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Interdisciplinary Learning Opportunities in Agriculture, Food, Natural Resources, and Science: The Role of the Teacher

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Abstract

Providing interdisciplinary learning opportunities in agriculture, food, natural resources (AFNR), and science is critically important. School-based agricultural education offers a valuable platform to connect AFNR and science; however, interdisciplinary teaching requires willing and able teachers. The current study considered the intentions of school-based agriculture teachers to teach science within AFNR curriculum. Using the theory of planned behavior, attitude toward teaching science, subjective norms, perceived behavioral control, and perceived science knowledge were considered as independent variables to teaching science within AFNR curriculum. The explanatory model was analyzed using structural equation modeling. In total, school-based agriculture teachers intended to teach science in 39.91% of AFNR curriculum. Only perceived science knowledge was a statistically significant, negative predictor of intended science teaching. Findings pinpoint the need for additional research into the unexpected relationship between perceived science knowledge and science teaching intentions. The need and nature of potential explorations, along with specific recommendations for practice, are discussed.

Keywords: science; attitude toward the behavior; subjective norms; behavioral control; perceived science knowledge; interdisciplinary teaching

Introduction

Throughout humanity, learning how to sustainably produce food, shelter, and clothing (i.e., agriculture, food, and natural resources [AFNR] education), and increasing human understanding of natural phenomena (i.e., science education) have been essential outcomes of any successful education system. In fact, one could argue an interdisciplinary understanding of AFNR and science as essential for the establishment, sustainability, and progress of any society (International Assessment of Agricultural Knowledge, Science, and Technology for Development, 2009). The important interconnections of AFNR and science demand curriculum in which individuals can experience, learn, and problem solve within the diverse interdisciplinary context of AFNR and science. As a feature, the interdisciplinary learning experiences of interest in this study include opportunities for students to develop knowledge and skills within AFNR and science, as well as

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identify relationships between AFNR and science. In this way, AFNR and science are conceptualized as knowledge systems with a multitude of overlapping ideas, concepts, and abilities (Scherer, McKim, Wang, DiBenedetto, & Robinson, 2017*)*.

In addition to the critical societal need for AFNR and science learning, combining AFNR and science offers students an opportunity to learn science within an applied context, a recommended approach to addressing student underperformance in science (Gonzalez & Kuenzi, 2012; National Research Council, 2009, 2011; Stubbs & Myers, 2015). Furthermore, offering learning experiences which illuminate the inherent connections between AFNR and science prepares individuals who can identify and implement sustainable solutions to ecological problems, a critical need for the increasingly wicked challenges facing the environment (Andenoro, Baker, Stedman, & Weeks, 2016; Huutoniemi, 2014; International Assessment of Agricultural Knowledge, Science, and Technology for Development, 2009; Klein, 1990).

School-based agricultural education (SBAE) provides an invaluable context to facilitate interdisciplinary learning of AFNR and science (Balschweid, 2002; Conroy & Walker, 2000; Enderlin & Osborne, 1992; Enderlin, Petrea, & Osborne, 1993; McKim, Velez, Lambert, & Balschweid, 2017; Roegge & Russell, 1990; Wilson & Curry Jr., 2011). However, facilitating interdisciplinary learning spaces within SBAE relies on the teacher teaching science content and practices within their curricula (McKim, 2016; McKim, Sorensen, & Velez, 2016). SBAE research has failed to provide a comprehensive, empirical model detailing the role of the teacher in facilitating interdisciplinary science and AFNR learning. The current study sought to address the identified gap by evaluating the intentions of SBAE teachers to teach science within AFNR curriculum.

Theoretical Framework

The purpose of the current study was to understand the role of the teacher in teaching science within AFNR curriculum. The theory of planned behavior (Ajzen, 1985, 2011) emerged as an appropriate framework for evaluating the human behavior of science teaching within AFNR curriculum. The theory of planned behavior posits three predictors of behavioral intentions: (a) attitude toward the behavior, (b) subjective norms, and (c) perceived behavioral control (Ajzen, 1985). Within the theory, each predictor is positively associated with greater intentions to perform the behavior of interest (Ajzen, 1985; Ajzen & Sheikh, 2013; Montano & Kasprzyk, 2006). For example, a SBAE teacher with higher subjective norms (i.e., one who perceives relevant stakeholders [e.g., administrators, fellow teachers] support teaching science within AFNR curriculum) will be more likely to teach science within AFNR curriculum. In addition to the three established predictors (i.e., attitude toward the behavior, subjective norms, and perceived behavioral control), research highlights the importance of a strong foundation of content knowledge in teaching (Darling-Hammond & Bransford, 2005). Within SBAE research, perceived science knowledge has been argued as an important variable to the quality and quantity of science teaching offered (Hamilton & Swortzel, 2007; Scales, Terry, & Torres, 2009; Wilson, Kirby, & Flowers, 2001); however, an empirical evaluation of the relationship between perceived science knowledge and science teaching intentions has not been completed on a national scale. Therefore, perceived science knowledge was added as a fourth potential predictor of teaching science within AFNR curriculum (see Figure 1).

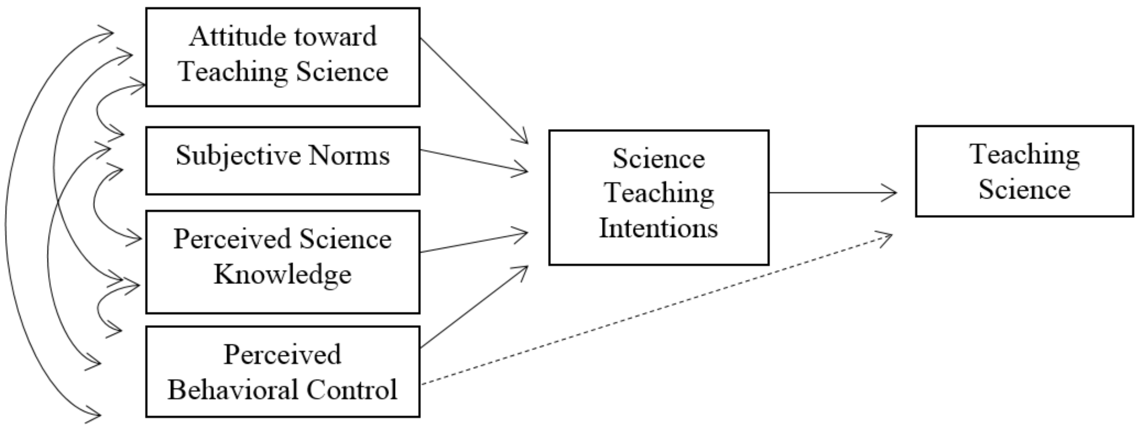

Figure 1. Model of the theory of planned behavior (Ajzen, 1985) with the addition of perceived science knowledge.

Literature Review

Operationalization of the theory of planned behavior yielded four potential variables predicting the intentions of SBAE teachers to teach science within AFNR curriculum. To provide an organized and meaningful review of relevant literature, existing research on the four potential predictors (i.e., attitude toward the behavior, subjective norms, perceived behavioral control, and perceived science knowledge) as well as the outcome variable of interest (i.e., intentions to teach science within AFNR curriculum) are discussed.

Attitude toward the Behavior

Ajzen defined attitude toward the behavior as, "the individual's positive or negative evaluation of performing the behavior" (1985, p. 12). Attitude toward the behavior is the personal element within the theory of planned behavior as it is the only predictor which does not rely on perceived attitudes, beliefs, and/or actions of others. Within SBAE, research has overwhelmingly identified teachers support for teaching science concepts within AFNR curriculum (Balschweid & Thompson, 2002; Connors & Elliot, 1994; Johnson, 1996; Myers & Washburn, 2008; Newman & Johnson, 1993; Peasly & Henderson, 1992; Thompson & Balschweid, 1999; Thompson & Warnick, 2007; Thoron & Myers, 2010). However, attitude toward science teaching in AFNR has not been explored in relation to intentions to teach science in AFNR curriculum, a critical relationship within the theory of planned behavior and missing component to understanding science teaching within AFNR curriculum.

Subjective Norms

Subjective norms serve as a measure of social influence toward intentions to enact a specified behavior (Ajzen, 1985; Montano & Kasprzyk, 2006). Ajzen defined subjective norms as an individual's "perception of the social pressures put on [him or her] to perform or not perform the behavior in question" (1985, p. 12). Research within SBAE has explored subjective norms related to a variety of stakeholders and found teachers perceive guidance counselors (Balschweid & Thompson, 2002; Myers & Washburn, 2008; Osborne & Dyer, 1994; Thompson & Balschweid, 1999; Warnick & Thompson, 2007), administrators, science teachers, parents (Balschweid & Thompson, 2002; Myers & Washburn, 2008; Thompson & Balschweid, 1999; Warnick & Thompson, 2007), community members (Balschweid & Thompson, 2002; Thompson &

Balschweid, 1999; Warnick & Thompson, 2007), and members of the agricultural industry (Warnick & Thompson, 2007) support teaching science within AFNR curriculum. Once again, however, the relationship between subjective norms and the intentions of teachers to teach science within AFNR curriculum has not been explored.

Perceived Behavioral Control

The third predictor within the theory of planned behavior, perceived behavioral control, represents the "degree of control a person has over internal and external factors that may interfere with the execution of an intended action" (Ajzen, 1985, p. 35). Importantly, perceived behavioral control differs from more trait-based models of control (e.g., locus of control), which are not malleable based on the specific experiences (Ajzen, 1991). When looking for comparable models, Ajzen points to the concept of self-efficacy, defined as "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p. 122). Self-efficacy is, in part, the ability an individual perceives to overcome identified obstacles (Bandura, 1977), a similar definition to perceived behavioral control. Though assessed in general science education (Haney, Czerniak, & Lumpe, 1996), research in SBAE has not specifically evaluated perceived behavioral control related to science teaching. However, research has considered self-efficacy. Science teaching self-efficacy research within SBAE suggests teachers are efficacious in their science teaching abilities (Hamilton & Swortzel, 2007; McKim & Velez, 2015, 2017); however, research has not considered the relationship between high self-efficacy and intentions to teach science within AFNR curriculum.

Perceived Science Knowledge

The additional variable considered in the model of science teaching intentions was perceived science knowledge. Perceived knowledge of science is an important predictor of science teaching within SBAE, as the confidence an individual perceives regarding their knowledge directly influences the level at which an individual teaches science (Hamilton & Swortzel, 2007; Scales et al., 2009; Wilson et al., 2001). Within SBAE, research has explored how referent individuals perceive the science knowledge of SBAE teachers, identifying that administrators and science teachers believe SBAE teachers possess the science knowledge required to teach science (Johnson & Newman, 1993; Warnick & Thompson, 2007; Warnick, Thompson, & Gummer, 2004). When the unit of analysis transitions to the SBAE teacher, findings consistently identify high levels of perceived science knowledge (McKim et al., 2017; Wilson et al., 2001) which have been contrasted with empirical assessments of science knowledge among SBAE teachers, revealing deficiencies in science knowledge as measured by standardized assessments (Hamilton & Swortzel, 2007; Scales et al., 2009). Given the direct relationship between perceived science knowledge and intentions to teach science, the focus of the current study is on perceived science knowledge. As was the case with previous predictors, the relationship between perceived science knowledge and teaching science within AFNR curriculum has not been evaluated.

Science Teaching within AFNR Curriculum

Existing research provides clues into the attitudes, subjective norms, perceived behavioral control, and perceived science knowledge of SBAE teachers with regard to teaching science. However, research does not address the degree to which teachers incorporate, or intend to incorporate, science within AFNR curriculum and how science content is distributed within different SBAE experiences, such as FFA, Supervised Agricultural Experiences, and course topics. SBAE is a unique discipline which includes a variety of course topics, ranging from agribusiness systems to plant systems. The diversity within SBAE curriculum must be represented in the research on science teaching within AFNR curriculum to provide a baseline of knowledge from which to support and improve interdisciplinary AFNR and science learning.

In addition to excluding the degree and distribution of science content within AFNR curriculum, existing analyses of the identified predictors of science teaching in AFNR are limited to state and regional studies and have not addressed, at a national level, how attitudes, subjective norms, perceived behavioral control or perceived science knowledge relate to intentions to teach science within AFNR curriculum. Analyzing the relationship between identified predictors and intentions to teach science within AFNR curriculum is a critical next step to understanding interdisciplinary teaching and learning as well as identifying influential variables to increasing science teaching within AFNR. The current study sought to advance existing scholarship by (a) providing the first national analysis of attitude toward the behavior, subjective norms, perceived behavioral control, perceived science knowledge, and science teaching intentions within AFNR curriculum and (b) using structural equation modeling to analyze the relationships between identified predictors and intentions to teach science within AFNR curriculum.

Purpose and Research Objectives

The purpose of the current study was to model science teaching intentions within AFNR curriculum among SBAE teachers. The identified purpose was accomplished using the theory of planned behavior. Operationalizing of the theory, three research objectives emerged: (a) describe the attitude toward teaching science within AFNR curriculum, subjective norms, perceived behavioral control, and perceived science knowledge among SBAE teachers, (b) describe the science teaching intentions of SBAE teachers, and (c) describe a model of science teaching intentions within AFNR curriculum.

Methods

A national analysis of the intentions of SBAE teachers to teach science within AFNR curriculum was completed as framed by the theory of planned behavior.

Instrumentation

Survey methodology was used in the current study. Within the survey, responses were collected for attitude toward the behavior (i.e., four item construct), subjective norms (i.e., three item construct), perceived behavioral control (i.e., four item construct), self-perceived science knowledge (i.e., three item construct), and intentions to teach science within AFNR curriculum (i.e., eleven item construct). The attitude toward the behavior construct was adapted from previous research (Davis, Ajzen, Saunders, & Williams, 2002) and included response options from 1 *(strongly disagree)* to 6 *(strongly agree)*. An example item within the attitude toward the behavior construct stated, "As an agriculture teacher, I enjoy integrating science content in the curriculum I teach." Subjective norms and perceived behavioral control were also measured from 1 *(strongly disagree)* to 6 *(strongly agree)* and adapted from previous research (Cheon, Lee, Crooks, & Song, 2012). An example item within the perceived behavioral control construct stated, "I have complete control over the level at which I integrate science content in my agriculture curriculum," and an example item within the subjective norms construct stated, "Stakeholders to my agriculture program (e.g., school administrators, community supporters) support the integration of science content in my agriculture program." Science knowledge, the additional predictor, was measured via a researcher-developed instrument in which respondents reported perceived knowledge on three domains (i.e., forces and interactions, energy, and Earth's place in the universe) of the Next Generation Science Standards (Next Generation Science Standards Lead States, 2013). The knowledge construct was scaled from 1 *(not knowledgeable)* to 4 *(very knowledgeable)*, a method utilized in past research (Diamond, Maerten-Rivera, Rohrer, & Lee, 2013).

Intentions to teach science within AFNR curriculum was measured using a researcher developed method. Within the survey, intentions to teach science were defined as "the purposeful inclusion of grade appropriate science (e.g. physical science, life sciences, and earth/space sciences) concepts and/or practices in the agriculture curriculum you teach." Respondents were asked to identify past, current, and anticipated teaching assignments within the eight AFNR pathways (i.e., agribusiness systems; animal systems; biotechnology systems; environmental service systems; food products and processing systems; natural resource systems; plant systems; and power, structural, and technical systems). For courses teachers had taught, were currently teaching, or planned to teach, respondents indicated the percentage of curricula that would include science content. Additionally, all respondents were asked to report the percentage of FFA and supervised agricultural experience (SAE) curriculum which would include science content. The method, as described, allowed respondents to document the percentage of science content taught across a range of curricular experiences. Summated percentages of science content were determined by averaging responses for individual teachers across curricular offerings.

Validity and Reliability

Face and content validity were evaluated by a panel of experts at Oregon State University, including four faculty members within SBAE, leadership education, science education, and math education. Feedback from the panel was used to improve the validity and overall quality of the instrument. Additionally, reliability was evaluated using a pilot test of 31 student teachers at Utah State University and Oregon State University. Past research illustrates reliabilities for theory of planned behavior constructs are consistently low (Ajzen, 2011); therefore, a conservative Cronbach's alpha minimum of .60 was utilized (Creswell, 2008; Robinson, Shaver, & Wrightsman, 1991). Three of the four constructs (i.e., attitude toward the behavior, subjective norms, and science knowledge) exceeded the threshold for acceptable reliability; however, in the pilot study, perceived behavioral control fell below the established minimum (i.e., Cronbach's alpha = .49). The low reliability of perceived behavioral control was discussed with the panel of experts and, given the audience of pre-service teachers, experts believed the low reliability was related to inconsistent perceptions of control due to the pre-service population. Therefore, the perceived behavioral control construct was included in the final analysis. The post-hoc reliability (i.e., Cronbach's alpha = .69) illustrated the perceived behavioral control construct exceeded the established reliability minimum (Creswell, 2008; Robinson et al., 1991). Furthermore, findings from the factor analysis within the structural equation model provide supporting evidence for maintaining the perceived behavioral control construct.

Data Collection

An aim of the current study was to infer findings to all SBAE teachers during the 2015-2016 school year; therefore, purposeful strategies were used to gain a nationally representative frame and sample. First, the number of necessary respondents was determined using sample size requirements of structural equation modeling (i.e., the statistical analysis used to accomplish research objective three). Sample size requirements identified a desired 5:1 case to parameter ratio (Kline, 2005). Within the current study, intentions to teach science within AFNR curriculum were modeled using 32 parameters (i.e., 10 factor loadings, four latent variance estimates, four interfactor covariances, and 14 error variances). Therefore, the minimum number of respondents needed was 160 (Kline, 2005; MacCallum, Browne, & Sugawara, 1996). Given the response rate limitations of national samples, a simple random sample of 950 teachers was requested and received from the National FFA organization, assuring a 20% response rate would yield 160 respondents.

Data were collected using Dillman's (2007) tailored design method in November and December of 2015. Due to frame error, the list of potential respondents was reduced to 828. A total of 212 useable responses were received for a 25.60% response rate (n = 212). Late responders (n = 44) were compared to on-time respondents (n = 168) in the variables of interest with no statistical differences (i.e., p-values > .05) between groups; therefore, non-response bias was not considered an issue in the current study (Lindner, Murphy, & Briers, 2001; Miller & Smith, 1983).

Data Assumptions and Analysis

Before data analysis, the assumptions of structural equation modeling (i.e., multivariate normality, absence of outliers, linearity, absence of multicollinearity, and complete data) were evaluated. Attitude toward the behavior was skewed left (Kline, 2005); therefore, a robust structural equation modeling procedure (i.e., asymptotically distribution free estimation; Bentler & Yuan, 1999) was utilized. Additionally, intentions to teach science contained statistical outliers, which were replaced by the value of the most extreme response, not identified as an outlier (Guttman & Smith, 1969; Moyer & Geissler, 1991).

Research objectives one and two were accomplished using means and standard deviations. Research objective three was accomplished using structural equation modeling. A brief overview of structural equation modeling is provided to justify and explain the approach.

Overview of Structural Equation Modeling

In general, structural equation modeling is a theory-driven approach which combines confirmatory factor and regression (Ullman, 2013). Structural equation modeling is unique from other statistical modeling procedures because constructs, confirmed through factor analysis, are left uncondensed (i.e., constructs are not distilled into an average score) for analysis (Ullman, 2013). Importantly, within structural equation modeling, individual construct items are not seen as predicting the unobserved construct. Instead, the construct is seen as predicting individual items (Ullman, 2013). For example, attitude toward the behavior (i.e., latent variable) is seen as predicting the responses of individuals to the four questions within the construct.

The latent variable predicting individual responses within a construct allows for individual error terms to emerge within each observed variable (i.e., item within the questionnaire). Individual error terms identify how much of the individual items *are not* being accounted for by the latent variable (i.e., the level of measurement and systematic error within the construct). Removing error variance from each item allows only the variance accounted for by the latent variable to influence additional relationships within the model (Bowen & Guo, 2012; Ullman, 2013). For example, if an individual responded to one of the attitude toward the behavior questions because of a construct other than attitude (e.g., confidence), the individual error variance term would account for the error and *not* include the estimated error in the prediction of intentions to teach science within AFNR curriculum.

Within structural equation modeling, once the individual error variances are accounted for, the remaining latent variables (i.e., attitude toward the behavior, subjective norms, perceived behavioral control, and science knowledge) are viewed as truer representations (Ullman, 2013). The relationships between predictor and predicted variables are then evaluated as dictated by the operationalized theory and model evaluated. The "fit" of the model is evaluated using matrix geometry, in which the hypothetical model (i.e., the conceptual/theoretical model) is compared to the best fitting model found within the data (Bowen & Guo, 2012). Comparing conceptual and realized models is typically done through a chi-squared analysis, in which accepting the null hypothesis of the hypothetical model equal to the realized model (i.e. seeking a chi-squared test statistic with a p-value > .05) is required.

Structural equation modeling was utilized for its quality and credibility as a research measure (Bowen & Guo, 2012), Additionally, structural equation modeling allows for one analysis to detail completely the complex models found within social science research (Ullman, 2013). In fact, structural equation modeling is one of the only statistical models to allow variables to simultaneously act as dependent and independent within one analysis (Ullman, 2013). Simply put, structural equation modeling is complex, challenging, and powerful.

Structural Equation Modeling Process

To complete the structural equation model for the current study, three steps were completed, (a) identification of the proposed model, (b) estimation of the model, and (c) evaluation of the model. First, structural equation models must be identified, which means "there is a unique solution for each of the parameters [i.e. statistical estimate] in the model" (Ullman, 2013, p. 714). A simple formula exists for determining if a model is overidentified, a requirement for using structural equation modeling. First, the number of distinct elements within the model are determined (i.e., $p[p + 1]/2$ where p is the number of observed/measured variables).

Within the model used for the present research, 15 observed variables are included (i.e. four items measuring attitude toward the behavior, three items measuring subjective norms, four items measuring perceived behavioral control, three items measuring perceived science knowledge, and one item measuring intentions to teach science within AFNR); therefore, the number of distinct elements within the model was 120. Once the number of distinct elements was identified, the number of parameters within the model was determined. As identified within the discussion of sample size, there are 32 parameters within the model. For the current study, the number of distinct elements within the model exceeded the number of parameters estimated (i.e., 120 > 32); therefore, the model met requirements for overidentification.

After model identification, model estimation occurred by creating a visual model of the theory of planned behavior within the Statistical Package for the Social Sciences: Analysis of Moment Structures (SPSS:AMOS). The created model provided a set of implied variance covariance matrixes which were analyzed against the population covariance matrix, estimated using data from the sample (Bowen & Guo, 2012). An acceptable model is one in which the population covariance matrix is statistically similar to the implied variance covariance matrix (Bowen & Guo, 2012; Byrne, 2010; Ullman, 2013). Within the current study, Asymptotically Free Distribution estimation technique was used because of the non-normal distribution of attitude toward the behavior (Bentler & Yuan, 1999).

Once estimated, the adequacy of the model fit (i.e., how consistent the model is at predicting all the data within the sample) was examined (Ullman, 2013). Within the current study, two common measures of model fit were utilized, the confirmatory fit index (CFI; Bentler & Yuan, 1999) and root mean square error of approximation (RMSEA; Ullman, 2013). Cut-off values of acceptable fit using CFI and RMSEA are a highly negotiated topic (Hooper, Coughlan, & Mullen, 2008). Within the current study, the cut-off for CFI was established *a priori* at .90; with values exceeding .90 indicating good fit (Blunch, 2013; Hu & Bentler, 1999). For RMSEA, values below .08 were identified as representing a good fitting model (Blunch, 2013; Hooper et al., 2008).

Findings

Before addressing the objectives of the current study, a brief description of respondents is provided. Respondents included slightly more males (52.70%; *f* = 106) than females (47.30%; *f* = 95) with 11 respondents opting not to respond. Respondents ranged from 22 years of age to 70, with an average age of 39.21 and an average of 12.92 years of teaching experience. Furthermore, respondents from 40 states and Puerto Rico responded to the study, with the highest proportion of respondents from Texas (*f* = 24), Missouri (*f* = 12), and Florida (*f* = 10). No SBAE teachers from Alaska, Delaware, Hawaii, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Rhode Island, or Vermont were included among respondents.

Research objective one sought to describe the attitude toward the behavior, subjective norms, perceived behavioral control, and perceived science knowledge of respondents (see Table 1). On average, respondents had a favorable attitude toward the behavior (*M* = 5.46; *SD* = 0.67), supportive subjective norms, (*M* = 5.34; *SD* = 0.70), and perceived a high amount of behavioral control (*M* = 4.87; *SD* = 0.75) toward teaching science within AFNR curriculum. Regarding perceived science knowledge, respondents identified themselves between "somewhat knowledgeable" and "knowledgeable" (*M* = 2.60; *SD* = 0.60).

Table 1

Attitude toward the Behavior, Subjective Norms, Perceived Behavioral Control, and Science Knowledge

	Minimum	Maximum	*M*	*SD*
Attitude toward the Behavior	1.00	6.00	5.46	0.67
Subjective Norms	1.00	6.00	5.34	0.70
Perceived Behavioral Control	1.00	6.00	4.87	0.75
Perceived Science Knowledge	1.00	4.00	2.60	0.60

Note. Items measuring attitude toward the behavior, subjective norms, and perceived behavioral control were scaled from 1 (*strongly disagree*) to 6 (*strongly agree*). Items measuring perceived science knowledge were scaled from 1 (*not knowledgeable*) to 4 (*very knowledgeable*).

Research objective two focused on the science teaching intentions of respondents (see Table 2). In total, respondents indicated just under 40% of AFNR curriculum would include science content (*M* = 39.91; *SD* = 14.93). The level of science teaching ranged from under 20% within FFA curriculum (*M* = 17.00; *SD* = 18.25) to over 57% within Plant Systems curriculum (*M* = 57.18; *SD* = 20.14).

The third research objective used structural equation modeling to model the role of the SBAE teacher in teaching science within AFNR curriculum (see Table 3). Within the measurement component of the model, factor loadings were statistically significant, a necessary element for model fit. Additionally, the chi-squared comparison of the conceptual model to the data was statistically insignificant (χ^2 = 90.47; *p*-value = .094), indicating the data represented the hypothesized relationships found within the theory of planned behavior. Finally, the fit indices (i.e., CFI = 0.96 and RMSEA = .03) confirmed the hypothesized model was an appropriate representation of the data (Blunch, 2013; Hooper et al., 2008; Hu & Bentler, 1999).

Table 2

Science Teaching Intentions within AFNR Curriculum

	F	Minimum	Maximum	*M*	*SD*
Plant Systems	176	0.00	100.00	57.18	20.14
Animal Systems	182	10.00	100.00	55.65	18.96
Biotechnology Systems	86	15.00	100.00	55.12	20.92
Environmental Service Systems	101	10.00	100.00	52.26	19.38
Natural Resource Systems	139	5.00	100.00	51.89	20.90
Food Products and Processing Systems	95	10.00	100.00	48.35	19.15
General Agriculture	192	0.00	100.00	42.46	18.39
Power, Structure, and Technology Systems	143	0.00	100.00	29.01	17.72
SAE: Supervised Agricultural Experience	188	0.00	100.00	25.34	18.39
Agribusiness Systems	128	0.00	100.00	18.03	17.55
FFA	167	0.00	100.00	17.00	18.25
Total	212	4.00	81.67	39.91	14.93

Note. Respondents reported percentage of science content intended for courses previously taught, currently teaching, and/or planned to teach.

Table 3

Model of Science Teaching Intentions within AFNR Curriculum

	Dependent variable: Intention to Teach Science					
	Zero-order correlation (*r*)	*p*-value	*B*	*SEB*	*γ*	*p*-value
Attitude toward the Behavior	.27	<.001	13.32	7.13	.31	.062
Subjective Norms	.18	.008	0.58	3.45	.02	.867
Perceived Behavioral Control	.13	.058	-1.42	2.63	-.05	.589
Perceived Science Knowledge	.02	.807	-2.70	1.34	-.12	.044

Note. Based on Asymptotically Distribution-Free Estimates; χ^2 = 90.47 (df = 74) *p*-value = .094; R^2 = .10, CFI = .96, RMSEA = .03; *γ* = standardized path coefficients; *B* = unstandardized path coefficients.

In combination, predictors explained 10% of the variance in the science teaching intentions within AFNR curriculum purported by SBAE teachers (R^2 = .10). Only one of the predictors (i.e., self-perceived science knowledge) was a statistically significant, negative predictor of science teaching intentions (*γ* = - .12; *p*-value = .044) with all other potential predictors falling outside the realm of statistical significance.

Conclusions, Implications, and Recommendations

Learning opportunities which combine AFNR and science are critical to social progress, contextualized science learning, and ecological problem solving. SBAE can serve as a valuable platform for student co-construction of AFNR and science knowledge (Balschweid, 2002; Conroy & Walker, 2000; Enderlin & Osborne, 1992; Enderlin et al., 1993; McKim et al., 2017; Roegge & Russell, 1990; Wilson & Curry Jr., 2011). However, the positive benefits of interdisciplinary learning within SBAE can only be realized if teachers are able and willing to teach science within AFNR curriculum (McKim, 2016; McKim et al., 2016). In the current study, the role of the teacher in incorporating science within AFNR was explored using the theory of planned behavior.

In the first research objective, the four identified predictors of intentions to teach science within AFNR were explored. Findings suggest SBAE teachers had a positive attitude, supportive subjective norms, and perceived a high amount of behavioral control with regard to teaching science, encouraging findings given the positive association between predictors and behavioral intentions posited within the theory of planned behavior (Ajzen, 1985, 2011). Unfortunately, the positive findings were not replicated within perceived science knowledge, in which respondents rated themselves between "somewhat knowledgeable" and "knowledgeable." The limited science knowledge perceived by respondents contrasts perceptions-based research in SBAE (McKim et al., 2017; Wilson et al., 2001), yet aligns with empirical assessments of science knowledge, as measured by standardized assessments (Hamilton & Swortzel, 2007; Scales et al., 2009). The presence, and quality, of AFNR and science connections within SBAE classrooms requires teachers confident in science knowledge. As a profession, SBAE must implement and evaluate diverse approaches to enhancing the science knowledge of preservice and practicing teachers; evaluations should include, but not be limited to, exploring enrollment in postsecondary science courses and engagement in professional development in relation to increases in science knowledge.

In the second research objective, the intentions of SBAE teachers to teach science within AFNR was considered. The current study was the first known analysis of science teaching within AFNR to evaluate science teaching amongst the diverse SBAE curricular offerings. From the analysis, a trend emerged as SBAE teachers intended to teach more science within life science-based AFNR courses (e.g., plant science systems and animal science systems) and less within other curricular experiences (e.g., FFA and agribusiness systems courses). Importantly, however, high standard deviations among intentions to teach science indicate substantial variance among teachers in the level of science intended within specific offerings and suggest qualitative research is needed to explore differences. Focusing on the general trends, however, the unbalanced approach to science teaching (i.e., high intentions to teach science in plant and animal course offerings and low intentions in offerings such as FFA and agribusiness) within AFNR details an opportunity to expand science teaching outside life-science, AFNR courses. For example, FFA offers many opportunities to teach science. Not only does FFA offer agricultural science fairs, but career development events like livestock judging, public speaking, and soil judging provide opportunities for teachers to illuminate scientific inquiry and support student learning of AFNR and science practices. As a practical recommendation, SBAE teacher educators are encouraged to emphasize opportunities for teachers to incorporate science practices, as detailed in the Next Generation Science Standards (Next Generation Science Standards Lead States, 2013), within the diversity of SBAE curricula.

In the final research objective, the relationship between attitude toward the behavior, subjective norms, perceived behavioral control, perceived science knowledge, and intentions to teach science within AFNR curriculum was evaluated, with two emergent findings. First, increased self-reported science knowledge was related to statistically significant decreases in intended amounts of science content within AFNR curriculum. Initially, two potential explanations for the unexpected relationship between self-perceived science knowledge and intentions to teach science are explored: (a) teachers less knowledgeable about science (i.e., not just self-reported) teach more science or (b) teachers who are more knowledgeable about science have a more realistic perception of science knowledge; therefore, rate themselves lower in science knowledge, yet intend to teach more science. The objectives of the current study were not designed to tease out which of the suggested possibilities is correct; therefore, qualitative research on teacher conceptualizations of science knowledge and science teaching within AFNR is recommended.

A third potential explanation for the negative relationship between perceived science knowledge and science teaching intentions is a product of how perceived science knowledge was measured. In consolidation of the perceived science knowledge construct to three items (i.e., forces and interactions, energy, and Earth's place in the universe), the breadth of science represented in the construct was reduced. Potentially, reducing the scope of science within the perceived knowledge construct, especially considering AFNR experiences in which the most science content was intended (i.e., plant systems, animal systems) were not well-represented by the three selected items, may have negatively impacted the modeling of the relationship between perceived science knowledge and intentions to teach science. However, follow-up analysis of the relationship between perceived science knowledge (i.e., measured using all 11 domains of the Next Generation Science Standards) and science teaching intentions revealed a similarly negative relationship; thus, weakening the potential validity of this explanation.

Findings also revealed the importance of attitude toward the behavior. While not statistically significant, the unstandardized beta (i.e., B = 13.32) suggests a one-unit increase in attitude toward the behavior was related to intentions to teach over 13% more science in AFNR curriculum. The potential impact of attitude toward the behavior on science teaching within AFNR provides a pragmatic opportunity for SBAE teacher educators to address attitude toward teaching science as a practical method for increasing science teaching within AFNR. Preservice lessons and inservice workshops around the interdisciplinary role of AFNR and science knowledge to social progress, contextualized learning of science, and ecological problem solving are encouraged as potential methods for increasing attitude toward science teaching within AFNR.

Using structural equation modeling to evaluate the science teaching intentions of AFNR teachers yielded a good fitting model; however, the ten percent of variance explained by the model fell below what was expected based on past applications of the theory of planned behavior using structural equation modeling (Armitage & Conner, 2001; McEachan, Conner, Taylor, & Lawton, 2011). Reduced variance explanation suggests operationalization of the theory of planned behavior could be enhanced or expanded. One area for future enhancement is to model precursors to attitudes, subjective norms, perceived behavioral control, and perceived science knowledge using structural equation modeling (Ajzen, 2011). In so doing, measurement of these latent variables would be strengthened while also uncovering the role of specific interactions and experiences (e.g., postsecondary science courses, specific barriers to science teaching, beliefs of referent individuals regarding science) on the proposed model of science teaching intentions.

Combining AFNR and science content creates a powerful learning experience for students and positions SBAE as a leading discipline in addressing social, environmental, and educational challenges. The current study provided a national look at the role SBAE teachers play in facilitating interdisciplinary AFNR and science learning experiences. The findings and recommendations from the current study have the potential to inform and enhance future investigations and practices as all involved in SBAE seek to enhance interdisciplinary student learning.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhi & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp. 11-39). Heidelberg: Springer.

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

Ajzen, I. (2011). The theory of planned behavior: Reactions and reflections. *Psychology & Health, 26*(9), 1113-1127. doi: 10.1080/08870446.2011.613995

Ajzen, I., & Sheikh, S. (2013). Action versus inaction: Anticipated affect in the theory of planned behavior. *Journal of Applied Social Psychology, 43*(1), 155-162. doi: 10.1111/j.1559-1816.2012.00989.x

Andenoro, A. C., Baker, M., Stedman, N. L. P., & Weeks, P. P. (2016). Addressing complex problems. In T. G. Roberts, A. Harder, & M. T. Brashears (Eds.), *American Association for Agricultural Education national research agenda: 2016-2020*. Gainesville, FL: Department of Agricultural Education and Communication

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behavior: A meta-analytic review. *British Journal of Social Psychology, 40*, 471-499.

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

Balschweid, M. A., & Thompson, G. W. (2002). Integrating science in agricultural education: Attitudes of Indiana agricultural science and business teachers. *Journal of Agricultural Education, 43(2)*, 1–10. doi: 10.5032/jae.2002.02001

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. doi:10.1037/0033-295X.84.2.191

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*, 122-147

Bentler, P. M., & Yuan, K. (1999). Structural equation modeling with small samples: Test statistics. *Multivariate Behavioral Research, 34*(2), 181-197. doi: 10.1207/S15327906Mb340203

Blunch, N. J. (2013). *Introduction to structural equation modeling: Using IBM SPSS statistics and AMOS* (2nd ed.). Thousand Oaks, CA: Sage.

Bowen, N. K., & Guo, S. (2012). *Pocket guide to social work research methods.* Oxford University Press.

Byrne, B. M. (2010). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (2nd ed.). New York, NY: Routledge.

Cheon, J., Lee, S., Crooks, S. M., & Song, J. (2012). An investigation of mobile learning readiness in higher education based on the theory of planned behavior. *Computers and Education, 59*, 1054-1064. doi: 10.1016/j.compedu.2012.04.015

Connors, J. J., & Elliot, J. (1994). Teacher Perceptions of Agriscience and natural resources curriculum. *Journal of Agricultural Education, 35*(4), 15-19. doi: 10.5032/jae.1994.04015

Conroy, C. A., & Walker, N. J. (2000). An examination of integration of academic and vocational subject matter in the aquaculture classroom. *Journal of Agricultural Education, 41*(2), 54–64. doi: 10.5032/jae.2000.02054

Creswell, J. W. (2008). *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE Publications, Incorporated.

Darling-Hammond, L., & Bransford, J. (2005). *Preparing teachers for a changing world.* San Francisco, CA: Jossey-Bass.

Davis, L., Ajzen, I., Sauders, J., & Williams, T. (2002). The decision of African American students to complete high school: An application of the theory of planned behavior. *Journal of Educational Psychology, 94*(4), 810-819. doi: 10.1037//0022-0663.94.4.810

Diamond, B. S., Maerten-Rivera, J., & Rohrer, R. (2013). Elementary teachers' science content knowledge: Relationships among multiple measures. *Florida Journal of Educational Research, 51,* 1-20.

Dillman, D. A. (2007). *Mail and internet surveys: The tailored design method* (2nd ed.). Hoboken, NJ: John Wiley & Sons, Inc.

Enderlin, K. J., & Osborne, E. W. (1992). Student achievement, attitudes, and thinking skill attainment in an integrated science/agriculture course. *Proceedings of the Nineteenth Annual National Agricultural Education Research Meeting*. St. Louis, MO.

Enderlin, K. J., Petrea, R. E., & Osborne, E. W. (1993). Student and teacher attitude toward and performance in an integrated science/agriculture course. *Proceedings of the 47th Annual Central Region Research Conference in Agricultural Education*. St. Louis, MO.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science technology, engineering, and mathematics (STEM) education: A primer* (Report No. R42642). Washington, D. C.: Congressional Research Service.

Guttman, I., & Smith, D. E. (1969). Investigation of rules for dealing with outliers in small samples from the normal distribution: I: Estimation of the mean. *Technometrics*, *11*(3), 527-550.

Hamilton, R. L., & Swortzel, K. A. (2007). Assessing Mississippi AEST teachers' capacity for teaching science integrated process skills. *Journal of Southern Agricultural Education Research, 57*(1), 1-12.

Haney, J. J., Czerniak, C. M., & Lumpe, A. T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching, 33(9),* 971-993.

Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural equation modeling: Guidelines for determining model fit. *Journal of Business Research Methods, 6*(1), 53-60.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structural analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1-55. doi: 10.1080/10705519909540118

Huutoniemi, K. (2014). Sustainability, transdisciplinarity and the complexity of knowing. In K. Huutoniemi and P. Tapio (Eds.), *Transdisciplinary sustainability studies: A heuristic approach* (pp. 1-14). New York, NY: Routledge.

International Assessment of Agricultural Knowledge, Science, and Technology for Development. (2009). *Agriculture at a crossroads: Synthesis report.* Washington, D. C.: Island Press.

Johnson, D. M. (1996). Science credit for agriculture: Perceived support, preferred implementation methods and teacher science course work. *Journal of Agricultural Education, 37*(1), 22-30. doi: 10.5032/jae.1996.01022

Johnson, D. M., & Newman, M. E. (1993). Perceptions of administrators, guidance counselors, and science teachers concerning pilot agriscience courses. *Journal of Agricultural Education, 34*(2), 46-54. doi: 10.5032/jae.1993.02046

Klein, J. T. (1990). The problem of interdisciplinary discourse. In J.T. Klein (Ed.), *Interdisciplinarity: History, theory, and practice* (pp. 11-15). Detroit, MI: Wayne State University Press.

Kline, R. B. (2005). *Principles and practices of structural equation modeling* (2nd ed.). New York, NY: The Guilford Press.

Lindner, J. R., Murphy, T. H., & Briers, G. E. (2001). Handling nonresponse in social science research. *Journal of Agricultural Education, 42*(4), 43-53. doi: 10.5032/jae.2001.04043

MacCallum, R. C., Browne, M. W., Sugawara, H. M. (1996). Power analysis and determination of sample size of covariance structure modeling. *Psychological Methods, 1*(2), 130-149. doi: 10.1037//1082-989X.1.2.130

McEachan, R. R. C., Conner, M., Taylor, N., & Lawton, R. J. (2011). Prospective prediction of health-related behaviors with the theory of planned behavior: A meta-analysis. *Health Psychology Review, 5*, 97-144.

McKim, A. J. (2016). *Leadership, mathematics, and science integration in secondary agricultural education* (Doctoral dissertation, Oregon State University).

McKim, A. J., Sorensen, T. J., & Velez, J. J. (2016). Exploring the role of agriculture teachers in core academic integration. *Journal of Agricultural Education, 57*(4), 1-15. doi: 10.5032/jae.2016.04001

McKim, A. J., & Velez, J. J. (2017). Developing self-efficacy: Exploring preservice coursework, student teaching, and professional development experiences. *Journal of Agricultural Education, 58*(1), 172-185. doi: 10.5032/jae.2017.01172

McKim, A. J., & Velez, J. J. (2015). Exploring the relationship between self-efficacy and career commitment among early career agriculture teachers. *Journal of Agricultural Education*, *56*(1), 127-140. doi: 10.5032/jae.2015.01127

McKim, A. J., Velez, J. J., Lambert, M. D., & Balschweid, M. A. (2017). A philosophical review of science and society within agricultural education. *Journal of Agricultural Education, 58*(2), 98-110. doi: 10.5032/jae.2017.02098

Miller, L. E., & Smith, K. L. (1983). Handling non-response issues. *Journal of Extension, 21*(5), 45-50.

Montano, D. E., & Kasprzyk, D. (2006). *Theory of reasoned action, theory of planned behavior, and the integrated behavioral model.* In K. Glanz, B.K Rimer, & R. K. Viswanath (Eds.). Health behavior: Theory, research, and practice (pp. 95-124). San Francisco, CA: Jossey-Bass.

Moyer, L. M., & Geissler, P. H. (1991). Accommodating outliers in wildlife surveys. *Wildlife Society Bulletin*, *19*(3), 267-270.

Myers, B. E., & Washburn, S. (2008). Integrating science in the agriculture curriculum: Agriculture teacher perceptions of the opportunities, barriers, and impact on student enrollment. *Journal of Agricultural Education, 49*(2), 27-37. doi:10.5032/jae.2008.02027

National Research Council. (2009). *Transforming agricultural education for a changing world.* Washington, DC: National Academies Press.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* Washington, DC: National Academies Press.

Newman, M. E., & Johnson, D. M. (1994). Inservice education needs of teachers of pilot agriscience courses in Mississippi. *Journal of Agricultural Education, 35*(1), 54-60. doi: 10.5032/jae.1994.01054

Next Generation Science Standards Lead States. (2013). *Next generation science standards: for states, by states.* The National Academies Press, Washington D.C.

Osborne, E. W., & Dyer, J. E. (1994). The influence of science applications in agricultural courses on attitudes of Illinois guidance counselors at model student teaching centers. *Proceedings of the 48th Annual Central Region Research Conference in Agricultural Education. St. Louis, MO.*

Peasley, D. D., & Henderson, J. L. (1992). Agriscience curriculum in Ohio agricultural education: Teacher utilization, attitudes, and knowledge. *Journal of Agricultural Education, 33*(1), 37–45. doi: 10.5032/jae.1992.01037

Robinson, J. P., Shaver, P. R., & Wrightsman, L. S. (1991). Criteria for scale selection and evaluation. In J. P. Robinson & L. S. Wrightsman (Eds.). *Measures of personality and psychological attitudes* (pp. 1-16). New York, NY: Academic Press

Roegge, C. A. & Russell, E. B. (1990). Teaching applied biology in secondary agriculture: Effects on student achievement and attitudes. *Journal of Agricultural Education, 31*(1), 27-31. doi: 10.5032/jae.1990.01027

Scales, J., Terry, R., & Torres, R. M. (2009). Are teachers ready to integrate science concepts into secondary agriculture programs? *Journal of Agricultural Education, 50*(2), 100-111. doi: 10.5032/jae.2009.02100

Scherer, H. H., McKim, A. J., Wang, H., DiBenedetto, C., & Robinson, K. (2017). Making sense of the buzz: Providing a taxonomy of "STEM" in agriculture, food, and natural resources education. *Proceedings of the American Association for Agricultural Education Research Conference, San Luis Obispo, CA,* 495-512.

Stubbs, E. A., & Myers, B. E. (2015). Multiple case study of STEM in school-based agricultural education. *Journal of Agricultural Education, 56*(2), 188-203. doi: 10.5032/jae.2015.02188

Thompson, G. W., & Balschweid, M. M. (1999). Attitudes of Oregon agricultural science and technology teachers toward integrating science. *Journal of Agricultural Education, 40*(3), 21-29. doi: 10.5032/jae.1999.03021

Thompson, G. W., & Warnick, B. K. (2007). Integrating science into agriculture education curriculum: Do science and agriculture teachers agree? *Journal of Agricultural Education, 48*(3), 1–12. doi: 10.5032/jae.2007.03001

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

Ullman, J. B. (2013). Structural equation modeling. In B. G. Tabachnick & L. S. Fidell (eds). *Using multivariate statistics* (pp. 681-785). Boston, CA: Pearson.

Warnick, B. K., & Thompson, G. W. (2007). Barriers, support, and collaboration: A comparison of science and agriculture teachers' perceptions regarding integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 48*(1), 75-85. doi: 10.5032/jae.2007.01075

Warnick, B. K., Thompson, G. W., & Gummer, E. S. (2004). Perceptions of science teachers regarding the integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 45*(1), 62–73. doi: 10.5032/jae.2004.01062

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

Wilson, E., Kirby, B., & Flowers, J. (2001). Agricultural educator's knowledge and perception of agricultural biotechnology curriculum. *Proceedings of the 28th Annual National Agricultural Education Research Conference,* New Orleans, LA. 409–421.