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Agriculture Teacher Perceptions of Preparation to Integrate Science and Their Current Use of Inquiry Based Learning

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The purpose of this study was to determine the perceived competence of agricultural education teachers in integrating science and use of inquiry based teaching techniques in agricultural education programs. Objectives included describing agriculture teacher perceptions of teacher preparation program needs based upon their personal competence to integrate science into the agricultural education curriculum, identifying factors influencing agriculture teachers' current and planned levels of science integration in the agricultural education programs, and describing the use of inquiry based teaching techniques in agricultural education programs. The population for the study was all secondary agriculture teachers in Florida. A total of 217 teachers participated for a 61.1% response. It was found that although agriculture teachers feel prepared to integrate science, they also believe more should be done to prepare future teachers to do so. Furthermore, nearly three fourths of the participants intended to increase their level of science integration. Finally, teachers reported using teacher–oriented inquiry strategies nearly three times per week, while they reported using student–oriented inquiry nearly once per month.

Introduction

The integration of science and other academic content across the curriculum has been central to legislative attempts at educational reform since the National Defense Education Act was instituted in 1954. The latest of these efforts is directed specifically at Career and Technical Education through the Carl D. Perkins Career and Technical Education Improvement Act of 2006. This legislation carries important ramifications for the future curricular focus of Career and Technical Education (CTE) programs. Among these are the "Core Indicators of Performance for Career and Technical Education Students at the Secondary Level" (109th U.S. Congress, 2006). The six indicators established by the legislative language outline the minimum areas in which states are to be held responsible for measuring CTE student performance. The first of these indicators highlights the critical need for Agricultural Education programs to integrate core academic content; as CTE program funding will be partially based on standardized assessments designed to measure student mastery of academic content standards. Specifically, the first Perkins Core Indicator requires the measurement of: ''Student attainment of challenging academic content standards and student academic achievement standards, as adopted by a State… and measured by the State determined proficient levels on the academic assessments" (109th U.S. Congress, p. 14).

Concurrent with the new Perkins language, the No Child Left Behind (NCLB) legislation mandates that beginning this year, states must measure student achievement in science at least four times during a student's progression from third to twelfth grade (USDE, 2006). The NCLB mandate, coupled with the Perkins legislation indicates the imperative nature of expectations that agriculture teachers join their science education colleagues in preparing students to meet science achievement standards. Agricultural education research has shown that on standardized achievement exams, students participating in agricultural education courses perform as well as their counterparts (Connors & Elliot, 1995), or better than their counterparts who did not complete instruction in Agriculture (Chiasson & Burnett, 2001). The question remains however, are agriculture teachers adequately prepared to integrate scientific concepts consistently and systematically?

The decision to integrate academic concepts in the agriculture curriculum should not be based solely on legislative expectations. It has also been argued that integration of science in real–world settings and with real–life experiences is essential simply as a means of effective practice (Maurer, 2000). The American Association for the Advancement of Sciences has advocated that effective instruction in science starts with questions about nature, engages students in real–world settings, and stresses active learning strategies (Rutherford & Ahlgren, 1990). Many would include these characteristics as basic premises of the agricultural education philosophy. Furthermore, previous findings suggest agriculture teachers believe integrating science in the agriculture curriculum aids students in making connections between scientific principles and agriculture (Enderlin & Osborne, 1992; Myers & Washburn, 2007; Thompson, 1998). These researchers also found that agriculture teachers perceive integration of science has the potential to increase program enrollment and stakeholder views of the program.

The importance and perceived benefits of science integration in agriculture are well–documented. Since the late 1980's, considerable research has produced mixed findings regarding agriculture teachers' perceived level of preparation to effectively integrate science. In Wilson, Kirby, and Flowers' (2001) study of 126 North Carolina agriculture teachers, prior to any intervention, low self–perceived knowledge in competency areas essential to biotechnology instruction were reported. Conversely, Thompson and Balschweid (2000) found that after an intensive preparation in science integration and mandated experience in collaboration with a science teacher during their teaching internships, pre–service teachers had a high degree of confidence in their ability to integrate science principles in their instruction. Thompson (1998) found that while participants in the National FFA Agriscience Teacher of the year awards program felt prepared to integrate, they also believed more inservice was needed in the profession on how teachers could integrate science. Regardless of level of preparation, agriculture teacher perceptions in Florida regarding science integration reflected beliefs that insufficient planning time, lack of requisite materials, and insufficient funding were barriers likely to prevent integration of science concepts (Myers & Washburn, 2007).

If efforts to more comprehensively integrate science in agriculture are to be fruitful, current areas of emphasis in the science education community should be heeded. Considerable attention has been given in the science education literature to the concept of Inquiry–Based Learning (Rutherford & Ahlgren, 1990; National Science Education Standards, 2006 National Science Teachers Association, 2007). The National Research Council (1996) provides the following description of scientific inquiry leading to inquiry–based learning:

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p.23)

In their 2007 position statement, the National Science Teachers Association (NSTA) stated "inquiry–based laboratory investigations at every level should be at the core of the science program and should be woven into every lesson and concept strand" (NSTA, p.2). Dunbar (2002) offered the following definition of inquiry: "scientific inquiry involves posing questions about the natural world and investigating observed phenomena; students are guided to use multiple science process skills, experimentation, argument, and explanation as they find satisfactory answers to their questions" (p. 4). The NSTA suggested that "at the high school level, all students should be in the science lab or field, collecting data every week while exploring science labs." (p. 2).

The present study was based on the theoretical science education literature pool which calls for wholesale educational reform in the systematic implementation of inquiry based learning. If agricultural educators are to effectively integrate science instruction, a reasonable assumption is that inquiry–based learning should be central to such efforts. Unfortunately a dearth of research exists regarding the current level of inquiry based learning implementation in the agricultural education curriculum. If we are to effect meaningful change in agricultural education, research is needed to establish the current status of science integration in agriculture generally, and the implementation of inquiry based learning more specifically

Purpose and Objectives

The purpose of this study was to determine the perceived competence of agricultural education teachers in integrating science and use of inquiry based teaching techniques in agricultural education programs. The objectives of the study were as follows:

1. Describe agriculture teacher perceptions of teacher preparation program needs based upon their personal competence to integrate science into the agricultural education curriculum.
2. Identify factors influencing agriculture teachers' current and planned levels of science integration in the agricultural education programs.
3. Describe the use of inquiry based teaching techniques in agricultural education programs.

Methods

This statewide study used a descriptive survey research design. The instrument used in this study was based on existing instruments used by other researchers in this field of study (Dunbar, 2002). For improved clarity, the researchers modified two instrument items slightly by adding the term "agricultural" and replacing the term "sophistication" with "complexity" and by replacing the word "orchestrate" with "facilitate." as follows. Teacher responses were measured on a Likert–type scale. A panel of experts consisting of faculty, administrators, and graduate students from the University of Florida reviewed the instrument for face and content validity. The authors of the original instrument report internal consistency using Cronbach's alpha of 0.90 (Dunbar). A post–hoc reliability analysis of this administration of the slightly revised instrument revealed a Cronbach's alpha coefficient of 0.81.

The population for the study consisted of all agricultural education teachers in Florida. The population frame of the study was established by using the state agriscience teacher directory (N = 355). Data were gathered from all members of the population. Whereas this is a census study, the findings are not generalizable to individuals beyond this population and only descriptive statistics were used to analyze the data.

In an attempt to address non–response error, a total of six respondent contacts were made (Dillman, 2000). These included a pre–study electronic mail contact, instrument mailings, and reminders via both electronic and land mail. Furthermore, 10% of the non–respondents were randomly selected and contacted via telephone and completed the questionnaire verbally (Ary, Jacobs, Razavieh, & Sorensen, 2006). Respondents and non–respondents were compared and no statistically significant difference was found. A total of 217 respondents returned questionnaires for a 61.1% response rate.

Findings

The gender demographic of the respondent group was found to be approximately even with a slight majority (54%) being male. Respondents reported a mean of slightly over 15 years of teaching experience. A majority (52.3%) reported teaching in high schools with almost a third (32.1%) teaching in middle school agricultural education programs. The remaining respondents (15.5%) reported teaching in blended (both middle and high school) agricultural education programs. The largest percentage of teachers reported their highest level of education as a bachelor's degree (37.5%), followed by a master's degree (26.6%), bachelor's plus some graduate courses (20.3%), master's degree plus some additional graduate courses (12.5%), and 3.2% of the teachers reported holding either a specialist or doctoral degree. Less than half (44%) of the teachers reported that their undergraduate major was agricultural education.

The first objective of this study was to describe agriculture teacher perceptions of teacher preparation program needs based upon their personal competence to integrate science into the agricultural education curriculum. Table 1 illustrates that most respondents reported that they feel prepared to teach both integrated biological science concepts (79.9%) and physical science concepts (71.4%). When asked to comment on teacher preparation programs, just over half (57.6%) suggested that students in those programs be required to complete more science courses. Furthermore, respondents suggested that students complete early field experiences (64.6%) and student teaching internships (79.6%) with teachers who integrate science. Responding teachers overwhelmingly supported (93.6%) the inclusion of instruction on how to integrate science concepts and principles in teacher preparation programs.

Table 1
Preparation To Integrate Science

Statement	%Agree (*f*)	%Neutral (*f*)	%Disagree (*f*)
Teacher preparation programs in agriculture should provide instruction for undergraduates on how to integrate science concepts/principles in agriculture.	93.6 (203)	5.1 (11)	1.4 (3)
I feel prepared to teach integrated biological science concepts.	79.9 (159)	10.6 (21)	9.5 (19)
When placing student teachers, teacher preparation programs should expect cooperating teachers to model science integration.	79.6 (172)	15.7 (34)	4.6 (10)
I feel prepared to teach integrated physical science concepts.	71.4 (142)	11.1 (22)	17.6 (35)
Teacher preparation programs should require that students conduct their early field experiences with a teacher who integrates science.	64.6 (139)	27.0 (58)	8.4 (18)
Teacher preparation programs in agriculture should require students to take more science courses.	57.6 (125)	25.3 (55)	17.1 (37)

Note. *n* = 217. Original scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree. Responses were collapsed into Disagree and Agree.

The second objective of this investigation was to identify the factors influencing agriculture teachers' current and planned levels of science integration in agricultural education programs. Most respondents (92.8%) indicated that they have integrated science into their agricultural education program. Almost three–fourths (74.6%) indicated they plan to increase the amount of science integration in their curriculum. While 24.4% stated that they plan no change in their current level of science integration. In response to an open–ended question, 42 respondents indicated that pressure to address state standards and administrator pressure caused them to integrate science into their program. (see Table 2). Several also noted one reason they integrated science was that agriculture is a science and it just makes sense to do so (*f* = 29) and the changing nature of the agriculture industry demands the integration (*f* = 25). One respondent noted that integration is "necessary to validate the relevance of the subject to exist in public schools." Another commented "I cannot see how you can teach agriculture without integrating science." Regarding the changing nature of the agriculture industry, one respondent replied "It [integration] is the only way to teach agriculture in the 21st century in which biotechnology and high order science skills and knowledge have become so critical to success in any agriculture career."

Table 2
Most Significant Factors That Caused Teacher To Integrate Science

Factor	*f*
State standards / Pressure from administrator	42
Agriculture is an (applied) science, it's the natural thing to do	29
Changing nature of the agriculture industry demands it	25
Agriculture course meeting science credit for graduation	19
It increased student learning	16
It increased student enrollment	15
I (the teacher) enjoy it	12
Students enjoy it	12

Note. Respondents were allowed to indicate more than one factor.

On a second open–ended question asking respondents to identify what they would need to integrate more science into their programs, the most frequently listed items dealt with increased funding for supplies and equipment (*f* = 72). (See Table 3) Also reported were the need for curricular materials and/or textbooks that highlight science integration (*f* = 56) and the need for training on how to integrate (*f* = 33).

Table 3
Items Needed To Integrate More Science

Item	*f*
Funding for supplies and equipment	72
Curriculum and textbooks highlighting integration	56
Training on how to integrate science	33
More time (planning time and preparation time)	30
Improved facilities (laboratory space, storage)	24
Smaller class size	7

Note. Respondents allowed to indicate more than one factor.

The third and final objective of this research was to describe the use of inquiry based teaching techniques in agricultural education programs. This was achieved through the use of two difference scales, the Teacher Inquiry Scale and the Student Inquiry Scale (Dunbar, 2002). The Teacher Inquiry Scale asked respondents to indicate the frequency in which they engage in inquiry activities in their classrooms (Table 4). A grand mean of 2.70 (*SD* = 0.78) for this scale was calculated from teacher responses. This can be interpreted as teachers engaging in inquiry–type teaching strategies almost three times a week.

Table 4
Teacher Inquiry Scale (n = 217)

	Percent					
On average, to what extent do you:	Never[b]	1x per week[c]	2x per week[d]	3x per week[e]	4x per week[f]	5x per week[g]
Use open–ended questions that encourage observation, investigations, and scientific thinking.	0.5	8.6	21.8	29.9	17.8	21.3
Encourage students to initiate further investigation.	1.0	14.1	27.8	25.8	17.7	13.6
Identify agricultural situation/issues that can be investigated at varying levels of complexity.	1.5	19.2	29.3	30.8	13.1	6.1
Use a textbook as the primary method for studying agriscience.[a]	2.5	1.5	17.3	27.4	39.6	11.7
Facilitate and encourage student dialogue about science.	3.6	11.7	23.4	28.9	15.2	17.3
Encourage students to defend the adequacy or logic of statements and findings.	5.1	20.2	20.7	24.7	14.1	15.2
Make readily available to students a wide variety of resource materials for scientific investigations.	10.1	12.6	24.2	16.7	16.2	20.2
Encourage students to design and conduct experiments.	17.9	32.3	17.9	13.8	9.2	8.7
Ask a question or conduct and activity that calls for a single correct answer.[a]	22.4	11.2	25.5	21.4	15.8	3.6

Note. Grand mean = 2.70 (SD = 0.78).
[a]This item reverse coded for analysis. For computation of grand mean: [b]Coded as zero, [c]Coded as one, [d]Coded as two, [e]Coded as three, [f]Coded as four, [g]Coded as five.

The Student Inquiry Scale asked respondents to indicate the frequency in which students are asked to engage in various inquiry activities (Table 5). The grand mean for this scale was calculated as 2.97 (SD = 0.53). This can be interpreted as, on average, students were asked to engage in inquiry–type activities almost once per month.

Table 5
Student Inquiry Scale (n = 217)

How often do you ask students in your classroom to:	Never[b]	1x per year[c]	1x per semester[d]	1x per month[e]	1x per week[f]	1x per day[g]
	Percent					
Ask questions during investigations that lead to further ideas, questions, and investigations.	0.0	4.1	7.6	16.8	45.2	26.4
Offer explanations from previous experiences and from knowledge gained during investigations.	0.5	3.5	10.6	19.2	41.4	24.7
Make connections to previously held ideas (or revise previous conceptions/assumptions).	1.0	3.0	9.6	20.2	39.4	26.8
Communicate investigations and explanations to others.	2.0	3.1	15.8	29.1	36.2	13.8
Use data to construct a reasonable explanation.	2.0	8.1	14.2	28.9	37.1	9.6
Choose appropriate tools for an investigation.	4.1	3.0	15.2	21.8	38.1	17.8
Use drawing, graphing, or charting to convey new information from an agriscience activity.	4.6	6.6	21.3	28.4	32.5	6.6
Use investigations to satisfy their own questions.	4.6	7.1	14.7	29.4	33.0	11.2
Seek and recognize patterns (trends in data).	4.6	9.2	19.4	28.1	33.2	5.6
Listen carefully to peers as they discuss scientific investigations.	5.1	8.2	16.3	25.5	31.6	13.3
Memorize scientific facts or information separately from activities. [a]	6.1	28.3	25.8	14.6	6.1	19.2
Wait for the teacher's explanation before expressing an observation or conclusion. [a]	8.2	30.3	21.5	9.7	5.1	25.1
Follow a set series of steps to get the right answer to a question. [a]	14.3	43.4	27.0	8.2	4.6	2.6
Wait to act until the teacher gives instruction for the next step in the investigation. [a]	14.5	39.4	19.7	13.0	6.2	7.3

Note. Grand mean = 2.97 (SD = 0.53)
[a]This item reverse coded for analysis. For computation of grand mean: [b]Coded as zero, [c]Coded as one, [d]Coded as two, [e]Coded as three, [f]Coded as four, [g]Coded as five.

Conclusions, Recommendations, Implications

Conclusions of this census study were based on the responses of 217 Florida agriculture teachers. Although the integration of science into the agriculture curriculum is a concern in other states, the reader is reminded to exercise caution when generalizing the results beyond the population of this study.

The respondents in this study were mostly males teaching in a high school with over fifteen years of teaching experience. The respondents on average held a bachelor's degree only and that degree was likely not in agricultural education. As Florida agricultural education state staff and teacher educators prepare and deliver professional development opportunities to assist teachers in integrating science, these findings will be useful in guiding their planning decisions. When working with a majority of teachers who did not follow the traditional bachelor's degree in agricultural education pathway to teaching, it is important to keep in mind that differences in philosophy and view of the purpose of agricultural education are likely present.

Regardless of their pathway to enter the teaching profession, results of the first research objective indicate respondents to this study overwhelmingly agreed that teacher preparation programs in agriculture should provide instruction for undergraduates related to preparation for integrating science. In addition, with nearly 80% of teachers agreeing that cooperating teachers should model for teaching interns how to integrate science, it can be concluded that in–service teachers see the current and future importance of science integration. This finding should also serve as an important recommendation to the researchers as they consider teaching intern placements in the future. If this recommendation is to be implemented however, a diagnostic tool intended to more accurately evaluate the degree of science integration would be extremely useful in assessing the characteristics of teaching internship sites and other programs. Additional research is needed to develop such an instrument or method.

The second objective sought to identify the factors that motivated teachers to initiate integration of science in their curricula. Three of the most frequently offered open ended responses dealt with factors related to some external pressure to integrate. These included state standards and administrative expectations, the changing nature of the agricultural industry, and the fact that courses being offered for science credit necessitated integration. Conversely, five factors related more to self–expectations of the professional teacher. These included the notion that as an applied science, agriculture should be taught via science integration, that integration increases student learning, enrollment and enjoyment, and that the teacher enjoys teaching using integrated science. These perceptions of teacher motivation to change behavior establish an important basis for further research. It can reasonably be concluded that more effective and lasting integration will be achieved if teachers appreciate the intrinsic value of integration rather than the need to respond to external pressures to do so. Additional empirical evidence is needed to either refute or confirm teacher opinions regarding student response to science integration to build upon the findings of Balschweid (2002) in one such study.

Previous survey research has examined the barriers teachers face in integrating science (Balschweid & Thompson, 2002; Myers & Washburn, 2007; Thompson, 1998; Thompson & Balschweid, 2000; Wilson, et. al., 2002). In response to an open ended question, teacher respondents in the present study independently identified many factors consistent with previously examined barriers. These included limited funding, lack of curricular resources, professional development, planning and preparation time, improved facilities, and smaller classes. While some of these items are typical teacher responses, others are truly reflective of the real challenges faced by agriculture teachers in Florida. Anecdotal evidence in this particular state supports legitimate concerns that capital and operating budgets for agricultural programs are extremely limited and school overcrowding results in either large classes or teachers choosing to teach during planning time. If progress is to be made in moving the integration of science to an advanced level in Florida, agricultural leaders must be equipped with empirical evidence to effect change with these resource–oriented barriers to science integration.

The majority of teachers responding indicated they feel prepared to integrate biological science concepts and physical science concepts. The higher degree of perceived preparation in biological sciences rather than physical sciences is consistent with previous findings (Thompson, 1998). The implication for practitioners and state leaders is that pre–service teacher curriculum should be examined to find ways to close the gap between biological and physical science competency among future generations of teachers. At the same time, curriculum development and professional development efforts should be exerted to address similar concerns with current practitioners.

With over 90% of respondents indicating they have already integrated science to some degree, the researchers conservatively concluded that at least limited integration of science is the norm rather than the exception in the 217 classrooms represented by these respondents. Furthermore, with nearly three quarters of respondents indicating their intention to increase their level of integration and no respondents anticipating a decrease in integration, it can be concluded that in coming years, the degree of science integration will expand in Florida agricultural education. Longitudinal research with the same participants would result in meaningful analyses in determining the degree to which teachers follow through with their stated intentions of increased future integration. If levels of science integration are to expand for nearly 75% of the responding teachers, a reasonable assumption to draw is that expanded professional development in effective integration strategies will be needed.

The teacher and student inquiry scales adapted from Dunbar (2002) hold promise as an important starting point for a continuing line of investigation into the current status of inquiry based learning in agricultural education. The present study found that teachers used inquiry–oriented strategies on average between two and three times per week. Furthermore, on average they asked students to engage in inquiry based strategies nearly once per month. These findings led the researchers to conclude that while the participants in this study may recognize the value of inquiry based strategies, they tend to implement them in a rather teacher–centered as opposed to student–centered way. In order to prepare agriculture teachers to meet the National Science Teachers Association's (2007) call for students to be engaged weekly in inquiry based data collection and learning, notable changes will be needed in agriculture teachers' current practices in Florida. Addressing previously discussed findings regarding facility and class size challenges may prove beneficial in increasing the degree of student–oriented inquiry. However, professional development will be needed to assist teachers in developing strategies to transition from student–oriented inquiry only once per month to an increased level of frequency.

Using these scales, a single measure of the level of inquiry agriculture teachers report means little. Additional examination using this instrument over time is recommended to assess changes in level of integration. The teacher and student inquiry scales are potentially useful in evaluating differences between groups of teachers with differing levels of experience, different program types, or with varying pathways to the profession. This tool also holds promise in measuring teacher change prior to and following interventions to assist them in enhancing their proficiency with inquiry based learning.

The call reflected by legislative action for all teachers to integrate core academic content is clear. The science education community has also made clear the educational need to increase the implementation of inquiry based learning in instructional practices. If these calls are to be answered by the agricultural education community, it is evident that additional work and diligence will be required.

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