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SBAE Teachers' Perceptions of Science Integration and Inquiry-Based Learning

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Abstract

The integration of science within an agricultural education classroom is very important. This study explored the influences CASE professional development institutes had on the teacher-participant's perceptions of science integration and inquiry-based instruction. This study utilized a pre and post-test comprised of the integrative science survey and the inquiry-based teaching techniques. We attempted a census of all (N = 38) high school agricultural educators who were participants in the Principles of Agricultural Science-Plant (ASP) and the Agricultural Power and Technology (APT) CASE institutes. Overall, respondents had more positive perceptions of science integration and IBI following the CASE institutes. Teacher educators should incorporate inquiry-based teaching techniques and examples of integrating science into preparation programs and offer professional development workshops to practicing teachers. Future research should take a deeper look into the impacts of CASE institutes on teachers' attitudes towards science integration and implementation of IBI in their classrooms. A larger population of teachers needs to be studied with the study taking a longitudinal approach to focus on the long-term implementation of IBI in the agricultural education classroom.

Introduction

Agricultural Education has encountered many calls for change. Over the years the change has been focused on curriculum modifications. In 1988, *Understanding Agriculture: New Directions for Education* provided several recommendations by the National Research Council (NRC). These recommendations focused on two key areas. The first called for new career opportunities in agriculture beyond the focus of production agriculture, while the second deconcentrated on revisions to the current curriculum which placed a more significant focus on agricultural sciences, agribusiness, marketing, and food production (National Research Council, 1988). The NRC has also called for the utilization of inquiry-based teaching methods which emphasize students' engagement and exploration of the content through inquiry in the science-based curriculum (1996; 2000).

The Curriculum for Agricultural Science and Education (CASE) was created in 2007 by the National Council for Agricultural Education (CASE, 2012). The CASE curriculum is designed to support student-directed learning so students can answer questions through inquiry-based

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learning (Lambert et al., 2014). This curriculum promotes scientific inquiry which is accomplished using several strategies (CASE, 2012). A primary goal of CASE is to "improve math and science education by creating a contest for student learning through agricultural education courses" (Witt et al., 2016, p. 20). In 2007, The National Council for Education created The Curriculum for Agriculture Science Education (CASE) to provide structure for courses, increase rigor, and integrate more science and math into the curriculum (CASE, 2012). The curriculum utilizes PowerPoints, teacher notes, student activities, and assessments to implement inquiry-based instruction (IBI) which increases STEM, as well aspects of English education, into the 5 different agricultural pathways supported by CASE. Using the CASE curriculum, students are engaged in guiding their learning in a self-directed manner in hopes that tasks would become more meaningful (Lambert et al., 2014). Teachers wishing to teach CASE courses within their secondary agricultural education program are required to complete 80 hours of professional development per course they wish to teach (Lambert et al., 2014).

In later years, the National Council for Agricultural Education (2016) identified eight initiatives to assist in the development of quality CTE programs. CTE's purpose is to "develop the knowledge and skills required for a successful employment within the industry" (Roberts & Ball, 2009, p. 82). Of the eight initiatives identified, one initiative called for a sequence of courses to enhance the delivery of Agricultural Education, which led to the development of the Curriculum for Agricultural Science Education (CASE, n.d.). The purpose of CASE was to develop a complete package of resources for teaching the curriculum and reduce the stress of having to prepare materials while putting the focus on instruction and student interaction (CASE, n.d.). Teachers had the chance to refocus and reflect on their teaching practices when the CASE curriculum was used (Lambert et al., 2014).

Inquiry-based learning has been incorporated into teachers' curricula to enhance student interest in several content areas (Wells et al., 2015). Inquiry-based learning has fundamentally been a part of agricultural education since its inception (Wells et al., 2015), though the term inquiry-based instruction hasn't always been used. This type of learning requires deep engagement from the students using questioning to create answers using research to solve problems (Wells et al., 2015) while the teachers transform into the role of learning facilitators (Thoron & Myers, 2012). As students become more engaged in the learning process through a student-based approach, the greater impact the method has on student learning through scientific inquiry (Parr & Edwards, 2004). When teaching science, an effective form of teaching is using an inquiry-based instructional approach (Parr & Edwards, 2004). The positive reactions and attitudes when using inquiry-based learning resulted in agriculture teachers becoming leaders and shifting this type of learning to align with the teaching methods being used within science education (Thoron et al., 2011).

The CASE curriculum has been noted as a curriculum that promotes inquiry-based learning and serves as a platform to bolster students' critical thinking skills (Bird & Rice, 2021). This study works to add to the knowledge base of the CASE curriculum and how it impacts the teachers' perceptions of utilizing inquiry-based instructional methods in their classrooms. This study contributes to the 2016-2020 National Research Agenda's Priority Area 4: Meaningful, Engaged Learning in all Environments. The National Research Agenda states, "Effective teaching has continually been hampered by pedagogical constraints, such as time, materials, and ever-changing technological advances. There are various interpretations on how best to incorporate educational practices to better educate learners" (Roberts et al., 2016, p. 38.) CASE works to incorporate the best practices of inquiry-based instruction with the essential content knowledge of agriculture to provide teachers with the resources necessary to engage students in their learning. The first step to understanding how the curriculum impacts student learning, we must first develop an understanding of how teachers perceive the instructional practices of the curriculum.

Conceptual Framework

The framework for this research was based on the technology acceptance model (TAM). TAM's variables focus on the external variables, perceived usefulness, perceived ease of use, and intentions (Davis, 1989; Sun et al., 2010). This model focuses on individual adoption and the use of technologies / innovations. The intention to use the technology / innovation is based on two factors focusing on the perceived usefulness and perceived ease of use.

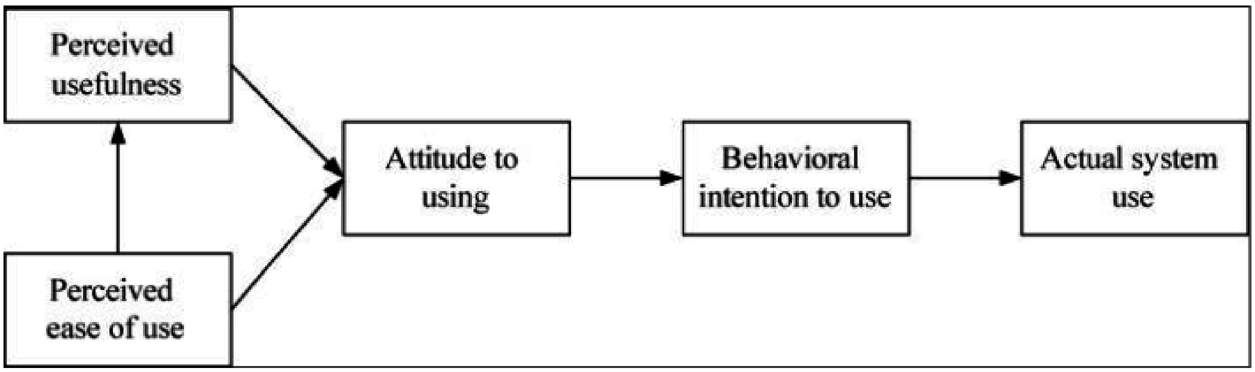

Figure 1. TAM Model by Davis (1989)

The perceived usefulness focuses on the degree to which one believes that the innovation would bolster their job performance (Davis, 1989). The perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis 1989, p. 320). Behavioral intentions are influenced by the attitude which is the general impression someone might have. The actual system use is the endpoint in which people would use the system. Several factors are encompassed in an individual's decision regarding how and when it will be utilized. External variables such as social influences are important factors to determine the attitude.

Purpose/Objectives

The purpose of this study was to describe the influence of CASE professional development institutes on the teacher-participant perceptions of science integration and inquiry-based instruction in agricultural education through a pre and post CASE professional development workshop.

The following objectives served to guide this research:

1. To describe the participants' perceptions of science integration in agricultural education pre and post a CASE professional development institute.
2. To describe the participants' immediate and long-term perceptions of inquiry-based instruction (IBI) implementation following a CASE professional development institute.

Methods

We attempted a census of all (N = 38) high school agricultural educators who were participants in the Principles of Agricultural Science-Plant (ASP) and the Agricultural Power and Technology (APT) CASE institutes. This was a descriptive study that employed a longitudinal, panel research design which was facilitated by administering an instrument before and after the teachers' engagement in the CASE institutes. The participants' contact information of the participants was collected from the host institution. Dillman et al.'s (2014) tailored design method was used for the data collection procedures. All participants of the two CASE institutes were notified of this study via email a week before arriving at the institutes. The email provided an overview of the study, a copy of the IRB protocol, and a link to access the pre-test instrument on Qualtrics. Upon the completion of the Institute, participants were asked to complete the post-test as the final activity of the workshop. Post-tests were only administered to the participants who had completed the pre-test (n = 28).

The survey instrument used in this study was comprised of three main components. Part one was the Integrative Science survey (ISS) instrument (Thompson & Schumacher, 1998), which included 11 statements focusing on the perceptions toward the integration of science, seven statements focusing on preparation to integrate science, five statements focusing on the impact of science integration on student recruitment, and 17 statements focusing on the perceptions of barriers to science integration. In part one, participants were asked to evaluate the perceived agreement on a five-point scale (SD = *Strongly Disagree,* D = *Disagree*, N = *Neither Disagree nor Agree*, A = *Agree*, SA = *Strongly Agree*, NA = *Not Applicable*).

In part two of the instrument, participants completed the Inquiry-based Teaching Techniques (ITT) instrument (Dunbar, 2002), which included nine statements focusing on general activities and planning when implementing inquiry-based instruction and 12 items that sought to determine the teachers' perceptions of student activities during classroom instruction. Finally, part three of the instrument contained demographic / background questions related to gender, age, years of experience, highest degree obtained, and engagement in previous professional development (e.g., NATTA workshops or CASE Institutes).

Reminder emails for the pretest were sent to non-respondents via email. The reminder emails were distributed three days after the initial emails were sent out. A total of 28 out of the 38 CASE participants responded to the first instrument, yielding a response rate of 73.68%. While the response rate was high, our attempt at a census of all CASE participants failed. The post-test was administered to individuals who completed the online pre-test. The post-test was completed as the last activity of the CASE institute, and all 28 respondents completed the post-test.

Participants

The average participant was female (61%), had an average age of 36.12 (SD = 13.22) years, and had an average of 10.46 (SD = 11.32) years of teaching experience. The school-based agricultural education teachers who responded to this study hailed from nine different states across the Nation. The highest frequency of participants (39%) earned a bachelor's degree plus some graduate courses and 35% of participants had earned a bachelor's degree. Eleven percent of the participants had previously attended an NATAA workshop and 7% had attended other agriscience integration workshops besides CASE or NATAA (see Table 1).

Table 1

Demographic Profile of Respondents (n = 28)

Characteristic	*f*	%
Gender		
Female	17	60.7%
Male	11	39.3%
Highest level of post-secondary education		
Bachelor's degree plus some graduate courses	11	39.3%
Bachelor's degree	10	35.7%
Master's degree	5	17.9%
Master's degree plus additional graduate courses	2	7.1%
Professional Development (PD)		
Previously attended an NATAA workshop	3	10.7%
Attended other Agriscience Integration workshops besides CASE or NATAA	2	7.1%

Validity & Reliability

The face and content validity of the instrument was assessed by sending the instrument to a panel of experts. The panel included three agricultural education faculty members who had previous experience working with the CASE curriculum. The panel members were asked to review the instrument for content and face validity and to provide recommendations for instrument improvement. We made augmentations to the wording of items and directions provided on the instrument based on the recommendations of the panel members.

The instrument used in this study was comprised of instruments (i.e., ISS and ITT) from two previous studies (Dunbar, 2002; Thompson & Schumacher, 1998). The developers of the aforementioned instruments assessed the reliability of the ISS (Cronbach's Alpha = .88; Thompson & Schumacher, 1998) and ITT (Cronbach's Alpha = .90; Dunbar, 2002) instruments in the seminal studies. While we only made minor augmentations to the original instruments to focus on the CASE curriculum, we did our due diligence to ensure the reliability of our instrument. Specifically, we conducted a pilot study and a post-hoc assessment of reliability. The pilot test was comprised of a sample of teachers who had previously engaged in CASE institutes (n = 15). Reliability analysis of the pilot test results rendered a Cronbach's alpha of 0.93. The post-hoc reliability test revealed acceptable levels of reliability on both the pre-test ($\alpha = .95$) and post-test ($\alpha = .97$) which were administered in this study.

Data Analysis

The data in this study were analyzed using the IBM® Statistical Package for the Social Sciences (SPSS©) Version 29. Descriptive statistics (i.e., frequencies, percentages, means, standard deviations) were used to analyze the demographic / background characteristics of the

SBAE teachers. The SBAE teachers' responses to the first part (Integrative Science survey [ISS]) and the second part (Inquiry-based Teaching Techniques [ITT]) of the instrument were analyzed by calculating the frequency and modes of each item for both the pre-test and post-test. The percentages of the scale anchor which represented the mode(s) were bolded for readability.

Results

Participants responded to perceptions toward the integration of science pre and post CASE institute. On the pre-test, two items had a mode of five (*Strongly Agree*), five items had a mode of four (*Agree*), two items had a mode of two (*Disagree*), and one item, Students are more motivated to learn when science is integrated into the Ag. Ed. Program was trimodal with modes of three (*Neither Disagree nor Agree*) and four (*Agree*), and five (*Strongly Agree*). Lastly, the item "Students are better prepared in science after they completed a course in Ag. Ed. that integrates science" was bimodal with modes of four (*Agree*) and five (*Strongly Agree*). Table two provides an overview of the respondents' perceptions toward the integration of science pre and post institute. For each item, the percentage of the scale descriptor associated with the mode was bolded for enhanced readability.

Table 2

Respondents' Perceptions Toward the Integration of Science Pre and Post Institute (n = 28)

		%						*Md*
		SD[b]	*D*	*N*	*A*	*SA*	*NA*	
Science concepts are easier for students to understand when science is integrated into the Ag. Ed. program.	Pre Post	0.0 3.7	0.0 3.7	7.1 11.1	39.3 37.0	**53.6** **44.4**	2.7 0.0	5 5
Students are better prepared in science after they completed a course in Ag. Ed. that integrates science.	Pre Post	0.0 7.4	0.0 0.0	7.1 7.4	**46.4** **51.8**	**46.4** 33.3	0.0 0.0	4/5 4
Students learn more about agriculture when science concepts are an integral part of their instruction.	Pre Post	0.0 0.0	3.6 7.4	14.3 7.4	28.6 **55.5**	**53.6** 29.6	0.0 0.0	5 4
Integrating science into the Ag. Ed. program requires more preparation time than teaching a more traditional agriculture curriculum.	Pre Post	0.0 7.4	17.9 7.4	17.9 3.7	**50.0** 33.3	14.3 **44.4**	0.0 3.7	4 5
Integrating science into agriculture classes increase the ability to teach students to solve problems.	Pre Post	0.0 7.4	0.0 0.0	7.1 0.0	**50.0** **62.9**	42.9 29.6	0.0 0.0	4 4
Students are more aware of the connection between scientific principles and agriculture when science concepts are an integral part of their instruction in Ag. Ed.	Pre Post	0.0 3.7	0.0 0.0	10.7 7.4	**57.1** **48.1**	32.1 40.7	0.0 0.0	4 4
Integrating science into the Ag. Ed. curriculum more effectively meets the	Pre Post	0.0 7.4	7.1 7.4	35.7 18.5	**50.0** **44.4**	7.1 22.2	0.0 0.0	4 4

needs of special population students (i.e. learning disabled).								
Agriculture concepts are easier for students to understand when science is integrated into the Ag. Ed. program.	Pre	0.0	3.6	21.4	**46.4**	28.6	0.0	4
	Post	3.7	0.0	33.3	**40.7**	22.2	0.0	4
Students are more motivated to learn when science is integrated into the Ag. Ed. program.	Pre	0.0	3.6	**32.1**	**32.1**	**32.1**	0.0	3/4/5
	Post	0.0	7.4	22.2	**48.1**	22.2	0.0	4
Less effort is required to integrate science in advanced courses as compared to introductory courses.	Pre	7.1	**53.6**	28.6	10.7	5.4	0.0	2
	Post	11.1	**48.1**	11.1	22.2	7.4	0.0	2
It is more appropriate to integrate science in advanced courses than into introductory courses.	Pre	3.6	**35.7**	32.1	14.3	14.3	0.0	2
	Post	11.1	**29.6**	22.2	25.9	11.1	0.0	2

Note: [b]*SD = Strongly Disagree*, *D = Disagree*, *N = Neither Disagree nor Agree*, *A = Agree*, *SA = Strongly Agree*, *NA = Not Applicable; Md* = Mode.

For the responses on the post-test two items had a mode of five (*Strongly Agree*), seven items had a mode of four (*Agree*), and two items had a mode of two (*Disagree*). The item with the highest percentage of *Strongly Agree* responses was *Science concepts are easier for students to understand when science is integrated into the Ag. Ed. Program* (Pre: *SA* = 53.6%, *Md* = 5; Post: *SA* = 44.4%, *Md* = 5). The two items with the overall lowest modes were *Less effort is required to integrate science in advanced courses as compared to introductory courses* (Pre: *D* = 53.6%, *Md* = 2; Post: *D* = 48.1%, *Md* = 2) and *It is more appropriate to integrate science in advanced courses than into introductory courses* (Pre: *D* = 35.7%, *Md* = 2; Post: *D* = 29.6%, *Md* = 2).

Participants were asked to respond to seven items associated with preparing to integrate science, pre and post institute. Based on the responses on the pre-test, all items had a mode of four (*Agree*). Six items on the post-test had a mode of four (*Agree*), and the item *I feel prepared to teach integrated biological science concepts* had a mode of five (*Strongly Agree*) and four (*Agree*). The item which the highest percentage of teachers indicated agreement with, both on the pre- and post-test, was *Teacher preparation programs in agriculture should provide instruction for pre-service teachers on how to integrate science concepts/principles in agriculture* (Pre: *A* = 78.6%, *Md* = 4; Post: *A* = 51.8%, *Md* = 4; see Table 3).

Table 3

Respondents' Preparation to Integrate Science Pre And Post Institute (n = 28)

		%						*Md*
		SD[b]	*D*	*N*	*A*	*SA*	*NA*	
Teacher preparation programs in agriculture should provide instruction for pre-service teachers on how to integrate science concepts/principles in agriculture.	Pre	0.0	0.0	0.0	**78.6**	21.4	0.0	4
	Post	3.7	3.7	0.0	**51.8**	40.7	0.0	4

I feel prepared to teach integrated biological science concepts	Pre	0.0	7.1	10.7	**60.7**	21.4	0.0	4
	Post	3.7	7.4	14.8	**37.0**	**37.0**	0.0	4/5
Teacher preparation programs should require that students conduct their early field experience programs (prior to student teaching) with a teacher who integrates science into the Ag. Ed. program.	Pre	0.0	7.1	14.3	**60.7**	17.9	0.0	4
	Post	3.7	3.7	22.2	**40.7**	29.6	0.0	4
Teacher preparation programs in agriculture should require students to take more science courses (biology, chemistry, physics, etc.)	Pre	0.0	0.0	32.1	**53.6**	14.3	0.0	4
	Post	3.7	7.4	25.9	**33.3**	29.6	0.0	4
Teacher preparation programs in agriculture should expect cooperating teachers to model science integration	Pre	0.0	0.0	28.6	**53.6**	17.9	0.0	4
	Post	3.7	7.4	14.8	**48.1**	25.9	0.0	4
Teacher preparation programs should require that students conduct student teaching internships with a teacher who integrates science into Ag. Ed. program.	Pre	0.0	10.7	25.0	**53.6**	10.7	0.0	4
	Post	3.7	7.4	18.5	**44.4**	25.9	0.0	4
I feel prepared to teach integrated physical science concepts	Pre	0.0	17.9	17.9	**46.4**	17.9	0.0	4
	Post	7.4	11.1	11.1	**40.7**	29.6	0.0	4

Note: SD = [b]*Strongly Disagree*, *D = Disagree*, *N = Neither Disagree nor Agree*, *A = Agree*, *SA = Strongly Agree*, *NA = Not Applicable*; *Md* = Mode.

Along with questions about preparation for science integration, teachers were also asked to respond to items related to the impact of science integration on the recruitment of students. Three of the items on the pre-test had a mode of four (*Increase*) and two pre-test items had a mode of three (*Neither*). All items on the post-test had a mode of four (*Increase*). When comparing the modes of the items between the two iterations of instruments, the modes representing the recruitment of *Minority students* (Pre: *N* = 53.6%, *Md* = 3; Post: *I* = 38.4%, *Md* = 4) and *Low achieving students* (Pre: *N* = 42.9%, *Md* = 3; Post: *I* = 40.0%, *Md* = 4) both increased from a three (*Neither*) to a four (*Increase*; see Table 4).

Table 4

Respondents' Perceptions of the Impact of Science Integration on Student Recruitment Pre and Post Institute (n = 28)

		%						*Md*
		Greatly Decrease	Decrease	Neither	Increase	Greatly Increase	NA	
Average achieving students	Pre	0.0	0.0	39.3	**57.1**	3.6	0.0	4
	Post	3.8	7.6	19.2	**57.6**	11.5	0.0	4
Total program enrollment	Pre	0.0	10.7	28.6	**53.6**	7.1	0.0	4
	Post	0.0	8.0	16.0	**64.0**	12.0	0.0	4

High achieving students	Pre	0.0	0.0	14.3	**60.7**	17.9	7.1	4
	Post	0.0	0.0	7.6	**57.6**	34.6	0.0	4
Minority students	Pre	0.0	10.7	**53.6**	32.1	3.6	0.0	3
	Post	7.6	7.6	34.6	**38.4**	11.5	0.0	4
Low achieving students	Pre	0.0	32.1	**42.9**	17.9	7.1	0.0	3
	Post	4.0	28.0	20.0	**40.0**	8.0	0.0	4

Note: Md = Mode.

The teachers were also asked to respond to items that gauged their perceptions of barriers to science integration in their local programs. Based on the responses in the pre- and post-test, the teachers agreed that three items served as barriers to science integration including: *Insufficient time and support to plan for implementation* (Pre: *A* = 42.9%, *Md* = 4; Post: *A* = 48.1%, *Md* = 4), *Don't have the necessary materials* (Pre: *A* = 32.1%, *Md* = 4; Post: *A* = 29.6%, *Md* = 4), and *Concerns about large class size* (Pre: *A* = 28.6%, *Md* = 4; Post: *A* = 40.7%, *Md* = 4). One item on the pre-test, *Lack of experience in science integration* (Pre: *D* = 39.3%, *A* = 39.3%, *Md* = 2/4) was bimodal which infers there is a split in agreement regarding the teachers' perceived experience associated with science integration. A total of 12 items on the pre-test and 14 items on the post-test had a mode of two (*Disagree*)—signifying the teachers did not perceive these factors to be barriers to science integration. The items where the teachers indicated their strongest levels of disagreement regarding the presence of barriers to science integration were *Have tried it and it was unsuccessful* (Pre: *D* = 71.4, *Md* = 2) and *Disagreement with the notion that science integration is necessary* (Pre: *D* = 67.9, *Md* = 2) on the pretest, and the items *Insufficient background in science content* (Post: *D* = 51.8, *Md* = 2) and *Lack of administrative support for science integration* (Post: *D* = 51.8, *Md* = 2) on the posttest (see Table 5).

Table 5

Respondents' Perceptions of Barriers to Science Integration Pre- and Post-Institute [a] (n = 28)

		%						*Md*
		SD[b]	*D*	*N*	*A*	*SA*	*NA*	
Insufficient time and support to plan for implementation	Pre	3.6	28.6	17.9	**42.9**	7.1	0.0	4
	Post	7.4	22.2	14.8	**48.1**	3.7	3.7	4
Don't have the necessary materials	Pre	3.6	28.6	25.0	**32.1**	3.6	7.1	4
	Post	11.1	25.9	18.5	**29.6**	14.8	0.0	4
Concerns about large class size	Pre	10.7	25.0	25.0	**28.6**	7.1	3.6	4
	Post	7.4	29.6	11.1	**40.7**	7.4	3.7	4
Reluctance to give up the role of primary source of classroom information	Pre	3.6	42.9	**50.0**	3.6	0.0	0.0	3
	Post	14.8	**37.0**	29.6	18.5	0.0	0.0	2
Lack of experience in science integration	Pre	3.6	**39.3**	17.9	**39.3**	0.0	0.0	2/4
	Post	7.4	**48.1**	14.8	22.2	7.4	0.0	2
Have tried it and it was unsuccessful	Pre	7.1	**71.4**	14.3	0.0	0.0	7.1	2
	Post	11.1	**37.0**	25.9	14.8	0.0	11.1	2

Disagreement with the notion that science integration is necessary	Pre	28.6	**67.9**	3.6	0.0	0.0	0.0	2
	Post	33.3	**48.1**	14.8	3.7	0.0	0.0	2
Lack of integrated science curriculum in courses I teach	Pre	3.6	**50.0**	14.3	32.1	0.0	0.0	2
	Post	11.1	**48.1**	22.2	14.8	0.0	3.7	2
Lack of parent and community support for science integration	Pre	0.0	**50.0**	28.6	17.9	0.0	3.6	2
	Post	3.7	**40.7**	37.0	14.8	0.0	3.7	2
Insufficient background in science content	Pre	17.9	**46.4**	21.4	14.3	0.0	0.0	2
	Post	11.1	**51.8**	22.2	14.8	0.0	0.0	2
Lack of agriscience jobs in the local community	Pre	10.7	**46.4**	10.7	25.0	0.0	7.1	2
	Post	18.5	**44.4**	22.2	14.8	0.0	0.0	2
Doubts about students' capacity to handle material	Pre	7.1	**46.4**	25.0	14.3	7.1	0.0	2
	Post	14.8	**44.4**	11.1	29.6	0.0	0.0	2
Lack of administrative support for science integration	Pre	21.4	**42.9**	21.4	3.6	3.6	7.1	2
	Post	18.5	**51.8**	18.5	11.1	0.0	0.0	2
Reluctance to diminish emphasis on agricultural production	Pre	0.0	**42.9**	35.7	14.3	7.1	0.0	2
	Post	7.6	**42.3**	11.5	34.6	3.8	0.0	2
Lack of support from local science teacher(s)	Pre	14.3	**39.3**	21.4	17.9	0.0	7.1	2
	Post	14.8	**44.4**	25.9	11.1	0.0	3.7	2
Concerns about discipline	Pre	3.6	**39.3**	28.6	25.0	0.0	3.6	2
	Post	7.4	**44.4**	18.5	25.9	0.0	3.7	2
Insufficient funding	Pre	17.9	**32.1**	7.1	21.4	14.3	7.1	2
	Post	7.4	**29.6**	22.2	22.2	14.8	3.7	2

Note: [a] All items are reverse coded, [b]*SD = Strongly Disagree*, *D = Disagree*, *N = Neither Disagree nor Agree*, *A = Agree*, *SA = Strongly Agree*, *NA = Not Applicable; Md* = Mode.

Respondents were asked to identify the frequency in which they engaged in various general and planning activities when implementing inquiry-based instruction. Of the items presented to the teachers, teachers indicated most frequently using open-ended questions to encourage observation, investigation, and scientific thinking of their students (see Table 6).

Table 6

Respondents' Perceptions of General Activities and Planning When Implementing Inquiry-Based Instruction Pre and Post Institute (n = 28)

		%							*Md*
		1	**2**	**3**	**4**	**5**	**6**	**7**	
On average, to what extent do you…		Never	<1x / wk.	1x / wk.	2x / wk.	3x / wk.	4x / wk.	5x / wk.	
Use open-ended questions that encourage observation, investigations, and scientific thinking.	Pre	0.0	0.0	3.6	28.6	**32.1**	14.3	21.4	5
	Post	0.0	0.0	14.8	11.1	**29.6**	25.9	18.5	5
Identify agricultural situations/issues that can be investigated at varying levels of complexity.	Pre	0.0	14.3	7.1	28.6	**32.1**	7.1	10.7	5
	Post	0.0	7.4	18.5	**22.2**	14.8	25.9	11.1	4
Encourage students to defend the adequacy or logic of statements and findings.	Pre	3.6	14.3	17.9	14.3	**28.6**	14.3	7.1	5
	Post	0.0	7.4	14.8	**22.2**	**22.2**	**22.2**	11.1	5/6/7
Encourage students to design and conduct experiments.	Pre	7.1	17.9	14.3	**25.0**	**25.0**	10.7	0.0	4/5
	Post	3.7	14.8	22.2	**25.9**	14.8	7.4	11.1	4
Make readily available to students a wide variety of resource materials for scientific investigations.	Pre	3.6	10.7	**21.4**	14.3	14.3	**21.4**	14.3	3/6
	Post	0.0	3.7	29.6	**33.3**	14.8	7.4	11.1	4
Encourage students to initiate further investigation.	Pre	0.0	3.6	17.9	**28.6**	21.4	17.9	10.7	4
	Post	0.0	3.7	18.5	**25.9**	11.1	**25.9**	14.8	4/6
Ask a question or conduct an activity that calls for a single correct answer.	Pre	7.1	7.1	17.9	**28.6**	14.3	14.3	10.7	4
	Post	0.0	11.4	18.5	**29.6**	14.8	11.1	14.8	4
Facilitate and encourage student dialogue about science.	Pre	3.6	17.9	10.7	**21.4**	**21.4**	10.7	14.3	4/5
	Post	0.0	11.5	15.3	**26.9**	23.0	11.5	11.5	4

Use a textbook as the primary method for teaching agriscience.	Pre	21.4	**46.4**	14.3	17.9	0.0	0.0	0.0	2
	Post	7.4	**55.5**	29.6	7.4	0.0	0.0	0.0	2

Note: Md = Mode.

This item was presented on a seven-point scale with one being *Never*, and seven representing *5 x / week*. On the pre-test, one item had a mode of five (*3x / week*), two items had a mode of four (*2x / week*), and one item had a mode of two (*<1x / week*). Moreover, the item *Make readily available to students a wide variety of resource materials for scientific investigations* was bimodal (*Md* = 3/6). Two items (i.e., *Encourage students to design and conduct experiments* and *Facilitate and encourage student dialogue about science*) were bimodal with modes of four (*2x / week*) and five (*3x / week*).

Concerning the post-test, one item had a mode of five (*3x / week*), five items had a mode of four (*2x / week*), and one item had a mode of two (*<1x / week*). *Encourage students to defend the adequacy or logic of statements and findings*, had three modes (*Md* = 5/6/7), and *Encourage students to initiate further investigation* had two modes (*Md* = 4/6).

The last group of items sought to describe the student activities which the teachers implemented in their SBAE programs. Eleven items on the pre-test had a mode of five (*1x / Week*) and one item, *Follow a set series of steps to get the right answer to a question*, had a mode of four (*1x / Month*) and five (*1x / Week*).

On the post-test, the item Ask questions during investigations that lead to further ideas, questions, and investigations, had the highest mode of all items (Post: *1x / day* = 38.4%; *Md* = 6). The mode for this item showed an increase when compared to the pretest where 25% of the teachers indicated they asked questions to spark inquiries once a day (Pre: *1x / day* = 25.0%; *Md* = 5). Furthermore, eight items on the post-test had a mode of five (*1x / Week*), two had a mode of four (*1x / Month*), and one was bimodal (Md = 4 [*1x / Month*], 5 [*1x / Week*]; see Table 7).

Table 7

Respondents' Perceptions of Student Activities During Classroom Instruction Pre and Post Institute (n = 28)

		%						*Md*
		1	**2**	**3**	**4**	**5**	**6**	
How often do you ask students in your classroom to:		Never	1x / Year	1x / Semester	1x / Month	1x / Week	1x / Day	
Use data to construct a reasonable explanation.	Pre	3.6	3.6	7.1	21.4	**60.7**	3.6	5
	Post	3.8	7.6	15.3	26.9	**30.7**	15.3	5
Choose appropriate tools for an investigation.	Pre	0.0	3.6	3.6	14.3	**53.6**	25.0	5
	Post	0.0	12.0	8.0	12.0	**36.0**	32.0	5
Listen carefully to peers as they discuss scientific investigations.	Pre	3.6	3.6	10.7	17.9	**53.6**	10.7	5
	Post	0.0	7.6	11.5	23.0	**30.7**	26.9	5

Wait to act until the teacher gives instructions for the next step in the investigation.	Pre Post	17.9 3.8	0.0 7.6	0.0 11.5	14.3 **30.7**	**53.6** **30.7**	14.3 11.5	5 4/5
Offer explanations from previous experiences and knowledge gained during investigations.	Pre Post	3.6 0.0	0.0 11.5	7.1 11.5	10.7 11.5	**50.0** **53.8**	28.6 11.5	5 5
Make connections to previously held ideas (or revise previous conceptions /assumptions).	Pre Post	0.0 0.0	0.0 11.5	3.6 11.5	25.0 15.3	**50.0** **38.4**	21.4 23.0	5 5
Use drawing, graphing, or charting to convey new information from an agriscience activity.	Pre Post	3.6 0.0	0.0 11.5	14.3 11.5	28.6 15.3	**46.4** **46.1**	7.1 15.3	5 5
Communicate investigations and explanations (purposes, procedures, and/or results of investigations) to others.	Pre Post	0.0 0.0	0.0 7.6	10.7 11.5	25.0 19.2	**46.4** **42.3**	17.9 15.3	5 5
Ask questions during investigations that lead to further ideas, questions, and investigations.	Pre Post	3.6 0.0	3.6 3.8	3.6 19.2	17.9 11.5	**46.4** 26.9	25.0 **38.4**	5 6
Seek and recognize patterns (trends in the data or observations).	Pre Post	3.6 3.8	3.6 7.6	10.7 15.3	35.7 **19.2**	**46.4** 8.4	0.0 15.3	5 4
Follow a set series of steps to get the right answer to a question.	Pre Post	0.0 0.0	0.0 3.8	3.6 15.3	**35.7** 19.2	**35.7** **30.7**	25.0 30.7	4/5 5
Memorize scientific facts or information separately from activities.	Pre Post	10.7 8.0	17.9 8.0	14.3 20.0	25.0 **32.0**	**28.6** 20.0	3.6 12.0	5 4

Note. *Md* = Mode.

Discussion

The purpose of this study was to describe the influence of CASE professional development institutes on the teacher-participant perceptions of science integration and inquiry-based instruction (IBI) before and after participating in the institute. The intent was not to generalize the results to all CASE participants, but rather to describe the sample of teachers who took part in these two specific CASE professional development institutes. Due to the lack of a probabilistic sample, caution should be exercised when attempting to generalize the results of this study beyond the CASE institute participants in this study.

Though there were differences in pre-post results of both CASE institutes overall, respondents had more positive perceptions of science integration and IBI following the CASE institutes. Similar to findings presented by Lambert et al. (2014) and Bird and Rice (2021), participants of the institutes experienced positive growth in science integration and inquiry-based instruction from their participation. In reference to the TAM model, the teachers' enhanced perceptions of inquiry-based learning imply they see the utility in this learning style (i.e., perceived usefulness) and have a desire to provide a more autonomous learning environment for their students (Davis 1989). These findings can guide future efforts in science integration and implementing IBI in agricultural education through teachers' professional development experiences. This leads to a recommendation that some of the specific findings need to be provided to CASE staff and lead teachers of the growth participants had from participating in the CASE institutes.

Previous studies have found that it takes time to adjust to implementing IBI (Blythe et al., 2014; Osman & Warner, 2020) so the teacher's immediate perceptions of future implementations may be skewed. Furthermore, Desimone (2009), indicated that professional development doesn't conclude when the face-to-face portion is over, it must include continued support and engagement while teachers implement what they learn. This study only examined the respondents' perceptions of their frequency of IBI pre-Institute participation and their plans to implement IBI upon returning to their classrooms. Research studies which examine CASE participants' classrooms following the institute would be beneficial, as well as following CASE teachers over years of implementing the curriculum This research only examined the perceptions of SBAE teachers at two CASE institutes (i.e., AFNR and APT). Similar studies should be conducted which examine SBAE teachers' perceptions of science integration and IBI at other CASE institutes.

In reference to the TAM, the teachers indicated a positive outlook on the perceived usefulness of science integration, but harbored negative feelings related to the perceived ease of use. Regarding perceived usefulness in the Technology Acceptance Model (TAM), teachers indicated the science integration helped their students understand science principles easier and that it had a positive impact on learning-disabled students. Furthermore, the teachers indicated it would be useful to include teacher preparation coursework on how to integrate science concepts/principles in agriculture classes. On the other hand, the teachers had negative feelings associated with the perceived ease of use. The teachers felt that the stronger integration of science concepts in SBAE classes does not make it easier to understand agricultural concepts and they felt that this style of science integration took too much time to prepare for science-integration lessons. The teachers also indicated they did not have the support and resources to implement all the CASE activities. The lack of financial support and resources is a commonly mentioned barrier for teachers to integrate CASE [Citation].

Teachers had mixed perceptions associated with their attitude toward using inquiry-based instruction (IBI) implementation. The teachers in this study showed some hesitation regarding the introduction of more science content in their SBAE classes. While the teachers were hesitant to integrate more science content in their SBAE classes and noted they had a lack of financial and administrative support, they disagreed with the presence of barriers on all other items.

The results of this study provide insight as to the potential growth which is possible by SBAE teachers who participate in a CASE institute in integrating science and inquiry-based teaching techniques. However, this growth is based on current practices and philosophies. There is a need to determine whether these techniques will need to be improved upon to meet the needs of future generations of teachers.

This study has implications for agricultural education programs. Teacher educators can incorporate inquiry-based teaching techniques and examples of integrating science into agricultural education. Facilitating discussion on this topic will provide an opportunity for preservice teachers to reflect on strategies for implementing inquiry-based teaching techniques and examples to integrate science. Additionally, training activities may help pre-service and agricultural educators to enhance their skills. In fact, the teachers in this study purported they felt better prepared to teach integrated biological and physical science concepts after taking part in the professional development. The enhancement of the teachers' perceived self-efficacy to teach the science concepts shows the perceived usefulness with their intention to use (Davis, 1989)

Additional research is needed to focus on the impacts of CASE institutes on teachers' attitudes towards science integration and implementation of IBI in their classrooms. A larger study needs to occur focusing on the long-term science integration and implementation of IBI within the agricultural education classroom. Having a longitudinal study to focus on this long-term implementation would provide more insight into the implementation.

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