

Agriscience Teachers' Perceptions of Integrating Science Within Plant Science Curricula in Secondary Schools



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Abstract

By the end of the 12th grade, regardless of future career paths, students need enough science knowledge to be functional members of society as informed consumers and decision-makers. To convey scientific core ideas and technical concepts in unison, teachers must have adequate knowledge and experience in both areas. Teachers' content knowledge and instructional practices have been shown to improve students' science and STEM learning. This study examined secondary agriscience teachers' intentions to illuminate science within their plant science courses. An exploratory, multiple time-series research design was utilized. Overall, teachers displayed increased mean scores in all five factors across the testing periods. Significant differences were found for four factors: attitudes and perceptions toward science integration, preparation to integrate science, support for integration, and perceived impact of integration on recruitment. Results indicated that content-specific professional development can significantly impact teachers' perceptions toward illuminating science in their secondary plant science courses. Only when teachers believe they can integrate science into their classes can students be exposed to the science of agriculture.

Keywords: beliefs, floriculture, horticulture, illumination, secondary

Today's agriculture industry is no longer powered by the yeoman farmer, producing enough for their family to subsist. While large-scale production in the form of farming is still the main driver of the world's agriculture, scientific agriculture is necessary to meet the continually increasing demands for food and energy on less available land (NRC, 2009). However, public perceptions of agriculture have remained low, leading much of the population to view the industry as less desirable for career possibilities. Today, less than 1.3% of US employment can be attributed to the agricultural industry (USDA ERS, 2021). While the romanticized image of agriculture remains markedly similar throughout American culture and literary traditions (Effland, 2021; Esbjornson, 1992), today's agricultural workforce requires skilled individuals who understand agriculture as a complex system but who also have mastery of applied science, engineering, technology, and math concepts (STEM; NRC, 2009).

The agricultural industry and the United States education system should work in unison to reflect one another to prepare a workforce with the high-STEM skills needed for today's scientific agriculture (CADRE, 2014). By the end of the 12th grade, regardless of future career paths, students should possess enough science knowledge to be functional members of society as informed consumers and decision-makers. Additionally, students must continue to learn and utilize science throughout their lives (NRC, 2012). Agriculture can add to the structural framework of the Next Generation Science Standards (NGSS) by providing a context for the application of scientific core ideas (NRC, 2012). School-based agricultural education (SBAE)

curricula provide ample opportunities to facilitate this type of knowledge acquisition, as many agricultural contexts and problems typically involve numerous disciplines (NRC, 2014). Career and Technology Education (CTE) courses, such as those included in SBAE programs, have helped provide a seamless education aligned with K-12 core concepts by drawing on the active and applied learning strengths found in CTE. CTE has helped make scientific core ideas meaningful by providing opportunities to apply concepts through real-world contexts, such as agriculture (CADRE, 2014).

The foundations of SBAE have resided in developing the knowledge and skills in agriculture to support industry and occupational needs (Phipps et al., 2008). Agricultural education as a discipline seamlessly combines education and agriculture into a single discipline undergirded by education processes. SBAE occurs in the formal classroom and comprises three distinct structural components: classroom and laboratory instruction, supervised agricultural experiences (SAEs), and the National FFA Organization. Classroom and laboratory instruction have allowed students to understand and learn the principles and skills to solve complex agricultural problems (Phipps et al., 2008). SBAE curricula have reflected real-world work experiences in agriculture as supported by scientific disciplines and have been rooted in the idea that students learn best through application (Phipps et al., 2008). Science illumination is a term used to describe the action of teachers connecting scientific core ideas with procedural or technical agricultural knowledge (McKim, Velez, Lambert, & Balschweid, 2017). Illuminating scientific principles in agriculture has allowed fundamental science concepts to be re-emphasized and applied concretely (Phipps et al., 2008). Some teachers may have been purposeful science illuminators, while others may have tried but could not illuminate science effectively, known as illumination attempters. The critical difference between purposeful illuminators and illumination attempters is knowledge of technical agriculture concepts paired with scientific core ideas (McKim, Velez, Lambert, & Balschweid, 2017).

The content knowledge and instructional practices that teachers develop have been shown to improve science and STEM learning (NRC, 2013). In recent years, the perceptions of teachers and their intention to feature science within the SBAE curricula have been a significant focus of research related to STEM in SBAE (Haynes et al., 2014; McKim et al., 2018; Pauley et al., 2019; Stubbs and Myers, 2015, 2016; Thompson & Warnick, 2007; Thoron & Myers, 2010; Warnick & Thompson, 2007). Barriers, attitudes, types of use, confidence, and overall perceptions were major themes explored in the studies. Collectively, previous literature supports a connection between agricultural curricula and core scientific ideas (Haynes et al., 2014; Myers & Washburn, 2008; Smith et al., 2015; Stubbs & Myers, 2016; Thompson & Warnick, 2007; Thoron & Myers, 2010). Agriscience teachers have noted that science is the most related and natural fit of the four STEM content areas within agriculture (Haynes et al., 2014), and they are most confident in teaching science (Smith et al., 2015). While science was shown as profoundly intertwined with

agriculture, teachers also reported that a significant amount of scientific knowledge is needed to teach scientific core ideas in an agricultural context (Stubbs & Myers, 2015). Interestingly, teachers have also noted that lack of scientific knowledge is the most significant barrier to integrating science within the agriculture curricula (Myers & Washburn, 2008; Stubbs & Myers, 2015; Thompson & Warnick, 2007; Thoron & Myers, 2010).

Teacher knowledge has been a less common focus of inquiry related to science within the SBAE curricula. Self-efficacy, perceived knowledge measures, and actual measured content knowledge have all been examined. McKim, Velez, Lambert, and Balschweid (2017) emphasized the need for knowledge and competence in science and technical content to illuminate science within the SBAE curricula effectively. The only recent study to test the science knowledge of agriscience teachers found that only nine percent of teachers were proficient on a biology exam (Scales et al., 2009). Teacher confidence and self-efficacy have been more frequently studied. Overall, agriscience teachers feel confident in their ability to teach science content within SBAE, regardless of their actual knowledge level (Hendrix et al., 2020; Scales et al., 2009). Further, self-efficacy to teach science content within SBAE has been found to be related to participation in professional development (Ferand et al., 2020; McKim, Velez, and Clement, 2017).

Few studies have investigated the abilities of agriscience teachers concerning plant science curricula. McKim et al. (2018) found that teachers perceived 57% of the plant science curricula to be related to scientific core ideas. However, the science knowledge of agriscience teachers was found to be a negative predictor of their intention to teach science within the SBAE curricula (McKim et al., 2018). Science knowledge is most likely seen as a negative predictor of the intent to teach science because those with more knowledge in science will have realistic expectations about their ability to incorporate science into their assigned curricula. Lastly, Chumbley et al. (2019) reported a low, negative correlation between teachers' confidence to incorporate science within their curricula and SBAE courses offered for science credit.

Teachers' views about and confidence in teaching a subject are essential as teachers play a vital role in student motivation and content capacity-building (Jones, 2011). Agriscience teachers, in particular, can support student interests in the science of agriculture by encouraging participation in content-specific career development events through the National FFA Organization or the development of interest in specific agricultural careers (Williams et al., 2016). However, teachers have been found to spend less time on content they believe they do not know enough about (Ramey-Gassert & Shroyer, 1992). Teachers' perceived science knowledge may represent an additional barrier, ultimately influencing students' knowledge and perceptions of scientific core ideas in the SBAE curriculum. McKim, Velez, Lambert, and Balschweid (2017) noted the importance of scientific knowledge in teachers' illumination of science in the SBAE curriculum. Further, horticulture-specific subject matter, such as floriculture, has been noted as a particular area of challenge for agriscience teachers (Williams et al., 2016).

Purpose and Objectives

The purpose of this study was to examine agriscience teachers' intentions to illuminate science within their plant science courses. The specific objectives for this study were to:

1. Describe agriscience teachers' mean level of science integration, preparation to integrate science, support for integration, the impact of integration on recruitment, and barriers to integration for pre-, post-, and post-post test assessments; and
2. Determine any differences in agriscience teachers' pre-, post-, and post-post test mean levels of science integration, preparation to integrate science, support for integration, the impact of integration on recruitment, and barriers to integration.

Methods

An exploratory, multiple time-series research design was appropriate for investigating the effects of professional development on agriscience teachers' intentions to illuminate science within their plant science courses (Campbell & Stanley, 1963). The multiple time-series design controls for selection-maturation interaction through testing on multiple occasions (Isaac & Michael, 1995).

The first observation consisted of a pre-test that measured teachers' attitudes, perceived behavioral control, subjective norms, and perceived science knowledge related to the teachers' intention to illuminate science within their classrooms. The first observation was completed before they participated in the three-day intensive program. The second observation, which measured the same items as the pre-test, was completed immediately following the three-day program's conclusion. The third observation, which consisted of a post-post test measuring the same items of teachers' attitudes, perceived behavioral control, subjective norms, and perceived science knowledge as related to the teachers' intention to illuminate science within their instructional practices, occurred in December 2020, 2021, and 2022 for each group respectively, approximately two months after the conclusion of all interventions.

Population and Sampling

This study's population consisted of secondary agriscience teachers in the U.S. who taught horticulture, floriculture, or plant science courses. The sampling frame consisted of a convenience sample of secondary agriscience teachers who applied to the STEM-it Up: Everything You Need to Know to Get Your Floriculture Curriculum in Bloom (SIU) program for the 2020, 2021, and 2022 cohorts. To be eligible to apply for the program, teachers were required to teach at least one high school level or grades 9–12 horticulture, floriculture, or plant science course during the fall semester following their enrollment in the program (either fall 2020 or 2021, or 2022). Teachers were also required to have completed at least two years of teaching, starting at least their third year in the fall. All teachers from the three years of the SIU program were invited to participate in the

study (N = 58). A response rate of 72.4% was achieved for completion of all three testing occasions (n = 42). Non-response threatens the external validity of a research study, which is a limitation of this study (Lindner et al., 2001).

Teachers were recruited to participate in this study through convenience sampling methods. Teachers participated in the program, which took place during the summers and falls of 2020, 2021, and 2022. The program was "designed to deliver an intentional, systematic, and high-quality professional development with embedded inquiry-based opportunities focused on promoting exposure to [plant science] curricula" (Ferand et al., 2020, p. 191). The participating teachers received a three-day intensive professional development program and six 90-minute virtual follow-up sessions. One follow-up session occurred each month from July through December, resulting in over 40 contact hours of content-specific professional development combined with the summer conference. The conference and additional sessions included plant systems, the international floral industry, pathology, agriscience experiments, and industry tours. To build a learning community to support the participants' needs, the programming was specialized each year. Barriers to STEM integration, the need for identified resources, and additional discussion about curricular standards and the use of inquiry-based instruction were commonly addressed.

The majority of the participants were female (f = 35; 83.3%), were an average of 38 years old (SD = 11.4; Min. = 24; Max = 66), and were white in ethnicity (f = 41; 97.6%). More than half of the teachers held a bachelor's degree (f = 25; 59.5%). Most of the teachers were certified to teach through a traditional university program in agricultural education (f = 35; 83.3%), as opposed to alternative certification or being initially certified in another subject area. Two-thirds (f = 28; 66.7%) of teachers reported they had taught only agriculture. Teachers had an average of 9.6 years of teaching experience (SD = 7.5; Min. = 0; Max = 27). Almost sixty-two percent (f = 26) of the programs taught by the participants offered at least one SBAE course for science credit.

Applications for the program were distributed nationwide through listservs of national agricultural education organizations, such as the American Association for Agricultural Education, North American Colleges and Teachers of Agriculture, and the National Association of Agricultural Educators. Solicitation to apply for the program was also posted on social media groups for current agriscience teachers, such as "Ag Teacher Buddies" on Facebook.

Instrumentation

A modified version of Myers and Washburn's (2008) Integrating Agriscience Instrument (IAI) was utilized to measure teachers' attitudes, perceived behavioral control, subjective norms, and perceived science knowledge related to their intention to illuminate science within their classrooms. Myers and Washburn (2008) utilized items from an instrument initially created by Thompson (1996) to identify characteristics associated with the integration of

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science into SBAE and the implications of such integration. The instrument has also since been used with other populations of agriscience teachers, resulting in Cronbach's alpha reliabilities of .84 and .80 (Balschweid & Thompson, 2002; Myers & Washburn, 2008).

Myers and Washburn (2008) operationalized the IAI elements to align with Ajzen's (1991) theory of planned behavior. The theory of planned behavior can be used to understand, predict, and ultimately change behavior and was applied to guide this study (Ajzen, 2012). Originally put forth by Ajzen (1985), the theory of planned behavior combined several central ideas from the social and behavioral sciences, such as motivation, self-efficacy, and control, to provide valuable information on behavioral changes (Ajzen, 1991). The individual elements of perceived behavioral control, subjective norms, and attitudes towards the behavior aggregate to provide the intention to complete a specific action or behavior (Ajzen, 1991). While intervening events can affect a person's intention between assessment and completion of the behavior, the stronger a person's intention to engage in a behavior, the higher the likelihood the person will complete the actual behavior. Using the theory of planned behavior is beneficial when there is a choice of behavior among available alternatives (Ajzen, 1991).

For this study, attitudes were operationalized as teacher perceptions of science integration, while subjective norms were viewed as support of integration from stakeholder groups. Finally, the effects of integration on enrollment and perceived barriers operationalized perceived behavioral control. The final IAI instrument used in this study consisted of five factors of perceptions toward the integration of science. Each factor ranged from six to 18 items with total of 48 total items related to integrating agriscience in the instrument. The five factors, along with example items from each section and included below.

1. Attitudes and perceptions toward science integration (PTIS): "students learn more about agriculture when science concepts are an integral part of their instruction" and "students are better prepared in science after they completed a course in agricultural education that integrates science"
2. Preparation to integrate science (PIS): "I feel prepared to teach integrated science concepts" and "teacher preparation programs in agriculture should require students to take more science courses"
3. Support for integration (SI): "how [do] you feel integrating science into your agricultural education program would (or does) increase or decrease the support you receive from: local administrators"
4. The impact of integration on recruitment (IIR): "how [do] you feel integrating science into your agricultural education program would (or does) increase or decrease the enrollment from the following student groups: high achieving students"
5. Barriers to integration (BI): "lack of support from local science teacher(s)" and "concerns about large class size"

Responses were measured on a five-point summated rating scale. Sections on perceptions toward integration of science, preparation to integrate science, and barriers to integration utilized the following scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. The two sections on support for integration and the impact of integration on recruitment also utilized a five-point scale: 1 = greatly decrease, 2 = decrease, 3 = no change, 4 = increase, and 5 = greatly increase. Lastly, a section on demographic information was included with questions about participants' gender, age, teaching experience, and education. Content and face validity for this instrument were established by a panel of experts consisting of agricultural and science education faculty at two land grant universities. This panel was considered experts based on their experience in teaching and learning, science integration, and experience with in-service teacher professional development.

The instrument was distributed to teachers via Qualtrics online survey software. Teachers completed the pre-test IAI immediately before participating in the initial 3-day conference (June of 2020, 2021, and 2022), and the post-test immediately following the conference's conclusion (July of 2020, 2021, and 2022). The post-post tests were administered the first week of December in 2020, 2021, and 2022. Post-hoc reliability analysis for the pre, post, and post-post tests of the instrument resulted in Cronbach's alphas of 0.73, 0.86 and 0.87, respectively.

Data Analysis

Data were analyzed using the R programming language Version 4.2.2 for macOS. Descriptive (mean, standard deviation, and frequency) and inferential statistics (repeated measures analysis of variance; ANOVA) were used to address all objectives. The average scores of the individual factors were utilized to conduct the repeated-measures ANOVA. An a priori level of significance was set at $p < 0.05$. Assumptions of outliers, normality, and sphericity were tested using the *rstatix* package in R. The R function `identify_outliers()` was used to check for outliers, and two extreme outliers were identified, one in SI pre-test and the other outlier was in the IIR post post-test. Results from analysis using the untransformed data were compared with transformed data using log and square root techniques and were found to be similar (Bartlett 1936; Feng et al. 2014). Therefore, all the cases, including outliers, were used for the analysis, considering that the outliers did not substantially affect the results.

Assumptions of normality were checked by computing the Shapiro-Wilk test using the R function `shapiro_test()` and QQ plot using `ggqqplot()` for each assessment point (Shapiro and Wilk 1965). QQ plot is recommended over the Shapiro-Wilk test when the sample size exceeds 50 (Mishra et al., 2019); therefore, both analyses were conducted for redundancy. The QQ plots and Shapiro-Wilk test results show that the post-post test of PIS, the pre-test of SI, and the pre-test of IIR violated the normality assumption. Schmider et al. (2010) indicated that ANOVA procedures are robust to violations of normality. Thus, along with data from the QQ plots, no data transformation were employed in this study.

Mauchly's (1940) test was conducted using the `anova_test()` R function to test the assumptions of sphericity. Mauchly's test for the PTIS ($X^2(2) = 0.99, p = 0.746$), SI ($X^2(2) = 0.96, p = 0.459$), IIR ($X^2(2) = 0.89, p = 0.1$), and BI ($X^2(2) = 0.98, p = 0.661$) factors indicated that assumptions of sphericity were not violated. However, the Mauchly's test results for the PIS ($X^2(2) = 0.72, p = 0.001$) revealed that assumptions of sphericity were violated. Greenhouse-Geiser (1959) estimate of epsilon was reported for the factors that violated the sphericity assumption, as it is a conservative correction.

Limitations

This study's population consisted of agriscience teachers who applied to be part of the SIU program. The sample was a convenience sample from this population. Therefore, the findings of this study were not generalizable beyond the population of teachers who applied. Additionally, the researchers acknowledge the small sample size and impact on effect size. However, common in the discipline of agricultural education, recruiting and maintaining participation is difficult despite best research practices

Results

Objective one sought to describe the mean levels of the attitudes and perceptions toward science integration (PTIS); preparation to integrate science (PIS); support for integration (SI); the perceived impact of integration on recruitment (IIR); and barriers to integration (BI) factors for the pre, post, and post-post tests (see Table 1). Teachers reported a pretest mean of 3.75 (SD = 0.33) for PTIS, 3.82 (SD = 0.43) for PIS, 3.66 (SD = 0.44) for SI, 3.62 (SD = 0.71) for IIR, and 2.92 (SD = 0.55) for BI. Post test results immediately after the conclusion of the conference signified an increase in mean scores of PTIS (M = 3.95, SD = 0.48), PIS (M = 4.04, SD = 0.48), SI (M = 3.77, SD = 0.47), and IIR (M = 3.76, SD = 0.65). However, post test results for the BI factor indicated a decrease mean in scores of BI (M = 2.86, SD = 0.61). The post-post test results from the final phase of the study indicated a further increase in means score from post test for PTIS (M = 4.01, SD = 0.53), PIS (M = 4.17, SD = 0.61), SI (M = 3.94, SD = 0.51), IIR (M = 3.93, SD = 0.63). Additionally, there was a post-post test increase in the mean score of BI to a level slightly above the pre-test (M = 2.94, SD = 0.53).

The second objective of this study was to determine differences in pre, post, and post-post test mean levels of the PTIS, PIS, SI, IIR, and BI factors. Results from the repeated-measures ANOVA, displayed in Table 1, indicated a significant effect of time for the testing period for PTIS ($F_{(2,82)} = 8.63, p = 0.000$), PIS ($F_{(1.56, 64.11)} = 12.95, p = 0.000$), SI ($F_{(2,82)} = 9.66, p = 0.000$), and IIR ($F_{(2,82)} = 6.88, p = 0.002$) factors. A significant effect for the testing period was not found for the BI factor, $F_{(2,82)} = 3.19, p = 0.728$. The generalized eta squared was computed to find the effect size of the mean differences, as the predictor variable was not manipulated but only observed (Bakeman, 2005). The eta squared values for the

factors suggested a small effect size for all five factors.

Post-hoc, pairwise paired t-tests were computed to determine any specific differences between group means for the four factors with significant differences (PTIS, PIS, SI, and IIR; see Table 2 and Fig. 1). The p-value was adjusted for the comparisons using the Bonferroni method. The pairwise comparisons for the PTIS and SI factors show that pre and post-post tests were significantly different. Whereas for the PIS factor, pre and post and pre and post-post tests differed significantly. Finally, the IIR factor indicated a significant difference between the pre and posttests, and the post and post-post testing periods. Pairwise comparisons using box plots showing the pre, post, and post-post tests' distribution are depicted in Fig. 1. The lines above the box plots show the pairwise comparisons' significance.

Discussion, Conclusions, and Recommendations

Overall, teachers displayed increased mean scores in all five factors across the total testing period. The positive increase indicated the professional development program was impactful in all four areas of the McKim, Velez, Lambert, and Balschweid (2017) modified version of the theory of planned behavior: perceived behavioral control, subjective norms, attitudes, and perceived science knowledge. The observed increases in mean scores after participation in targeted professional development align with previous research (Ferand et al., 2020; McKim, Velez, and Clement, 2017; Ulmer et al., 2013).

Attitudes and perceptions toward science integration (PTIS) increased from a neutral score to an overall level of agreement at the end of the program. Additionally, the standard deviation remained relatively tight across the testing periods. The IIR, or impact of integration on recruitment, factor was similar to PTIS, displaying an overall increase in means across the testing period, with participants moving from neutrality on average to agreement. As the SIU program is an elective professional development program, it can be assumed that the participants voluntarily entered it with fairly positive attitudes toward integrating science into their curricula. Additionally, it is also likely that teachers with more positive attitudes and perceptions of integrating science within the plant science curricula would self-select into a program with aims that align with their personal beliefs (McKim, Velez, and Clement, 2017). Participation in the program additionally supported the teachers' positive attitudes.

Unique to this study, perceived science knowledge (PIS) was also investigated in relation to the intention to integrate science. Previous research has noted a negative correlation between the level of science knowledge and intention to teach science (McKim et al., 2018). For this study, the PIS factor resulted in a positive increase over the program, moving from neutral to agreement, with a significant difference between the pre and post and post and post-post tests. As providing scientific content knowledge and hands-on experience in implementing science integration in the plant science curricula is the program's main purpose, the results of the PTIS, IIR, and PIS factors were affirmative that the targeted professional development program was successful.

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Table 1

Means, standard deviations, and repeated-measures analyses for variance for PTIS, PIS, SI, IIR, and BI factors

| Factor | Pre Test (n = 42) | | Post test (n = 42) | | Post-Post test (n = 42) | | F | η ² |
|-------------------|----------------------|------|-----------------------|------|----------------------------|------|-------------------------|-------------------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| PTIS ⁱ | 3.75 | 0.33 | 3.95 | 0.48 | 4.01 | 0.53 | (2, 82) = 8.63** | 0.06 ^a |
| PIS ⁱ | 3.82 | 0.43 | 4.04 | 0.48 | 4.17 | 0.61 | (1.56, 64.11) = 12.95** | 0.07 ^a |
| SI ⁱⁱ | 3.66 | 0.44 | 3.77 | 0.47 | 3.94 | 0.51 | (2, 82) = 9.66** | 0.06 ^a |
| IIR ⁱⁱ | 3.62 | 0.71 | 3.76 | 0.65 | 3.93 | 0.64 | (2, 82) = 6.88* | 0.04 ^a |
| BI ⁱ | 2.92 | 0.55 | 2.86 | 0.61 | 2.94 | 0.53 | (2, 82) = 3.19 | 0.01 ^a |

Note. * $p < 0.05$; ** $p < 0.01$. *i1* = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. *ii1* = greatly decrease, 2 = decrease, 3 = no change, 4 = increase, and 5 = greatly increase. *a*Eta² guidelines: 0.02 = small, 0.13 = medium, and 0.26 = large. Attitudes and perceptions toward science integration (PTIS); Preparation to integrate science (PIS); Support for integration (SI); The impact of integration on recruitment (IIR); Barriers to integration (BI).

Table 2

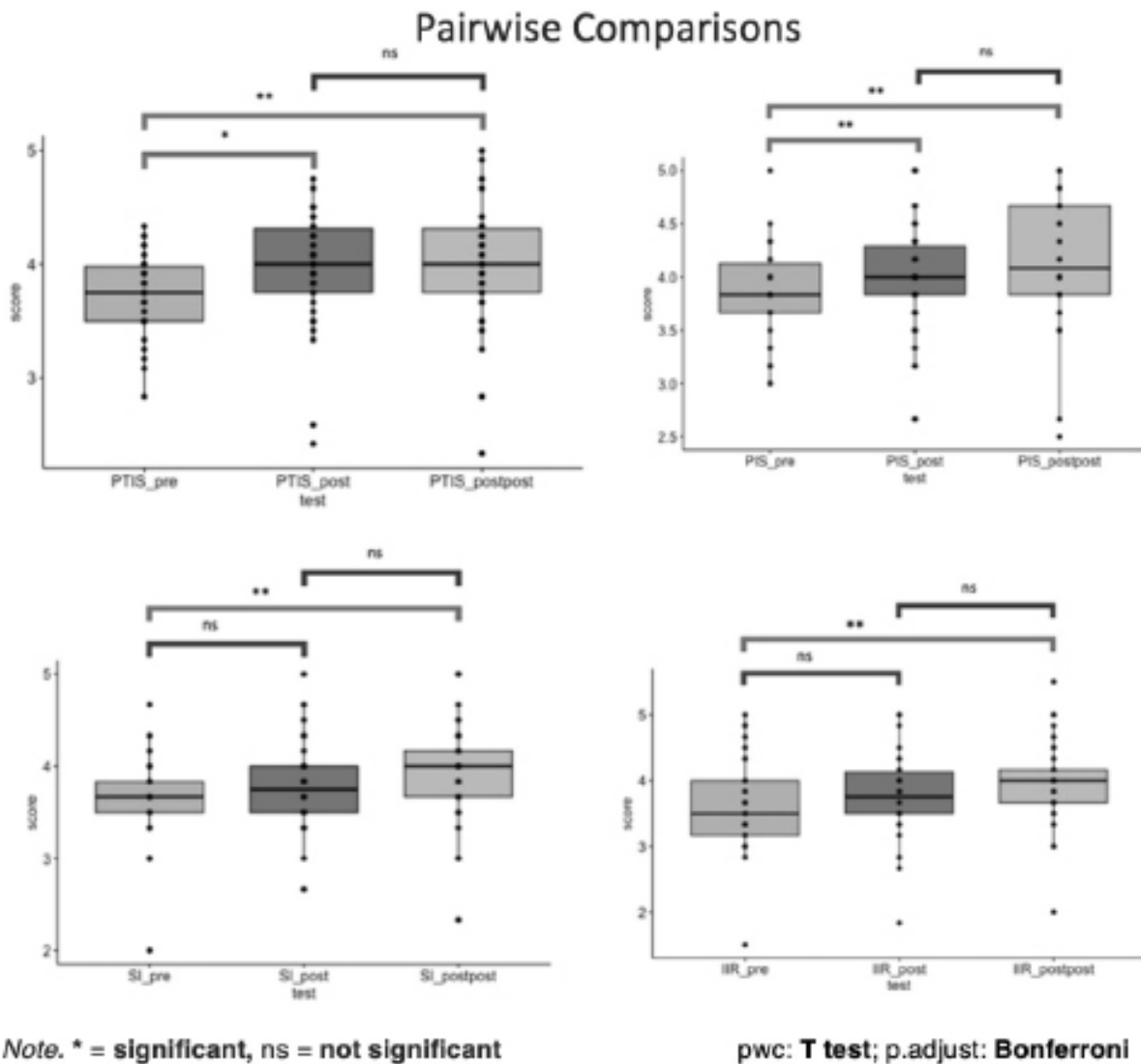
Pairwise comparisons between the pre, post, and post-post tests

| Measure | Group 1 (n = 42) | | Group 2 (n = 42) | | t | df | p (adjusted) |
|---------|---------------------|-----------|---------------------|----------------|-------|----|--------------|
| | Pretest | Post test | Post test | Post-Post test | | | |
| PTIS | Pretest | | Post test | | 3.07 | 41 | 0.011* |
| | | | | Post-Post test | 3.79 | 41 | 0.001** |
| | Post test | | Post-Post test | | -0.83 | 41 | 1.000 |
| PIS | Pre test | | Post test | | 3.36 | 41 | 0.005** |
| | | | | Post-Post test | 4.10 | 41 | 0.000** |
| | Post test | | Post-Post test | | -2.42 | 41 | 0.06 |
| SI | Pre test | | Post test | | 1.65 | 41 | 0.321 |
| | | | | Post-Post test | 4.83 | 41 | 0.000** |
| | Post test | | Post-Post test | | -2.50 | 41 | 0.05 |
| IIR | Pre test | | Post test | | 1.50 | 41 | 0.426 |
| | | | | Post-Post test | 3.57 | 41 | 0.003** |
| | Post test | | Post-Post test | | -2.46 | 41 | 0.054 |

Note. * $p < 0.05$; ** $p < 0.01$. Attitudes and perceptions toward science integration (PTIS); Preparation to integrate science (PIS); Support for integration (SI); The impact of integration on recruitment (IIR); Barriers to integration (BI).

Figure 1

Pairwise Comparisons Between Pre, Post, and Post-Post Tests



The barriers to integration (BI) factor did not have significant differences. The lack of significant results was not entirely surprising as the program could not provide any solutions to many items included in this factor, such as funding, class size, infrastructure, or classroom management. However, several items, such as lack of curricula, lack of experience integrating science, and content knowledge, were items addressed through the program. While previous research found that lack of scientific knowledge is the most significant barrier to the integration of science within agriculture (Myers & Washburn, 2008; Stubbs & Myers, 2015; Thompson & Warnick, 2007; Thoron & Myers, 2010), a positive sense of perceived behavioral control, or success in completing the action has been noted as very influential in decision making (Ajzen, 1991). The BI factor had the lowest mean scores of any factor with mean scores starting in the “slightly disagree” choice and ending in “neutral.” The growth in results could indicate that items participants did not see as a barrier, or they slightly disagreed were a barrier, were seen as a greater barrier

after participating in the program.

Across the factors, the effect size for the significant difference was small, suggesting a small proportion of change associated with perceptions resulting from teachers participating in the program. The pairwise comparison indicated that the changes in perception observed before and after the program were more evident at six months than immediately after completion of the program. When one leaves a professional development program, especially during the summer, there is often a positive attitude and desire for change. However, after re-entering the classroom, and especially when nearing the end of a semester, the realities of teaching and the impact of perceived barriers are more likely to take precedence over positive attitudes; therefore, the smaller increase in mean score from the post to post-post test was not surprising. As Ajzen (1991) noted, the fewer obstacles to complete action, the greater the likelihood of a person accomplishing the behavior. However, even small levels of growth are growth, nonetheless. Growth in any capacity should not be discounted as any positive

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change for teachers can impact their students and, thus, the students' career trajectories.

We recommend measuring teachers' actual content knowledge to compare perceived knowledge. This comparison would allow us to see specific content areas where teachers need development in conjunction with perceptions of their knowledge level versus reality. Future research should investigate teachers' thoughts on the "rigor" provided through science integration and SBAE courses offered for science credit versus those offered in traditional SBAE courses. Such research could reveal more about teachers' attitudes toward integrating science into their curricula. Future research should focus on removing barriers to integrating science within the plant science curricula, such as by providing teachers funding stipends or materials and curricular resources to see the effects on their intentions. Finally, this study should be repeated with a larger sample size.

Recommendations for university teacher educators include providing more science and integration techniques instruction to pre-service and in-service teachers. Targeted, content-specific professional development has been shown to provide teachers with both the specific content knowledge needed to effectively integrate science within the SBAE curricula, to help them develop more positive attitudes, and to develop higher perceived behavioral control. Courses in integrated instruction for pre-service teachers, as well as more technical science courses, could improve expectations and could provide the tools needed for integration after pre-service teachers enter their classrooms.

Lastly, recommendations for in-service teachers focus on knowledge and support. In-service teachers should look for targeted, content-specific professional development opportunities through university programs, teachers' organizations, and the horticulture industry. Teachers should share their positive attitudes on the impact of integration toward increased support and student enrollment with their administration. Such conversations could also open doors for communication around teachers' perceived barriers to integration, such as lack of funding, time, and space. Teachers are encouraged to contact other teachers, both agriscience and core science teachers, community members, and local horticulture enterprises to find additional support. Lastly, there is no measure of what constitutes science integration. Teachers are encouraged to attempt illuminating science in modest ways, little by little if they wish to integrate more plant science into their courses. Minor steps can increase efficacy while also making barriers, such as funding or resources, seem less daunting.

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