the minds of this group of agriculture teachers related to STEM integration in agricultural education. Engineering was the content area with the lowest rating of both importance and confidence, leading to concerns about agriculture teachers' ability to effectively integrate engineering concepts, or their inability to identify where agriculture courses employ engineering concepts.

Significant differences were found both statistically and practically between male and female agriculture teachers' confidence in integrating engineering. Engineering confidence has been historically lower for females (Zeldin & Pajares, 2000), and the nature of gender differences may be a factor in this finding. Another possible suggestion for the difference is the relatively low percentage of female teachers instructing courses like agricultural mechanics (Foster, 2001), where engineering concepts may be more easily integrated into existing course content. With the number of female agriculture teachers increasing, this finding has increasing implications for stakeholders in the area of teacher preparation as it relates to the engineering area of STEM. Could we as a profession be doing more to help increase engineering confidence in our novice female agriculture teachers?

Agriculture teachers reported preparation in many instructional methods. All agricultural educators surveyed reported being trained in cooperative learning, perhaps indicating that cooperative learning has been validated as a method worth incorporating in teacher preparation programs. Although lecture was reported as the instructional method used most in agricultural courses and was the method with the highest confidence ranking, only 85% of respondents reported receiving training in this method, and respondents ranked lecture seventh in effectiveness. Similar differences occurred with supervised study, the method ranked lowest in training received, but in the middle of the group with regard to use (fifth), confidence (fifth), and effectiveness (sixth). Teachers are likely spending time instructing in methods they have not been trained in, and do not believe are the most effective at increasing student understanding.

Recommendations

Results of this study highlight several areas for further research and practical application in secondary agricultural education. With regard to future research, STEM integration studies should be conducted to determine the reasons that female agriculture teachers are less confident integrating engineering concepts. It is also recommended to replicate this study including a content knowledge component, similar to Scales, Terry, and Torres (2009), to determine if relationships exist between content knowledge and efficacy in each of the components of STEM education. With regard specifically to instructional method use, it is suggested that the relationships be examined related to factors influencing teacher choice of instructional method. Understanding how teachers select instructional methods could reveal best practices for encouraging agriculture teachers to use more effective methods to deliver content. In addition, it is suggested to replicate this study on a broader scale to determine if the results are generalizable to the national population of agricultural educators. The final suggestion for research from this study is the need for systematic experimental research into the effectiveness of specific instructional methods for student learning and retention of STEM concepts.

This study provides information which can be practically applied by stakeholders in agricultural education. Teachers rated confidence in integrating engineering as the lowest of the four STEM components, especially with regard to female teachers. Increasing teacher exposure to the integration of engineering, through either increased pre-service instruction, or professional development in-service training could show an increase in the confidence of teachers in integrating these concepts in agriculture courses. Allowing an increase in the amount of available curriculum resources for integrating engineering concepts in the broad spectrum of agriculture courses could also allow for an overall increase in confidence integrating these concepts.

Female agriculture teachers in this study were not as likely to view integration of technology as important to their agricultural education courses. It could be that these teachers are not aware of the vast technology integration activities which exist outside of traditional agricultural mechanics courses. Allowing agricultural educators, especially females, to understand the breadth of technology as it relates to agricultural education could be an important step in overcoming this discrepancy.

This study highlights the need for our profession to examine the instructional methods that should be included in preservice education, as varying levels of preparation exist. Researchers have found that novice teachers are most likely to be most efficacious in instructional methods they have seen modeled in their teacher preparation program (Darling-Hammond & Bransford, 2005). Effective teaching methods should be modeled in teacher preparation, as a critical step toward building confidence in these methods for novice teachers. With teachers being most confident in lecture, while doubting the effectiveness of this method, two practical steps should be taken. Teacher educators should make sure that instruction is included for preservice teachers in effective lecture techniques, and instruction should be given to allow novice educators to make appropriate decision related to when it is appropriate to substitute student-centered alternatives to traditional lecture methods.

Effective instruction in STEM concepts will depend on the use of effective instructional methods. Through the examination of teacher perceptions of integrating STEM, an understanding of how agriculture teachers view integration can be used to pinpoint intervention for teachers to ensure they are confident and well qualified to prepare 21st century learners in STEM concepts.

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