Journal of Southern Agricultural Education Research

Volume 66, #1
2016

ISSN 1953-6412

Priority Research Areas:

Agricultural Communications
Agricultural Leadership
Extension Education
Teacher Education and School-based Agricultural Education
Teaching and Learning in Undergraduate and Graduate Academic Programs
Understanding the Food and Fiber System
(Agricultural Literacy)

Table of Contents

The Impact of Socioscientific Issues-based Instruction on College Students' Knowledge Acquisition

Catherine W. Shoulders
University of Arkansas

Jarred D. Wyatt
University of Arkansas

Author note: Corresponding author, Catherine W. Shoulders, Department of Agricultural Education, Communications and Technology, University of Arkansas, 205 Agriculture Building, Fayetteville, AR 72701. cshoulde@uark.edu

Abstract

The need for STEM literacy among undergraduates has fueled the exploration of innovative teaching methods in the higher education setting. Socioscientific issues (SSI)-based instruction is an instructional model that has yielded positive results in a variety of settings, including agricultural education. However, the multiple variables contributing to the impact of classroom instruction on student outcomes merits further investigation into the effectiveness of SSI-based instruction at the undergraduate level. This quasi-experimental study examined the impact of SSI-based instruction on undergraduate students' knowledge of solar energy. Nonequivalent groups were randomly assigned to either an SSI-based instructional module or a traditional instructional module. Results indicated that while both groups experienced significant gains in their knowledge of solar energy, SSI-based instruction was not more impactful than traditional instruction. Findings suggest that instructors looking to invigorate their classroom through innovative teaching methods explore the use of SSI-based instruction, as their students' learning should not be negatively impacted. Recommendations are made for researchers in order to better understand the impact SSI-based instruction has at the undergraduate level.

Keywords: socioscientific issues, instruction, solar energy, college students

Introduction

The need for U.S. citizens to be literate in science, technology, engineering, and mathematics (STEM) is undisputed (Zollman, 2012) – STEM skills and competencies "are integral and essential parts of daily life for virtually everyone in the United States and around the globe" (National Research Council, 1999, p. 1). Voting issues can be organized into 43 distinct categories, over half of which are tied to at least one aspect of STEM, according to data collected by Project Vote Smart (2014). STEM literacy also impacts business practices; public concern for environmental protection, animal welfare, and food safety have for years been important in establishing best practices in the agricultural, food, and natural resource sectors (Dimitri, Effland, & Conklin, 2005). The need for STEM literacy is founded in reports recommending efforts to "resolve (1) societal needs for new technological and scientific advances; (2) economic needs for national security; and (3) personal needs to become a fulfilled, productive, knowledgeable citizen" (Zollman, 2012 p. 12). Leaders in education acknowledge the value of STEM-literacy through standards, reports, and funding opportunities, yet efforts to improve STEM education have fallen short, as indicated by the focus of STEM literacy in the Next Generation Science Standards, the common core standards initiative, and the goals of the National Science Foundation's Improving Undergraduate STEM Education program (National Governors Association Center for Best Practices, 2010; Next Generation Science Standards Lead States, 2013). While national focus has been given to improving science education at the K-12 level, the "responsibility for sustaining excellence in science in the United States falls on research universities" (Howard Hughes Medical Institute, 2013, p. 3). Universities have responded to continued calls for increased quality in STEM education through establishing innovative centers and projects (Iglinski, 2012), employing alternative approaches to recruiting and retaining students to STEM majors, and experimenting with novel teaching approaches (President's Council of Advisors on Science and Technology, 2012).

Socioscientific issues (SSI)-based instruction is a STEM-focused teaching method that guides student learning in the context of complex societal issues. SSIs are multi-faceted, present in society, and controversial in nature (Chang-Rundgren & Rundgren, 2010). The vast majority of SSIs are rooted in agriculture, providing the industry with opportunities to teach agricultural concepts and literacy to students outside of school-based agricultural education. Faculty members within departments of Agricultural Education and related fields frequently focus on informal and nonformal methods of agricultural education, agricultural communications, and agricultural leadership, each of which is an appropriate context for learning about SSIs. Examples of SSIs include genetics and genetic engineering (Dori, Tal, & Tsauschu, 2003; Jimenez-Aleixandre, et al., 2000; Tal, Kali, Magid, & Madhok, 2011; Sadler & Zeidler, 2003; Zohar & Nemet, 2002), public health threats (Eastwood, Schlegel, & Cook, 2011; Kolsto, 2001; Tal & Hochberg, 2003; Wong, Hodson, Kwan, & Yung, 2008), animal welfare (Osborne, Eduran, & Simon, 2004), and environmental and energy issues (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Dori & Herscovitz, 1999; Eastwood, et al., 2011; Klosterman & Sadler, 2011; Roth & Lee, 2004; Sadler, Klosterman, & Topcu, 2011). Through a framework of learning experiences, students engaged in SSI-based instruction learn about the complex perspectives surrounding a specific SSI, as well as how to make decisions regarding that SSI (Sadler, 2011). Because students gain an understanding of multiple STEM-related fields and must make decisions based on that understanding, SSI-based instruction is an ideal method to develop a STEM literate populace.

Current research has examined the impact of SSI-based instruction on undergraduate students within the specific disciplines of science (Sadler & Zeidler, 2004), education (Sadler & Zeidler, 2003), biotechnology (Halverson, Siegel, & Freyermuth, 2009), biology (Sadler, 2004), psychology (Sadler, 2004), teacher education (Topcu, Sadler, & Yilmaz-Tuzun, 2010), and agriculture (Shoulders & Myers, 2013). While a few researchers have branched out to examine attitudes and gather information regarding SSIs from multi-disciplinary groups of students, little research has been conducted to examine the impact an SSI-based intervention would have on multi-disciplinary groups of students at the undergraduate level (Chang & Chiu, 2008; Fowler & Ziedler, 2010). The need for agricultural literacy among the nation’s general public suggests that investigating appropriate methods for teaching multidisciplinary groups of students may be required in order to promote educated agricultural views among students in other fields.

Theoretical Framework

This study sought to examine the impact of an SSI-based intervention on undergraduate students’ knowledge acquisition following Dunkin and Biddle’s (1974) model of the theory of classroom teaching (see Figure 1).

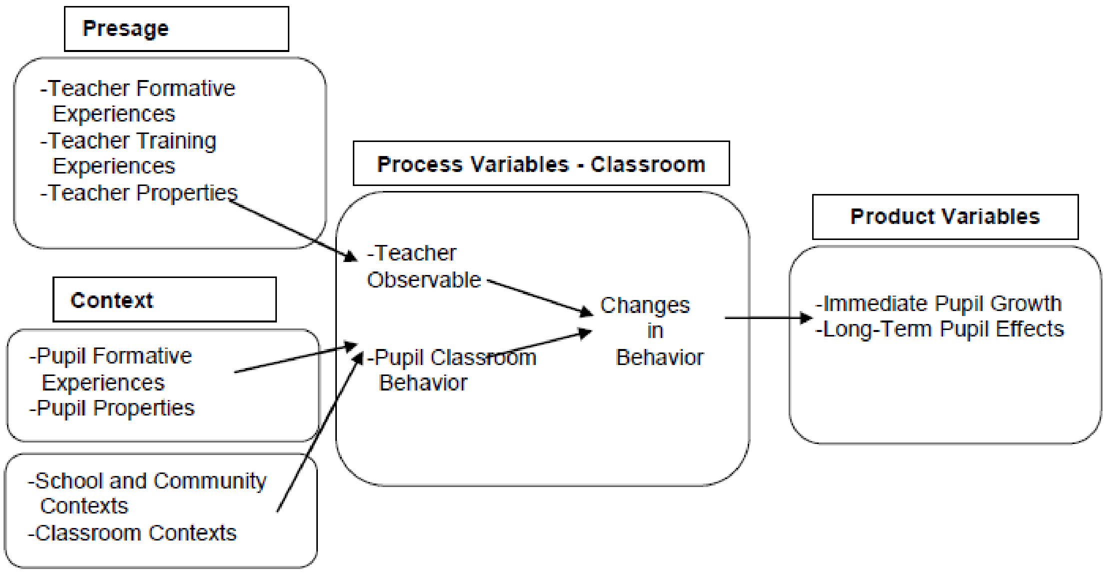

Figure 1. Model of the theory of classroom teaching (Dunkin & Biddle, 1974)

Dunkin and Biddle posited that a combination of presage, context, and process variables lead to impacts on product variables. Presage variables include teacher formative experiences, teacher training experiences, and teacher properties, each which contribute to the teacher's contributions to the classroom environment in which students engage. Context variables include pupil formative experiences, pupil properties, school and community contexts, and classroom contexts, which make up the components of the classroom environment unalterable by the teacher. The presage and context variables meet in the physical setting of the classroom, where process variables, including teacher and pupil behaviors, interact with one another to impact the reacting behaviors of each. These behaviors impact teachers' and students' perceptions, personal and professional growth, knowledge, and long term personal and professional actions. This study modified the classroom context of teaching methods to determine the impact of SSI-based instruction on the product variable of knowledge acquisition.

SSI-based instruction improves student learning experiences by allowing them to practice using scientific principles and concepts in situations similar to those they will experience in the future as citizens in a scientific society (Sadler, 2011). Because SSIs involve multiple facets of learning, including scientific principles and processes, consideration of morals and ethics, and political venues (Sadler, 2011), the mere insertion of relevant issues into existing educational practices does not provide students a substantial opportunity for developing scientific literacy. Eilks (2010) offered a five-step model for the operationalization of SSI-based instruction (as cited in Sadler [2011]):

1. Problem analysis. In this step, students are presented with an issue of interest through media reports or other strategies that highlight the reality and relevance of the issue.
2. Clarification of the science. Teachers help students understand the basic science underlying the issue.

3. Refocus on the socioscientific issue dilemma. Students refocus their attention on the issue and the associated social problems or controversies.
4. Role-playing task. Students assume roles for engaging in the negotiation of SSI. These roles may include parties to the issue debate or creators of media related to the issue.
5. Meta-reflective activity. Students are encouraged to reflect on their overall experiences with the issue and the underlying science. (p. 359)

While Eilk's model is helpful in designing one type of SSI-based instruction, Sadler (2011) posited the model to be "too prescriptive" to be applied to a variety of educational contexts, and proposed a framework that highlights considerations when designing SSI-based instruction rather than a step-by-step approach. This framework for SSI-based education includes four elements: classroom environment and teacher attributes, which impact the learning experience, and design elements and learner experiences, which make up the learning experience.

Design elements include the components instructors must consider when creating units of instruction based on an SSI. Essential design elements involve selection of an appropriate SSI and the early incorporation of that SSI into instruction. Also considered essential design elements are scaffolding to develop higher-order thinking skills, such as argumentation and decision-making, as these are not expected to be developed without overt and deliberate practice, and the inclusion of a culminating experience, designed to allow learners to come full circle in the experiential learning cycle by tying concepts and reflections back to the original SSI. Sadler (2011) recommended the use of media to increase student interest in the SSI and to tie the SSI to the students' world outside of school, as well as the use of technology as an ever-current learning tool due to the rapidly changing nature of SSIs.

Learner experiences include the actions and experiences in which students engage during the instruction. Sadler stated essential experiences should allow learners to engage in higher-order thinking skills, address the scientific concepts and theories related to the SSI, test ideas by collecting and analyzing data, and negotiate the social dimensions of the issue. Sadler also recommended that learner experiences consider both ethical dimensions and nature of science themes related to the SSI, as these aspects enhance student learning, but are not completely necessary in SSI-based instruction.

Classroom environment includes factors that aid in the successful implementation of an SSI within the culture of a given classroom. Essential features include established high expectations and norms for student participation, a collaborative and interactive culture, a demonstration of respect between teachers and students, and a safe environment in which differing perspectives can be expressed. These factors of classroom environment are crucial to the enrichment of student learning experiences because of the controversial nature of SSIs and the level of collaboration and discussion required in order to develop higher-order thinking skills (Sadler 2011).

Teacher attributes also impact successful implementation of SSIs into enriched student learning; Sadler (2011) specified four essential teacher attributes necessary when incorporating SSI-based instruction. These require that teachers are familiar with both the science content and social considerations of the SSI and surrounding issues, as they should help students connect the issue with the science surrounding it. Teachers should also hold a realistic view about limitations of their own and society's knowledge regarding the SSI, as the evolving nature of SSIs has implied that even the science community does not know everything about the issue. Teachers ought to be willing to accept uncertainties in the classroom, as the controversial nature of SSIs leads students to discuss alternative opinions, resulting in multiple potential acceptable decisions.

Conceptual Framework

The impact of SSI-based instruction on various student learning outcomes, based on grade level, assessment method, subject, and student ability, has been examined over the past decade. Yager, Yim, and Yager (2006) compared middle school students' academic gains between classes taught through an SSI-based approach and through a traditional approach. Ten weekly quizzes were utilized as a pre- post-test to measure middle school students' differences in concept mastery over the course of a semester. General science achievement was measured through the use of a common science semester exam, which was again administered as both a pre- and post-test to each group. Statistically significant gains were found for students in both groups with both measures. However, the gains between the two groups were not statistically significant, implying that the students taught through the SSI-based approach mastered science concepts at a level equal to that of students learning through traditional methods. Additionally, because the authors classified their study as action research, no attempt was made to validate the instruments or measure the reliability of their scores. While these findings suggest SSI-based instruction may not be any more impactful on student learning than traditional methods of instruction, the validity of the instrument brings a level of uncertainty to the results. Further, the study's focus on middle school education may not allow generalizability to undergraduate students, where excellence in science teaching is expected (Howard Hughes Medical Institute, 2013).

High school students are more akin to undergraduates than middle school students, though still separated in maturity and cognitive ability by four to five years. Zohar and Nemet (2002) conducted a study designed to explore the effects of a genetics-based SSI unit on ninth grade Israeli students' biological knowledge. Through the use of experimental and comparison groups, the authors compared biological knowledge gains between the two groups as evidenced by pretest and posttest questionnaires. While the experimental group learned about advanced genetics concepts through the Genetic Revolution unit, those in the comparison group learned the same genetics concepts through a booklet that presented information in a traditional textbook approach. The pretest and posttest consisted of an item designed to "[address] the extent to which students consider biological knowledge while thinking about the dilemma" (p. 43) and a 20-item multiple choice genetics knowledge test. With regard to consideration of biological knowledge, the authors found that students in the comparison group did not consider biological knowledge when considering the dilemma as frequently as those in the experimental group. This trend was continued with respect to the use of false considerations, as those were found more frequently in the comparison group responses. Alternatively, students in the experimental group correctly considered specific biological knowledge more frequently than those in the comparison group. With regard to biological knowledge gains, results indicated that students experiencing the SSI-based Genetic Revolution unit scored significantly higher than those in the comparison group.

Sadler, et al. (2011) sought to determine the impact of SSI-based instruction on student scientific content knowledge in two high school classes of average-achieving students. The authors posed problems associated with assessments directly aligned with interventions, which are not ideal for use as summative assessments due to their lack of assessment of knowledge transfer, and those that are broader in scope, which are insensitive to small changes resulting from a short-term intervention. To address these issues with types of assessments, this study utilized two different assessments based on their distance from the intervention in order to assess the unit's impact on students' scientific content knowledge. Proximal data were collected through the use of a test with items that related directly to the unit, while distal data were collected through the use of items from state and national exams. The proximal assessment included five open-ended questions relating to climate change, which was the SSI focus, and was analyzed using the constant comparative method. The distal test measured student knowledge in climate and temperature, greenhouse effects and climate change, chemical principles and processes, and graphical creation and analysis. Comparing results for pre and posttests, the authors found that there was a significant increase between the pretest and posttest responses for the first three items of the proximal assessment, indicating that the SSI-based instruction significantly improved students' proximal responses. Distal measures resulted in a significant increase in students' correct responses from the pretest to the posttest, with a medium effect size, implying that the SSI-based instructional unit not only helped students learn scientific content in the SSI context, but also transfer the content to other scientific contexts.

Klosterman and Sadler (2011) also incorporated both proximal and distal level measures into their study of the impact of a three-week global warming unit on eleventh- and twelfth-grade students' science content knowledge gains. As in the study by Barab, et al. (2007), the authors developed a distal-level measure assessing specific science standards from a pool of publicly released standardized test items. The proximal-level measure contained five open-ended questions regarding the specific curriculum of focus in the global warming instrument. Proximal-level response analysis indicated a statistically significant difference between pre-and post-assessments on three of the five questions; the final two questions were not analyzed due to the low frequencies in each scoring level. Contrary to the results in the 2007 study, Klosterman and Sadler (2011) found a statistically significant gain with a medium level effect size in students' distal-level scores. However, no comparison was done with alternative treatments to determine the treatment's effect as compared to traditional instruction.

Tal, et al. (2011) examined Israeli student scientific and genetics knowledge after exposure to the two-week WISE Simple Inheritance module. The science-knowledge integration test combined an original WISE knowledge-integration assessment with a revised version of the test that focused specifically on students' integrated understandings of the principles of simple inheritance, and lastly, contained a complex question related to how large family exterminations during the Holocaust has influenced simple inheritance, as this situation is relevant to Israeli families. Students were given the test after they were exposed to the module and one of two "enhancements," which were online interaction with a cystic fibrosis patient and a field trip to a hospital. The authors examined student responses to find evidence of differences in knowledge acquisition between the two groups, and found no significant differences. Because no pretest was administered, the authors could not determine the impact of the overall module on student knowledge acquisition.

In agricultural education, Shoulders and Myers (2013) sought to determine the impact of SSI-based instruction on secondary education agriculture students through the issue of lab-grown meat. Findings indicated that students' knowledge regarding animal science increased as a result of the SSI-based instruction. However, knowledge gains were influenced by grade level, number of completed agricultural education classes, and FFA membership.

Studies have displayed the impact of SSI-based instruction on student learning of scientific content in grades 5-12, largely in single group, pretest-posttest designs. These studies suggest the potential for SSI-based instruction to yield gains in student learning at other grade levels, such as the undergraduate level, where students should expect to be exposed to excellent science teaching (Howard Hughes Medical Institute, 2013). In addition to the advanced maturity and cognitive ability of undergraduate students as compared to the younger subjects of previous studies, the course selection process of undergraduates may yield different results, as students select their own courses of study. This study sought to address how these variables within the undergraduate population may impact student learning during SSI-based instruction.

Purpose and Objectives

The purpose of this study was to determine the impact of an SSI-based instructional module on undergraduate students' knowledge acquisition when compared to a traditional instructional module. To achieve this purpose, the following objectives were created:

1. To determine the impact of an SSI-based instructional module on undergraduate students' knowledge of solar energy.
2. To determine the impact of a traditional instructional module on undergraduate students' knowledge of solar energy.
3. To determine whether a difference exists between the impact of an SSI-based instructional module and a traditional instructional module on undergraduate students' knowledge of solar energy.

The following hypotheses were developed in order to meet the aforementioned objectives:
H_O^1: The SSI-based instructional module does not have an impact on students' knowledge of solar energy.
H_O^2: The traditional instructional module does not have an impact on students' knowledge of solar energy.
H_O^3: There is no difference between the impact of the SSI-based instructional module and the traditional instructional module on students' knowledge of solar energy.

Methods

This study employed a quasi-experimental nonequivalent control group design to assess students' knowledge acquisition before and after an SSI-based instructional module or a traditional module. While the classes themselves were randomly assigned to treatments, students were not randomly assigned to classes, so the groups were assumed to be nonequivalent (Cook & Campbell, 1979). Both the control and treatment modules introduced students to solar energy and its uses.

Participants

Due to the renewable energy content focus, the population for this study was the undergraduate student body at the University of Arkansas enrolling in undergraduate courses identified by a panel of experts to have a focus on sustainability offered during the Fall 2013 semester (*N* = 258). This panel of experts consisted of three faculty and one graduate student, each of whom have expertise in sustainability and renewable energy education. Courses were selected from the list of courses offered as electives to students pursuing a Sustainability Minor. These courses contained both Sustainability Minor students and students pursuing a variety of majors without the Sustainability Minor. The list of courses was then reduced to those focusing on some aspect of renewable energy, leading to a total of eight courses, seven of which were offered during the Fall 2013 semester. Instructors of six classes agreed to participate, leading to a total accessible population of 248 students. Absences led to a sample size of 141. Based on the population size, a sample size of at least 154 was necessary to obtain generalizable results at the 5% precision level (Israel, 2009). Therefore, the precision level of the study was adjusted to 7%.

Classes were randomly selected to participate in either the treatment or control. A total of 82 students from three classes were exposed to the SSI-based instructional module, while a total of 59 students from three classes were exposed to the traditional instructional module.

Intervention

Both the treatment and control consisted of one 90-minute lesson plan. While a greater intervention duration would have been favorable, instructors were not willing to give up their classes for longer than one class period. Because SSI-based instruction can be utilized for any duration (Sadler, 2011), the 90-minute lesson was deemed acceptable. Each intervention aligned with a set of five objectives focusing on solar energy: a) students will define solar energy and identify benefits and drawbacks of solar energy; b) students will explain how solar energy is used to create electricity; c) students will compare and contrast different materials used in solar technologies; d) students will analyze different solar array configurations; and e) students will use mathematical calculations to correctly size solar arrays for specific settings and evaluate a system’s impact on electricity bills.

The treatment lesson plan followed an SSI-based instructional format. Students first were presented with the issue through a video displaying the need for alternative energy sources. They were then introduced to the University of Arkansas’ sustainability plan and its performance on ASHE STARS, which is a benchmarking system used by the university to measure its sustainability efforts. Students saw on this benchmarking system that the University of Arkansas is currently not pursuing renewable energy investments. Students were then presented with the task of determining whether solar arrays should be installed at the university, supporting their decision, and determining the array configuration which would be most feasible. The students were given a worksheet to guide them through this decision making process during the class period. The worksheet allowed students to evaluate information given to them during the class lecture in order to inform their decisions. After the informative lecture, which focused on delivering content related to the five objectives, the students were asked to discuss their decisions using their newly acquired information as support.

The control lesson plan followed a traditional instructional format. Students were first introduced to the topic through a video that displayed the global interest of solar energy without presenting a need to increase renewable energy use. Students were then shown a small array located at the University of Arkansas for educational purposes. During the lecture, they were asked to complete a worksheet. This worksheet enabled students to apply information they learned during the lecture without asking them to make any decisions regarding solar energy investments. The class concluded by discussing their worksheet answers; students recited correct answers, and incorrect answers were corrected through discussion.

To ensure fidelity of intervention, O'Donnell's (2008) five criteria, including adherence, duration, quality of delivery, participant responsiveness, and program differentiation were considered. Adherence and duration were ensured by consistency in the lesson deliverer and in the delivery. All lessons for both interventions were taught by the same researcher. Quality of delivery was ensured through the use of a second researcher, observed each class and confirmed that each action on the lesson plan was followed by the researcher delivering the lessons. Duration was ensured by the use of 90-minute lessons within the setting of 90-minute class sessions. Participant responsiveness was observed by the evaluating researcher, who monitored students' use of the worksheets and guided off-task students as needed. Program differentiation was ensured through the use of a panel of experts, who evaluated both of the lessons for face, content, and construct validity. The panel consisted of three faculty members with expertise in SSI-based instruction, sustainability, renewable energy, and education.

Instrumentation

Pretests and posttests were to assess students' knowledge. Six multiple choice items were developed to assess learning on each of the five objectives for a total of 30 items. These items were placed into two random orders to create equivalent forms of a pretest and posttest. A panel of four experts in solar energy education and assessment development established face and content validity of the tests, as well as confirmed alignment between the items, learning objectives, and lessons. The assessments were pilot tested with a group of 149 undergraduates from the University of Arkansas; calculations of internal consistency yielded scores of .81 and .90, which was deemed acceptable (George & Mallery, 2003).

Data Collection

In-tact classes were recruited via electronic communication to their instructors prior to the Fall 2013 academic year. Instructors were able to select the date of the experiment for their classes in order to increase instructors' likelihood to allow their classes to participate. Each intervention was held during the regularly scheduled class time and in the class' regularly scheduled location. Researchers were first introduced to the students as guest speakers sharing information about solar energy. The researchers then briefly explained the study and dispersed paper copies of the consent form and pretest. Students were given 20 minutes to complete the pretest on provided scantron forms. Following that 20 minutes, materials were collected, worksheets were distributed, and the 45-minute lesson began. At the conclusion of the lesson, students were given paper copies of the posttest. Students had 20 minutes to record their answers on the accompanying scantron form. Materials were collected as students finished their posttests.

Data Analysis

Data were analyzed using SPSS Version 20 computing software. Descriptive data are reported using means and standard deviations of pretest and posttest scores. Null hypotheses were tested using dependent samples *t*-tests to compare pretest scores to posttest scores from each group and analysis of covariance to compare differences in scores between the two groups (Field, 2009). Analysis of covariance used standardized raw change scores as a dependent variable and standardized pretest scores as the covariate in order to account for differences among groups (Kenny, 1975). Effect sizes were calculated using Cohen's *d* for those differences which were found to be significant. They were interpreted using Cohen's (1988) recommendations.

Findings

Objective one sought to determine the impact of an SSI-based instructional module on undergraduate students' knowledge of solar energy (Table 1). Students whose classes were randomly selected to receive the SSI-based instructional module (n = 82) displayed a mean pretest score of 16.59 (SD = 3.46) and a mean posttest score of 20.12 (SD = 2.83). This mean score increase of 3.54 was found to be statistically significant by use of a dependent samples *t*-test. Interpretation indicated the effect size was large; students' mean posttest score fell at the eighty-eighth percentile of their pretest scores (Cohen, 1988).

Objective two sought to determine the impact of a traditional instructional module on undergraduate students' knowledge of solar energy (Table 1). Students whose classes were randomly selected to experience the traditional instructional module (n = 59) displayed a mean pretest scores of 15.34 (SD = 3.39) and a mean posttest score of 19.63 (SD = 2.82). This mean score increase of 4.29 was found to be statistically significant by use of a dependent samples *t*-test. Interpretation indicated again the effect size was large; students' mean posttest score fell into the ninety-first percentile of their pretest scores (Cohen, 1988).

Table 1.

Mean Pretest and Posttest Scores and Their Significance of Both Interventions

Intervention	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	*t*	*p*	*d*
SSI-based Instructional Module	16.59	3.46	20.12	2.83	4.27	<.0005	1.12
Traditional Instructional Module	15.34	3.39	19.63	2.82	14.43	<.0005	1.37

Note. All tests had possible score ranges of 0 – 30.

Objective three sought to determine whether a difference exists in the impact of the SSI-based instructional module and the traditional instructional module on undergraduate students' knowledge of solar energy. An ANCOVA using standardized scores indicated no significant difference between the two groups' changes in scores after adjustment for pretest scores, $F(1, 138) = .023$, $p = .88$.

Conclusions

Both intervention groups displayed significant increases in their knowledge of solar energy from pretest to posttest, leading the researchers to reject the null hypotheses stating the SSI-based instructional module and traditional instructional module would have no impact on students' knowledge of solar energy. These findings conflict those found by Barab, et al. (2007), which can be attributed to the 2007 researchers' acknowledgement of a possible ceiling effect. The results of this study support those found by Klosterman and Sadler (2011) and Yager, et al. (2006), who found significant gains in high school students' and middle school students' content knowledge scores following an SSI-based instructional module, respectively. Effect sizes for both groups were large, indicating that both instructional modules were considerably influential on changes in students' knowledge of solar energy.

While both groups displayed gains in their solar energy, findings indicated that students engaging in the SSI-based instructional module did not learn more or less information than the students engaging in the traditional instructional module. Therefore, the null hypothesis that no difference exists between the impact of the SSI-based instructional module and the traditional instructional module on students' knowledge of solar energy was retained. These findings are similar to those reported by Yager, et al. (2006), who found that SSI-based instruction led to gains in student knowledge that were at a level equal to those of students learning through traditional methods.

Implications and Recommendations

The results of this study imply that as a process variable, SSI-based instruction can lead to significant student learning, similar in its impact to traditional instructional methods. Examination of students' mean scores indicate that while students from both groups learned, both groups also failed to produce a mean score higher than 68% on any of the tests. Neither Eilks (2010) nor Sadler (2011) make recommendations as to the duration of an SSI-based instructional module. Similarly, traditional instructional modules occur at a variety of durations, often dependent upon the depth and breadth of the topic and the course's timeline. Findings from this study suggest that one 90-minute class period may be sufficient to improve students' content knowledge scores, but not to a level deemed to be satisfactory. While constraints related to the use of classes under the control of other instructors limited the researchers' ability to extend the duration of these particular instructional modules, instructors are encouraged to manipulate the duration of SSI-based instructional modules as they see fit within the specifics of their own classrooms.

Because of the multiple variables left unexamined in the model of the theory of classroom teaching (Dunkin & Biddle, 1974), this study's findings lead more to recommendations for future research than it does to recommendations for practitioners. This study examined one product variable related to student content knowledge. As shown in previously conducted studies, SSI-based instruction has the potential to impact students' proximal and distal content knowledge, as well as other outcomes such as argumentation, reasoning, and views of the nature of science. While results of this research display that SSI-based instruction is no more impactful on student knowledge than traditional instruction, the examination of additional outcomes could uncover additional benefits of SSI-based instruction. Researchers are encouraged to replicate this study in order to evaluate SSI-based instruction's impact on additional outcomes related to undergraduate students.

Researchers controlled for presage variables in this study by utilizing the same researcher to deliver all instructional modules. Dunkin and Biddle (1974) have posited that instructors' formative experiences, training experiences, and personal properties influence their teaching, and thereby influence process variables' impact on student outcomes. Future studies should examine the impact specific process variables, such as instructors' perceptions toward a specific SSI, have on student outcomes.

While classes were randomly assigned to interventions, the context variable of students' knowledge of solar energy before the intervention could have impacted the results of this study. These students may have had previous knowledge regarding or interest in solar energy because of their pursuit of a Sustainability Minor. Additional context variables, such as students' experience with specific SSIs and educational interests, should be acknowledged, and possibly controlled for, in future studies. Finally, this study examined learning impacts as a result of one SSI. Because varied SSIs are so prevalent in society, researchers are encouraged to examine the impact selection of SSI has on student outcomes.

The results of this study indicate that SSI-based instruction can remain a viable method of increasing outcomes related to STEM literacy among undergraduate students. However, maintaining a single focus on student content knowledge gains would do a disservice to the mission of the higher education system; STEM literacy, similar to undergraduate education, seeks to improve student outcomes in a variety of social, affective, and cognitive areas. The multi-faceted goals of STEM literacy and undergraduate education require instructors and researchers to investigate the impact of SSI-based instruction on numerous areas of student growth as they seek to improve STEM education.

References

Barab, S. A., Sadler, T. D., Heiselt, C., Hickey, D., & Zuiker, S. (2007). Relating narrative, inquiry, and inscriptions: Supporting consequential play. *Journal of Science Education and Technology, 16*(1), 59-82. doi:10.1007/s10956-006-9033-3

Chang, S. N., & Chiu, M. H. (2008). Lakatos' scientific research programmes as a framework for analyzing informal argumentation about socioscientific issues. *International Journal of Science Education, 30*(13), 1753-1773.

Chang-Rundgren, S. N., & Rundgren, C. J. (2010). SEE-SEP: From a separate to a holistic view Of socioscientific issues. *Asia-Pacific Forum on Science Learning and Teaching, 11*(1), 1-24.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design & analysis for field settings.* Chicago: Rand McNally.

Dimitri, C., Effland, A., & Conklin, N. (2005). *The 20th century transformation of U.S. agriculture and farm policy.* No. Bulletin 3. Economic Research Service/USDA.

Dori, Y. J., & Herscovitz, O. (1999). Question posing capability as an alternative evaluation method: Analysis of an environmental case study. *Journal of Research in Science Teaching, 36*, 411-430.

Dori, Y. J., Tal, T., & Tsauschu, M. (2003). Teaching biotechnology through case studies – can We improve higher order thinking skills of nonscience majors? *Science Education, 87*, 767-793. doi:10.1002/sce.10081

Dunkin, M. J., & Biddle, B. J. (1974). *The study of teaching*. Washington, DC: University Press of America, Inc.

Eastwood, J. L., Schlegel, W. M., & Cook, K. L. (2011). Effects of an interdisciplinary program on students' reasoning with socioscientific issues and perceptions of their learning experiences. In T. D. Sadler (Ed.), *Socioscientific issues in the classroom* (pp. 89-131).

New York, NY: Springer.

Eilks, I. (2010). *Making chemistry teaching relevant and promoting scientific literacy by focusing on authentic and controversial socioscientific issues.* Presentation at the annual meeting of the Society for Didactics in Chemistry and Physics, Pot*SD*am, Germany.

Field, A. (2009). *Discovering Statistics using SPSS* (3rd. ed.). Los Angeles, CA: Sage Publications.

Fowler, S. R., & Zeidler, D. L. (March, 2010). *College students' use of science content during socioscientific issues negotiation: Evolution as a prevailing concept.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Philadelphia, PA.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed.). Boston: Allyn & Bacon.

Halverson, K., Siegel, M. A., & Freyermuth, S. (2009). Non-science majors' critical evaluation of websites in a biotechnology course. *Journal of Science Education Technology, 19,* 612-620.

Howard Hughes Medical Institute. (2013). Sustaining Excellence: New awards for science education to research universities. Retrieved from http://www.hhmi.org/sites/default/files/Programs/Universities/2014-hhmi-universities.pdf

Iglinski, P. (2012). University joint national effort to improve undergraduate STEM education. University of Rochester. Retrieved from http://www.rochester.edu/news/show.php?id=4043.

Israel, G. D. (2009). Determining sample size, PEOD6, Agricultural Education and Communications Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). Doing the lesson or doing science: Argument in high school genetics. *Science Education, 84*(6), 757-792. doi: 10.1002/1098-237X

Klosterman, M. I., & Sadler, T. D. (2011). Multi-level assessment of scientific content knowledge gains associated with socioscientific issues-based instruction. *International Journal of Science Education, 32*(8), 1017-1043. doi:10.1080/09500690902894512

Kolsto, S. D. (2001). 'To trust or not to trust,...' -pupils' ways of judging information encountered in a socioscientific issue. *International Journal of Science Education, 23*(9), 877-901. doi:10.1080/09500690010016102

National Governors Association Center for Best Practices and Council of Chief State School

Officers. (2010). *Common Core State Standards Initiative.* Retrieved from http://www.corestandards.org/

Next Generation Science Standards Lead States (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

National Research Council. (1999). *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology.* Washington, DC: The National Academies Press.

O'Donnell, C. L. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention. *Review of Educational Research, 78*(1), 33-84.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), No4-1020. doi:10.1002/tea.20035

President's Council of Advisors on Science and Technology. (2012). Engage to excel: producing on million additional college graduates with degrees in science, technology, engineering, and mathematics. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel final_feb.pdf

Project Vote Smart (2014). Issues. One Common Ground, Philipsburg, MT. Retrieved from http://votesmart.org/issues#.UurNbU2A05s

Roth, W. M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education, 88*(2), 263-291.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-536.

Sadler, T. D. (2009). Situated learning in science education: Socioscientific issues as contexts for practice. *Studies in Science Education, 45*, 1-42.

Sadler, T. D. (Ed.) (2011). *Socioscientific Issues in the Classroom: Teaching, Learning, and Research*. New York, NY: Springer.

Sadler, T. D., Klosterman, M. I., & Topcu, M. S. (2011). Learning science content and socioscientific reasoning through classroom explorations of global climate change. In T. D. Sadler (Ed.), *Socioscientific issues in the classroom: Teaching, learning and research* (pp. 45-77). New York, NY: Springer.

Sadler, T. D., & Zeidler, D. L. (2003). Scientific errors, atrocities, and blunders. In D. L. Zeidler (Ed.), *The Role of Moral Reasoning on Sococscientific Issues and Discourse in Science*

Education (pp. 261-288). Netherlands: Kluwer Academic Publishers.

Sadler T., & Zeidler, D. L. (2004). Negotiating gene therapy: Controversies. *American Biology Teacher, 66*(6), 428-434.

Shoulders, C. W., & Myers, B. E. (2013). Socioscientific issues-based instruction: An investigation of agriscience students' content knowledge based on student variables. *Journal of Agricultural Education, 54*(3), 140-156. doi: 10.5032/jae.2013.03140

Tal, T., & Hochberg, N. (2003). Reasoning, problem-solving and reflections: Participating in WISE project in israel. *Science Education International, 14*(4), 3-19.

Tal, T., Kali, Y., Magid, S., & Madhok, J. J. (2011). Enhancing the authenticity of a web-based module for teaching simple inheritance. In T. D. Sadler (Ed.), *Socioscientific issues in the classroom: Teaching, learning and research*, pp. 11-38. New York, NY: Springer.

Topcu, M. S., Sadler, T. D., & Yilmaz-Tuzun, O. (2010). Preservice science teachers' informal Reasoning about socioscientific issues: The influence of issue context. *International Journal of Science Education, 32*(18), 2475-2495. doi: 10.1080/09500690903524779

Wong, S. L., Hodson, D., Kwan, J., & Yung, B. H. (2008). International Journal of Science Education, 30(11), 1417-1439. doi:10.1080/09500690701528808

Yager, S. O., Lim, G., & Yager, R. (2006). The advantages of an STS approach over a typical textbook dominated approach in middle school science. School Science and Mathematics, 106, 248-260.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through Dilemmas in human genetics. Journal of Research in Science Teaching, 39, 35-62.

Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics, 112*(1), 12-19. doi: 10.1111/j.1949-8594.2012.00101.x

Are Champions Born or Made?
Differences Between Low Performers and High Performers in a Missouri Career Development Event

Erica B. Thieman, University of Illinois,

William A. Bird,School Principal, Tennessee

Stacy K. Vincent, University of Kentucky – Point of Contact
505 Garrigus Builiding
Lexington, KY 40546
Stacy.vincent@uky.edu

Robert Terry, Jr., Oklahoma State University

Type of Research: Quantitative

Research Priority Area: School-Based Agricultural Education

Are Champions Born or Made?
Differences Between Low Performers and High Performers in a Missouri Career Development Event

Abstract

The purpose of this descriptive-correlation study was to describe and identify the differences between high performers and low performers among participants in the Missouri FFA Livestock Evaluation Career Development Event. The variables of interest included: marital status of parents, Free/reduced lunch status, Individual Education Plan (IEP) status, academic grade level, cumulative grade point average, and previous Career Development Event (CDE) experience as factors related to the individual's performance. Characteristics investigated in this study were determined from a review of related literature on student achievement. This research detected differences between the demographic characteristics of the high performing participants and low performing participants including: IEP status, grade level, free/reduced lunch status, grade point average, marital status of guardian(s), previous experience in livestock evaluation, and gender. Recommendations include increased professional development in accommodating all learners, reinforcement of the purpose of CDEs, and an analysis of other CDE areas.

Introduction

The mission of the National FFA Organization is, "FFA makes a positive difference in the lives of students by developing their potential for premier leadership, personal growth and career success through agricultural education" (National FFA Organization, 2009, p. 5). This mission is accomplished through three components of agricultural education: classroom/laboratory instruction, supervised agricultural experience, and the National FFA Organization (National FFA Organization, 2009). The amount of time school-based agriculture teachers dedicate to each of these areas varies by program (Phipps, Osborne, Dyer, and Ball, 2008). Each component, however, is considered to be equally important to the success of students enrolled in agricultural education courses (Phipps, et al., 2008).

Ideally, agricultural education introduces all students to the opportunities provided by the three components of agricultural education and prepares each student for a career in the agriculture industry (National FFA Organization, 2009). Chiasson and Burnett (2001) stated that "agriculture programs educate students to achieve in diverse areas that are very practical for dealing with the challenges in today's world" (p. 62). The end result is a student with enhanced knowledge in agriculture, leadership abilities, and direction toward a chosen career of interest (National FFA Organization, 2009). There are approximately 800,000 students enrolled in more than 100 different agricultural education courses in the United States (National FFA Organization, 2009). As Morgan, Chelewski, Lee, and Wilson (1998) stated, this curriculum is intended to prepare students of all levels and backgrounds for future careers in agriculture and related fields.

Involvement in the National FFA organization is intended to provide real world learning opportunities outside the classroom for all agricultural education students (Talbert &

Balschweid, 2005). According to Reis and Kahler (2007), students identified the FFA and Career Development Events (CDEs) offered through FFA to be the most satisfying experiences while they were involved in school-based agricultural education courses. The first CDEs, originally referred to as "evaluation contests," can be traced to state contests for vocational agriculture students held in 1919 (Tenney, 1977). These organized competitions were designed for students to compete using knowledge of specific areas of agriculture attained from instruction. According to the Missouri FFA Career Development Event Handbook (Missouri FFA Association, 2008), CDEs aid and enhance student interest in the agricultural industry. CDEs are designed to, "motivate students to acquire additional knowledge, develop skills and abilities, and stimulate student interest in furthering their education" (Missouri FFA Association, 2008, p. 1). CDEs are also designed to "assess the level of proficiency each student has achieved" in specific subject areas taught in secondary agriculture classroom settings (Missouri FFA Association, 2008, p. 1). As such, CDEs are linked to instruction and relate to all students enrolled in agriculture classes. This assertion suggests that the purpose of CDEs has expanded since their adoption by the National FFA Organization.

Based upon literature, the purpose of agricultural education is to prepare all students for entry into the agriculture industry (Association for Career and Technical Education, 2010; Missouri Department of Elementary and Secondary Education, 2009; National FFA Organization, 2009; Phipps, et al., 2008). If agricultural educators truly believe in its purposes, as defined by these authorities, then it can be assumed that all students, regardless of their individual differences, are provided the opportunity to participate and can find success in these areas of agricultural education, FFA, and CDEs. However, there are varying factors among students that can affect the likelihood of student achievement (U.S. Department of Education, 2009). These varying student demographics can include previous experience in the subject area, parent marital status, low socioeconomic status, and the ability level of the student to learn and apply information (Gohm, Oishi, Darlington, & Diener, 1998; Kopcha & Sullivan, 2008; Okpala, 2002; Rumburger & Palardy, 2005). According to the National Research Council (2000), it is crucial to student success that teachers address student diversity when providing instruction, allowing all students the opportunity to achieve success inside and outside the classroom.

Research has been conducted to determine diversity among FFA members participating at state and national CDEs (England, 1996; Johnson, 1991; Rayfield, 2006; Rayfield, Fraze, Brashears, & Lawver, 2007). Research concerning characteristics of students participating at state qualifying CDEs is limited. Furthermore, little research exists explaining characteristics of low performing students in CDEs. This study seeks to expand knowledge about the role CDEs have in accomplishing the FFA mission by comparing characteristics of high achieving students and low achieving students participating in state qualifying CDEs.

Theoretical Framework

The theoretical model for this research is derived from the attribution theory of achievement established by Weiner et al., (1971), and is based on causal factors and individual differences. Causal factors for student achievement, identified by Weiner, include students' ability, the level of effort put forth, the difficulty of the task at hand, forms of support, and luck (Schunk, 2004). In most cases, only one or two of these factors are identified as being primarily responsible for the outcome (Weiner et al., 1971). These descriptors can contribute to or restrict the likelihood of student success unless they can be recognized and managed by the student, parent, or teacher (Schunk, 2004).

Weiner et al. (1971) organized causal factors into three causal dimensions. The dimensions and categories for causal factors are: a) internal or external to the student; b) stable or unstable over time; and c) controllable or uncontrollable by the student (Weiner, 1979). Figure 1 displays a conceptualization of this theory.

	Internal		**External**	
	Stable	*Unstable*	*Stable*	*Unstable*
Controllable	Typical effort	Immediate effort	Teacher support	Support from others
Uncontrollable	Ability	Mood	Task difficulty	Luck

Figure 1. Model of Causal Attribution displaying the interactions between the dimensions by Weiner, B., Frieze, I. H., Kukla, A., Reed, L., Rest, S., & Rosenbaum, R. M. (1971).

The framework design in Figure 1 highlights the relationships of attributes commonly possessed by students (Schunk, 2004). The attributes described occur in varying situations and degrees (Schunk, 2004). Various combinations of these attributes can increase or decrease the likelihood of student success (Weiner, 1979). Success is influenced by level of stability perceived by students in internal and external variables but controllability of attributes does not necessarily determine success (Schunk, 2004).

Individual differences, such as previous experiences, sex, parental relationships, and socioeconomic status, are considered to contribute to the success or failure of students (Schunk, 2004). Schunk (2004) stated that previous experiences can play a role in student motivation as well as their level of aspiration. This assertion is congruent with the findings of England (1996), Johnson (1991), Rayfield (2006), and Rayfield, et al. (2007). Sex and student achievement are correlated based on subject area and age of students (Rayfield, 2006; Rayfield, et al., 2007; Thomas & Stockton, 2003). Sutton and Soderstrom (1999) found an inverse relationship between socioeconomic status and student achievement. Bokhorst, Sumter, and Westenberg (2009) stated that the relationship between parents and 9 to 18 year old youths, or lack thereof, can contribute to student self-efficacy. Applied to the agricultural education context, can these causal factors and individual differences contribute to the performance of students in the Livestock Evaluation CDEs?

Purpose/Objectives

The purpose of this study was to determine the demographic characteristics including IEP status, cumulative GPA, previous experience in livestock evaluation, free/reduced lunch, guardian marital status, and sex of student of selected students who participated in the Missouri FFA

Livestock Evaluation CDE in 2009. Specifically, this research compared selected characteristics of participants who performed poorly in this activity to those of participants who performed exceptionally well. The following three research objectives were formulated to accomplish the purpose:

1. What are the selected demographic characteristics of students who scored among the highest 2.5% at the state finals of the Missouri Livestock Evaluation CDE in 2009?

2. What are the selected demographic characteristics of the students who scored among the lowest 2.5% (lowest performing) at district Missouri Livestock Evaluation CDEs in 2009?

3. What are the differences between selected demographic characteristics of the highest performing students and lowest performing students in the Missouri Livestock Evaluation CDE in 2009?

Methods/Procedures

This study was a descriptive-correlation research design. The purposive sample was composed of the top and bottom 2.5% of all participating competitors in the 2009 Missouri FFA Livestock Evaluation CDE (*n* = 32). The lowest performers (LP) were identified based upon scores earned by individuals at each of the six district events, which serve as the qualifying round for the state CDE finals. The highest performers (HP) where identified based upon scored earned by individuals at the state CDE finals. All subjects were identified from official results of district and state CDEs posted on JudgingCard.com. Data were collected from the FFA Advisor each subject selected for the study.

The Missouri FFA Livestock Evaluation CDE is divided into three subject matter areas that contribute to a total possible individual score of 550. Individuals competing in the Missouri FFA Livestock Evaluation CDE (*N* = 640) in 2009 had a mean score of 423.91 (*SD* = 41.83). The highest performers group was composed of students who scored 2.00 SD above the mean (*n* = 16; 2.5%). The lowest performers group was composed of students who scored 2.00 SD below the mean (*n* = 16; 2.5%). It is evident that differences exist in these students' scores. However, it is not assumed that a difference exists in the students characteristics.

The researchers contacted the subjects' FFA Advisors through personal or telephone contact following the state CDE finals. Each Advisor was asked to provide information about 18 characteristics included in this investigation through an interview administered by a single person who served as the data collector. These items were derived through the findings of research addressing factors of achievement among high school students (Johnson, 1991; Rayfield, 2006; Rayfield, et al., 2007). A panel of experts (*n* = 5), composed of former school-based agriculture teachers and FFA advisors, examined the items for content validity. Because data collection was conducted through interviews, there was no need to establish face validity. Because this study only utilized nominal data, it was unnecessary to conduct a pilot study to establish reliability (Ary, Jacobs, Razavieh, & Sorensen, 2006).

Following the data collection period, data were coded and entered into SPSS for Windows. Descriptive statistics of central tendency and variability were calculated to summarize the data. Independent sample *t*-tests, Cohen's *d*, and *phi* correlations were conducted to test differences between the groups, and binary logistic regression was computed to explain the variance in individual characteristics. Effect sizes were calculated and interpreted using Cohen's (1988) *d* coefficients: negligible effect size ($d < 0.15$, small effect size ($d < 0.40$), medium effect size ($d < 0.75$), large effect size ($d < 1.10$), very large effect size ($d < 1.45$), and huge effect size ($d > 1.45$). Phi effect sizes were calculated and are described as: .10 - .29 = weak, .30 - .49 = moderate, .50 and above = strong (Huck, 2008). An alpha level of .05 was established a priori for tests of significance.

Results/Findings

Objective One

Objective One sought to describe selected demographic characteristics of the students who were among the top 2.5% of participants in the 2009 Missouri Livestock Evaluation CDE. In this group, juniors ($n = 7$; 43.75%) and seniors ($n = 6$; 37.50%) outnumbered freshmen ($n = 1$; 6.25%) and sophomores ($n = 2$; 12.5%). No students in the HP group had an IEP. Only 1 (6.25%) of the 16 students in this group qualified for free/reduced lunch. None of the subjects had a grade point average (GPA) below a 3.00 on a 4.00 scale. Eight (50%) had a GPA of 3.00 – 3.99 and 6 (37.50%) had a GPA of 4.00 or better. The mean GPA for the HP was 3.72 ($n = 14$). Marital status of guardian(s) was categorized as either married or single and/or divorced. All but two ($n = 14$; 87.50%) of the parents of HP were married. More than 40% ($n = 7$; 43.75%) of the HP had previous evaluating livestock experience. Table 1 shows a summary of these data.

Objective Two

The goal of Objective Two was to describe the selected demographics of the students who were among the lowest 2.5% of the Missouri Livestock Evaluation CDE. The majority of the students in this group were freshmen ($n = 10$; 62.50%) with the remainder being composed of 2 sophomores (12.50%), 2 juniors (12.50%) and 2 seniors (12.50%). Nearly half the LP subjects were reported to have an IEP ($n = 7$; 43.75%) with one student having an unknown status. Seven of the LP subjects were reported to receive free/reduced lunch (43.75%) while 5 (31.25%) were reported to not receive free/reduced lunch, and the status of 4 (25.00%) students was unknown. None of the students in the LP category had a GPA of 4.0 or above with two responses being unusable. The mean GPA for students in the LP category was 2.55. The marital status of guardian(s) of LP students was split evenly between the categories of married (50.00%) and single/divorced (50.00%). Only one LP student (6.25%) had previous experience in the Livestock Evaluation CDE. These data are also displayed in Table 1.

Table 1

*Characteristics of Highest Performing (HP) Participants and Lowest Performing (LP) Participants in the Missouri Livestock Evaluation CDE (*n *= 32)*

Characteristic	HP (n = 16) *f*	HP (n = 16) %	LP (n = 16) *f*	LP (n = 16) %	Total (n = 32) *f*	Total (n = 32) %
Grade						
Freshman	1	6.25	10	62.50	11	34.28
Sophomore	2	12.50	2	12.50	4	12.50
Junior	7	43.75	2	12.50	9	28.13
Senior	6	37.50	2	12.50	8	25.00
GPA						
4.0 and Above	6	37.50	0	0.00	6	18.75
3.0-3.99	8	50.00	6	37.50	14	43.75
2.0-2.99	0	0.00	6	37.50	6	18.75
2.0 and Below	0	0.00	2	12.50	2	6.25
Sex						
Female	3	18.80	5	31.30	8	25.00
Male	13	81.30	11	68.80	24	75.00
IEP Status						
No	16	100.00	8	50.00	24	75.00
Yes	0	0.00	7	43.75	7	21.88
Recipient of Free/Reduced Lunch						
No	15	93.75	7	43.75	22	68.75
Yes	1	6.25	5	31.25	6	18.75
Marital Status of Guardian(s)						
Married	14	87.50	8	50.00	22	68.75
Single and/or Divorced	2	12.50	7	43.75	9	28.13
Previous Experience in Livestock						
No	9	56.25	15	93.75	24	75.00
Yes	7	43.75	1	6.25	8	25.00

Note. HP = Highest Performers; LP = Lowest Performers. Not all responses were useable.

Objective 3

The purpose of Objective Three was to compare differences between HP group and LP group in the Missouri Livestock Evaluation CDE. A *phi* coefficient was utilized to estimate the degree of correlation between the selected demographic variables (IEP status, cumulative GPA, previous experience in the Livestock Evaluation CDE, free/reduced lunch, guardian marital status, and sex of student) and student performance. *Phi* was chosen because the variables are dichotomous and nominal in nature and it is a measure of the degree of association between the variables (Huck, 2008). Pearson product-moment correlation coefficient (r_f) was used for correlation analysis. IEP Status was the only variable that identified a strong effect size (r_f = .56). Variables having moderate effect sizes to contestant achievement included: Previous experience in the Livestock Evaluation CDE (r_f = .43), free/reduced lunch (r_f = .43), and guardian marital status (*rf* = .38). Sex was found to have a weak effect size (*rf* = .14) to student performance in the CDE. See Table 2 for *phi* coefficient values.

Table 2

Comparison of Student Characteristics Between Highest Performers and Lowest Performers in the Missouri FFA Livestock Evaluation CDE (n = 32)

Variable	r_φ	r^2	Effect Size[a]
IEP Status	.56	.31	Strong
Previous Experience	.43	.18	Moderate
Free/Reduced Lunch	.43	.18	Moderate
Guardian Marital Status	.38	.14	Moderate
Sex of Student	.14	.02	Weak

Note. IEP Status coded: With = 0, Without = 1; Previous Experience Coded: Yes = 0, No = 1; Free/Reduced Lunch: Recipient = 0, Non-recipient = 1; Guardian Marital Status: Married = 0, Single/Divorced = 1; Sex of Student: Male = 0, Female = 1. [a]Phi effect size (Huck, 2008)

An independent (two-tailed) *t*-test detected a difference, *t(26)* = 3.99; *p* = .02] in the GPA of the HP group (*M* = 3.72; *SD* = .32) and LP group (*M* = 2.55; *SD* = .64). It should be noted that four scores, two from each of the HP and LP categories, were deemed unusable. Cohen's *d* was calculated (*d* = 2.31) and using Cohen's descriptors a "Large" effect size (Cohen, 1988) was noted (see Table 3).

Table 3

*Difference in Raw Grade Point Average of Highest Performers versus Lowest Performer (*n *= 28)*

Category	*n*	*M*	*SD*	Cohen's *d*
Highest Performers	14	3.72	0.32	
				2.31 (Large[a])
Lowest Performers	14	2.55	0.64	

[a]Effect size defined by Cohen (1988)

Conclusions

Results of this study indicate that there are certain demographic characteristics that will portend students' achievement level in the Livestock Evaluation CDE in Missouri. These results are consistent with the findings from several previous studies about FFA member achievement (England, 1996; Johnson, 1991; Rayfield, 2006; Rayfield, et al., 2007). However, the findings of this study contradict results of certain factors affecting student achievement (Thomas & Stockton, 2003; Webster, Young, & Fisher, 1999). A previous study found that males scored higher on the National Livestock Evaluation CDE (Rayfield, 2006; Rayfield, et al., 2007). This study did not find a substantial relationship between sex and achievement. A profile of highest performers in the 2009 Livestock Evaluation CDE in Missouri can be concluded from these data. Highest performers were predominately upperclassmen with above a B grade point average in school and did not require specialized education services. Their families had two parents in the household and they were not in the lower socioeconomic status bracket as indicated by free/reduced lunch. These students also had previous experience with the Livestock Evaluation CDE.

Similarly, a profile can be constructed of lowest performers in the Missouri Livestock Evaluation CDE. They were underclassmen with a C average GPA. Compared to highest performers, it was more likely that lowest performers required specialized education services. It was more likely that lowest performers qualified for free/reduced lunch, indicating their guardians earned less than $41,000 (Child Nutrition Programs, 2009) per year for a family of four. These students were also more likely to come from a home with a single parent. It is unlikely that lowest achievers had previous experience with the Livestock Evaluation CDE.

Implications/Recommendations

The conclusion of this study regarding the impact of prior livestock evaluation experience correlating to success in Livestock Evaluation CDEs were in agreement with findings by Rayfield (2006), Rayfield, et al. (2007), and England (1996). The influence of sex regarding CDE achievement varies among different studies. Contradictory to previous studies (Thomas & Stockton, 2003; Rayfield, 2006; Rayfield, et al., 2007) sex was not found to have an influence on participant achievement in this research. This finding is, however, in agreement with the findings of England (1996) and Webster, Young and Fisher (1999). Obviously, more research needs to be conducted to investigate the influence of this factor upon achievement in this and other FFA activities.

This study confirms the findings of Thomas and Stockton (2003) stating that socioeconomic status, as measured by status of free/reduced lunch, affects student achievement. Conversely, the conclusion of this study related to socioeconomic status conflicts with the findings of Webster, Young and Fisher (1999). This study suggests individual student differences, including prior experience and socioeconomic status, play a role in student achievement (Weiner et al. 1971; Sutton & Soderstrom, 1999; Schunk, 2004). In future research, the category of free/reduced lunch should be separated into free lunch and reduced lunch as there is a difference in the socioeconomic status categories of the two categories.

In agreement with a study of the relationship in demographic variables and performance in a National FFA CDE by Rayfield, et al. (2007), this study found GPA to have an impact on student performance. The researchers draw caution to comparing these results of these two studies, however. The 2007 study evaluated students at a national CDE, implying that each student was successful at the state level, whereas this study compared students who competed at the district level used to qualify to compete at the state level.

The results of this study suggest that IEP status and previous experience in Livestock Evaluation CDE are associated with student success. The positive aspect of this finding is that both of these factors have a degree of manageability by the agriculture teacher. Considering it is the responsibility of the teacher to meet the educational needs of all students, it is recommended that school-based agriculture teachers be given additional professional development opportunities and training on how to accommodate the specialized needs of diverse learners. If school-based agriculture teachers are able to obtain proper training for working with students with special needs, the accommodations could increase the likelihood of overcoming the dimensions and causal factors that limit the student's success according to Weiner's theory (1971).

Further research is needed to determine the variation of the characteristics investigated in this research between national and state level competitions. For this study, data were collected only on students at the extreme ends of performance in one CDE. Students composing the complete range of performance at such FFA activities should be examined. A study in which data are collected on every student from multiple CDEs would add to the body of knowledge related to the effect of demographic variables on participant performance. Such information would provide another method to evaluate whether or not FFA CDEs contribute to the mission of the organization.

Teacher educators and state staff should consider reinforcing the purpose of CDEs, as defined by the National FFA Organization, to all school-based agricultural teachers. It could be argued that results of this study illustrate that a diverse group of students are presented with the opportunity to compete in CDEs. However, the homogeneity of the two groups studied in this investigation, highest performers and lowest performers, indicates that the educational needs of lowest performers are not being met. Further research is needed to determine how agricultural educators can best help students facing issues of socioeconomic status and academic ability. Such information could enhance educators' ability to help students overcome success barriers in competitive events like CDEs.

References

Alfeld, C., Hansen, D. M., Aragon, S. R., & Stone, J. R. (2006). Inside the black box: Exploring the value added by career and technical student organizations to students' high school experience. *Career and Technical Research*. *31*(3), 121-155.

Ary, Donald, Jacobs, L.C., Razavieh, A., & Sorensen, C. (2006). *Introduction to research in education (7th edition).* Belmont, CA. Thomson Higher Education.

Association for Career and Technical Education (2010). *About ACTE*. Retrieved April 2010 from: http://www.acteonline.org/

Ball, A. L., Garton, B. L., & Dyer, J. E. (2001). The influence of learning communities and 4-H/FFA participation on college of agriculture students' academic performance and retention. *Journal of Agricultural Education*. *42*(4), 54-62.

Berry, W. D. & Feldman, S. (1991). *Multiple Regression in Practice.* Newbury Park, CA: Sage Publications.

Bokhorst, C., Sumter, S., and Westenberg, M. (2009) Social support from parents, friends, classmates, and teachers in children and adolescents aged 9 to 18 years: who is perceived as most supportive? *Social Development*. *19*(2), 417-426.

Chiasson, T., & Burnett, M. (2001). The influence of enrollment in agriscience courses on the science achievement of high school students. *Journal of Agriculture Education*. *42*(1), 61-71.

Child Nutrition Programs—Income Eligibility Guidelines / 58,74 Federal Register § 13412 (2009)

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2^{nd} ed.). Lawrence Erbaum Associates.

England, L.M. (1996). *Training methods of national FFA judging teams.* Unpublished master's thesis, Texas Tech University, Lubbock.

Gohm, C., Oishi, S., Darlington, J., & Diener, E. (1998). Culture, parental conflict, parental marital status, and the subjective well being of young adults. *Journal of Marriage and the Family*. *60*(1), 319-334.

Greenland, S., Schwartzbaum, J. A., & Finkle, W. D. (2000). Problems due to small samples and sparse data in conditional logistic regression. *American Journal of Epidemiology, 151*(5), 531-539.

Huck, S. W. (2008). *Reading statistics and research.* Boston, MA: Pearson.

Johnson (1991) Student achievement and factors related to achievement in a state FFA agricultural mechanics contest. *Journal of Agricultural Education, 32*(3), 27-28.

Kopcha, T., & Sullivan, H. (2008). Learner preferences and prior knowledge in learner controlled computer based education. *Education Technology Research, 56*(1), 265-286.

Licht, B.G., & Kistner, J. A. (1986). *Psychological and educational perspectives on learning disabilities*. Orlando, FL: Academic Press.

Missouri Department of Elementary and Secondary Education (2009). *About agricultural education*. Retreived April 2010 from http://dese.mo.gov/divcareered/ag_about.htm

Missouri FFA Association. (2008). State career development handbook 2006-2010. (City, State): Missouri Vocational Agriculture Teacher Association.

Morgan, E. M., Chelewski, R. E., Lee, J. S., & Wilson E. (1998). *Agriscience explorations*. Danville, IL: Interstate Publishers.

National Research Council (2000). *How people learn*. Washington, D.C.: National Academy Press.

National FFA Organization. (2009). *Official FFA manual*. Indianapolis, IN: National FFA Organization.

Oliver, J.D. & Hinkle, D.E. (1982). Occupation education research: Selecting statistical procedures. *Journal of Studies in Technical Careers, 4*, 199-208.

Okpala, C. O. (2002) Educational resources, student demographics and achievement scores. *Journal of Education Finance*, 27(3), 885-908.

Phipps, L. J., Osborne, E. W., Dyer, J. E., & Ball, A. L. (2008). *Handbook on agricultural education in public schools (6th edition)*. Clifton Park, NY: Thomson Delmar Learning.

Rayfield, J. (2006). *An assessment of recruitment and training practices of the National FFA livestock career development event.* (Doctoral dissertation, Texas Tech University). Retrieved from http://esr.lib.ttu.edu/handle/2346/1041

Rayfield, J., Fraze, S., Brashears, T., & Lawver, D. (2007). The relationship between student demographic variables and performance in a National FFA career development event. *Journal of Southern Agricultural Education Research*, 57(1), 4-15.

Reis, R., & Kahler, A. A. (1997). Factors influencing enrollment in agricultural education programs as expressed by Iowa secondary agricultural education students. *Journal of Agricultural Education*, *38*(2), 38-48.

Rumburger, R., & Palardy, G. (2005). Does segregation still matter? The impact of student composition on academic achievement in high school. *Teachers College Record, 107*(9), 2000-2045.

Schunk, D. H. (2004). *Learning theories: An educational perspective (4th edition)*. Upper Saddle River, New Jersey: Pearson Education.

Sutton, A., & Soderstrom, I. (1999). Predicting elementary and secondary school achievement with school-related and demographic factors. *The Journal of Educational Research*, *92*(6), 330.

Talbert, B.A., & Balschweid, M.A. (2005). Engaging students in the agricultural education model: Factors affecting student participation in the National FFA Organization. *Journal of Agricultural Education*, *45*(1), 29-41.

Tenney, A. W. (1977). *The FFA at 50: A golden past a bright future*. Alexandria, VA: The Future Farmers of America.

Thomas, J., & Stockton, C. (2003). Socioeconomic status, race, gender, & retention: Impact on student achievement. Available: http: //www.usca.edu/essays /vol72003 /stockton.pdf.

U.S. Department of Education (2009). *National center for educational statistics.* Retrieved April 2010 from http://www2.ed.gov/rschstat/facts.html

Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology*, *71*, 3-25.

Weiner, B., Frieze, I. H., Kukla, A., Reed, L., Rest, S., & Rosenbaum, R. M. (1971). *Perceiving the causes of success and failure*. Morristown, NJ: General Learning Press.

Undergraduate Students' Knowledge of International Agricultural Issues by Academic Standing

Author Note

Sarahi Morales and M. Todd Brashears, Department of Agricultural Education and Communications at Texas Tech University.

Correspondence concerning this article should be addressed to Sarahi Morales, Department of Agricultural Education and Communication, Texas Tech University 79409-2131. E-mail: sarahi.morales@ttu.edu

Type of Research: Quantitative

Research Priority Area 3: Sufficient Scientific and Professional Workforce That Addresses the Challenges of the 21st Century

Undergraduate Students' Knowledge of International Agricultural Issues by Academic Standing

Abstract

Future agricultural professionals and scientists will be required to have broader perspectives and apply their technical knowledge to keep pace with global trends. The purpose of this study was to assess and compare United States (U.S.) and Latin American (L.A.) students' knowledge of international agricultural issues. A modified version of the International Agricultural Awareness and Understanding instrument by Wingenbach et al. (2003) and Hurst (2013) was used. Findings in this study were similar to previous studies indicating a continuing lack of knowledge regarding international agricultural issues among undergraduate students. Despite an overall increase in students' scores by their academic standing, from freshmen to seniors, only 3.5% of the population obtained a passing score. Findings from the ANOVA suggest scores from freshmen and sophomores are significantly different than the scores from juniors and seniors. Overall, accurate knowledge of international agricultural issues from Zamorano University students was significantly different than the scores from Texas Tech University students. The significant differences found in this study have small to medium Cohen's effect sizes (Kotrlik, Williams, & Jabor, 2011). It is recommended for future research to explore actions that may provide students with a global perspective and identify mechanisms that may reinforce students' knowledge of agriculture in an international context.

Introduction/Theoretical Framework

Globalization is a multi-faceted term used to describe the complex dynamics between countries or regions, which are shaped by the interaction of their economics, politics, culture, labor force, technology, and communications. Continuing globalization has increased competition between nations and enhanced their abilities to respond rapidly to the world's demands (Stromquist & Monkman, 2014).

Trends in globalization, along with global issues such as food security, sustainability, and sociopolitical stability have intertwined, becoming solutions and problems simultaneously (Whigham & Acker, 2003). Agriculture may be considered one of the biggest contributors to these challenges, yet agriculturalists can play an important role in the development of agricultural solutions to problems worldwide and contribute significantly to the improvement of global food security, environmental sustainability, and poverty reduction (Acker, 1999; Christiaensen, Demery, & Kuh, 2011; McIntyre, Herren, Wakhungu, & Watson, 2009). The 2016 -2020 National Research Agenda of the American Association for Agricultural Education (AAAE) suggested future agriculturists should be able to perform in a global setting as needed. For that reason, academic institutions should be able to provide students with an internationally infused curriculum to enhance their college preparation (Stripling & Ricketts, 2016). These perspectives are highlighted in the AAAE's third research priority "the demand for a sufficient scientific and professional workforce to address the challenges of the 21st century" (Stripling & Ricketts, 2016, p. 29).

In this context, formal education has become an important symbol of a nation's ability to compete. Formal education has transformed from child-centered to work skills preparation and ultimately is becoming the pathway to competitiveness (Stromquist & Monkman, 2014). Formal education, along with current pressing world issues, have led countries, business leaders, and educators to discuss the need for schools to prepare students for international work. In addition, there is a need to include students' abilities to address diversity and agriculture-related issues (Spring, 2008; Olson, Evans, & Shoenberg, 2007; Whigham & Acker, 2003), as students may potentially fill work positions worldwide that require international knowledge and awareness (Anthony, Bederman, & Yarrish, 2013). The terms of internationalization and globalization of education tend to be used interchangeably (Altbach, 2004); however, globalization of education refers to the global trends influencing educational programs worldwide, while internationalization of education refers to countries' educational policies designed to keep pace with other countries (Altbach, 2015). Internationalization of higher education became prominent after World War II (Olson et al., 2007) and has continued to evolve ever since (Bonfiglio, 1999; Olson et al., 2007).

The U.S. hosts the majority of international students and in doing so, fosters a cross-cultural education for their students. Yet, there is a nationwide lack of consistency of actions by institutions to intentionally internationalize U.S. students (Altbach, 2015). The Latin American (L.A.) educational system faces similar challenges when it comes to preparing students for a global context (Torres & Schugurensky, 2002). However, L.A. countries face the additional challenge of access to resources used to conduct research coupled with abilities to provide job opportunities (De Wit, 2005). Agricultural departments in L.A. universities started in the mid-1850s similar to the U.S., yet have not seen equivalent growth when compared to their U.S. counterparts. Initially, this discrepancy was assumed to be the result of the separation of higher education and extension programs, social unrest at national and local levels, lack of availability of funds, and insufficient faculty (Rio, 1964). Currently, a greater emphasis is being placed on higher education in L.A., but the region continues to lag behind developed countries. Challenges in the region continue to be similar as in 1964, focusing on the out-of-date curriculum, teaching materials, insufficient faculty, and how to introduce graduates into the professional market (Holm-Nielsen, Thorn, Brunner, & Balán, 2005).

Over the years, efforts have been made to infuse international dimensions into the students' curriculum. These efforts include firsthand international experiences, which have been considered an important element in the students' education (Coers, Rodriguez, Roberts, Emerson, & Barrick, 2012). However, only one percent of students majoring in agricultural sciences participated in study abroad programs during the 2011-2012 academic year (Institute of International Education, 2014); therefore, other ways to internationalize students' agricultural sciences curriculum should be explored (Wingham, Acker, 2003). Olson et al. (2007) suggested academic institutions should employ educators who understand current global trends and world implications to effectively teach students the complex interactions of globalization and its impacts. Over the past 15 years, researchers have assessed college students' knowledge of international agricultural issues and their awareness. Results have consistently found a lack of knowledge among students (Hurst & Roberts, 2013; Radhakrishna & Dominguez, 1999; Wingenbach et al., 2003).

This study was based on the Theory of Planned Behavior (Ajzen, 1985) and supported by the Human Capital Theory, initially developed by Adam Smith in his book *The Wealth of Nations* in 1776. It was later applied to education by Schultz in 1961 and Becker in 1962 (Sweetland, 1996). The Theory of Planned Behavior explains "individuals' intention to perform a given behavior; intentions are assumed to capture the motivational factors that influence behavior" (Ajzen, 1985, p. 181). According to Ajzen (2006), behavior is guided by three considerations: behavioral beliefs, normative beliefs, and control beliefs. In this study, we focused on the students' knowledge of international agricultural issues as part of their control beliefs, which refers to the "beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors" (Ajzen, 2006, p. 1). The application of the Theory of Human Capital lies in the hypothesis that "[the] pursuit of education leads to individual and national economic growth" (Sweetland, 1996, p. 356). Moriba (2011) proposed, if investments in education are done for the purpose of advancing a nation's economy, then we might assume investments in internationalized education are done with the purpose of helping a nation keep up with a globalized world.

Purpose and Objectives

The purpose of this research study was to assess and compare U.S. and L.A. students' knowledge of international agricultural issues. The following objectives guided this study:

1. Describe students enrolled in agricultural sciences at TTU and ZU.
2. Assess students' knowledge of international agricultural issues at TTU and ZU.
3. Determine if there is a significant difference in students' overall knowledge of international agricultural issues by academic institution.
4. Determine if there is a significant difference in students' knowledge of international agricultural issues by academic standing.

Methods/Procedures

The study design was causal-comparative, which is used to identify cause and effect relationships with the critical feature of an independent categorical variable (Gall, Gall, & Borg, 2007). The target populations were undergraduate students enrolled in agricultural sciences at TTU and ZU. A non-probabilistic convenience oversample of students in classes with large numbers of enrollment was taken at both academic institutions. We used this procedure to minimize sampling error by maximizing participant response rate. Findings by Sax, Gilmartin, and Bryant (2003) highlighted low response rates among college students in paper-only instruments and web surveys. Therefore, we oversampled the population following the guidelines by Bartlett, Kotrlik, and Higgins (2001). General data collection procedures were established to maintain consistency between groups. A total of 1,300 students volunteered to complete the instrument. Instruments with less than 90% completion were considered invalid and were eliminated. Students who opted not to participate in this research study were considered non-respondents, based on enrollment records at both academic institutions. Students in more than one class were considered duplicates and were asked not to complete the instrument more than a single time. An overall response rate of 90% was obtained. No control for non-response error was followed in this study, as participants were part of a convenience sample with no way to contact the non-respondents given IRB constraints and lack of identifiers on the instrument.

In order to evaluate students' knowledge of international agricultural issues, the researcher used a modified version of the International Agricultural Awareness and Understanding instrument by Wingenbach et al. (2003) and Hurst (2013). The original instrument consisted of three sections assessing knowledge, attitudes and beliefs of international agricultural issues. The knowledge section of the instrument consisted of "20 multiple-choice, knowledge questions related to international agricultural policies, products, peoples, and culture" (Wingenbach, 2003, p. 27). Questions which were determined to be no longer relevant were replaced with others addressing issues highlighted by the Food and Agriculture Organization of the United Nations (FAO) in 2014, in the post-2015 development agenda and the Millennium Development Goals (MDG). A comprehensive literature review was conducted to find the most accurate and current information per question selected. A panel of experts from TTU and Texas A&M evaluated the final instrument for face and content validity. A demographic section was included consisting of students' gender, academic standing, major, ethnic background, international experiences and language proficiency. The final instrument was originally developed in English and translated into Spanish by a Spanish-speaking student with a background in agriculture.

The descriptive statistics of central tendency and variability were used to describe and assess students in terms of their demographic characteristics and knowledge of international agricultural issues. An independent t-test was used to determine if there was a significant difference between students' overall knowledge scores based on their institution of enrollment. The null hypothesis stated there would be no difference in the participants' knowledge scores relating to international agricultural issues (H_o: $\mu_1 = \mu_2$). An ANOVA was conducted to evaluate mean differences between students' knowledge scores by academic standings. The null hypothesis stated there would be no significant difference in the participants' knowledge of international agricultural issues based on their academic standing (H_o: $\mu_1 = \mu_2 = \mu_3 = \mu_4$). An alpha level of .05 was established *a priori* for significance.

Results/Findings

Research objective one sought to describe students' demographic characteristics. A total of 1,218 students completed the instrument, 612 (50.2%) from TTU and 606 (49.8%) from ZU. Overall, the majority of the participants were males (53.8%). At TTU the majority were females (56.8%) and at ZU the majority were male (64.6%).

In terms of academic standing, the largest group of respondents classified themselves as freshman (*n* = 356), followed by sophomores (*n* = 324), juniors (*n* = 261), and seniors (*n* = 255). Freshman students were the majority at TTU (*n* = 214), but at ZU seniors were the majority (*n* = 195). Twenty-two of the participants did not specify their academic standing. Table 1 summarizes students' academic standing by academic institution.

Table 1

Summary of Students' Academic Standing

Characteristic	Total (n = 1196)		TTU (n^a =604)		ZU (n^b = 592)	
	f	%	*f*	%	*f*	%
Freshman	356	29.8	214	35.4	142	24.0
Sophomore	324	27.1	180	29.8	144	24.0
Junior	261	21.8	150	24.8	111	18.8
Senior	255	21.3	60	9.9	195	32.9

Note. [a] sample of participating students at TTU. [b] sample of participating students at ZU.

Research objective two assessed the students' knowledge of international agricultural issues. Students answered 20 multiple-choice items. Results were coded as correct and incorrect with a binary code of 1 and 0, respectively. Therefore, the sum of correct answers resulted in the overall knowledge of international agricultural issues score based on 20 possible points.

Overall, the majority of the students (90.4%) responded correctly to the item "the _____ desert is the world's largest hot desert". While, the question receiving the most incorrect answers was: "Although large areas of land are brought into cultivation throughout the world each year, large amounts are also rendered useless or are reduced in productive capacity because of the following reason". Only 5% answered this question correctly. These two questions were the most correct and incorrect answered items at both academic institutions. See Table 2 for a summary of students' knowledge of international agricultural issues per question.

Table 2

Summary of Students' Knowledge of International Agricultural Issues

Question	Correct Answer	Total (n = 1218) %	TTU (n^a = 612) %	ZU (n^b = 606) %
11. The ___ desert is the world's largest hot desert.	Sahara	90.4	86.9	93.9
2. What is the primary household fuel in lower income groups in Latin America?	Wood	72.2	58.8	85.6
6. Which of the following languages are the four most spoken languages worldwide?	Chinese, English, Hindi, Spanish	56.4	64.1	48.7
8. These countries are part of the European Union?	France, Ireland, Italy, Sweden	47.0	42.2	52.0
19. Worldwide population will be approximately ____ billions by 2050	9	46.9	45.3	48.5
12. What country produces the largest volume of swine?	China	46.2	40.7	51.8
20. Which of the following food nutrients is most lacking in the diets of the world's population?	Proteins	41.9	43.1	40.6
7. In what part of the world are you most likely to find a hand-dug underground irrigation system called a ghanat (quanat) that may extend for many miles from the mountains to fields out to the plains?	Middle East	39.9	26.5	53.5
14. Considering developing and developed countries, the projection of the world population for the year 2050 shows that the largest segment will be in:	Asia and Oceania	38.1	46.1	30.0
18. Worldwide food production need to increase at least___% to meet global food demand in 2050	60	36.7	37.7	35.6
15. Which country is the largest producer of tea?	China	36.5	29.2	43.7
17. The economic strength of a country can be measured by	Gross national product (GNP)	35.1	24.5	45.9

Table 2 continued

Question	Correct Answer	Total (n = 1218) %	TTU (n^a = 612) %	ZU (n^b= 606) %
13. Which cereal grain is the basic food for more than half of the world's population?	Rice	34.7	45.3	24.1
5. Which means of communication currently reaches the largest number of people throughout the world?	Radio	32.6	38.7	26.4
1. Who carries out most of the field work on an African farm?	Women	30.9	37.1	24.6
16. In East Africa, it is expected that everyone will____ upon greeting each other at a meeting, and upon departure from meetings.	shake hands	19.5	13.2	25.9
3. As of 2013, what percentage of the world population suffers from chronic hunger?	12%	18.4	14.9	21.9
4. Which of the following is the major reason why more countries in Asia, Africa, and Latin America have become net food importers in the last 50 years?	A production shift from food to cash crops earns money to offset trade imbalances	14.4	12.3	16.5
10. Which food sector uses a greater variety of biological diversity?	Capture fisheries	13.5	10.3	16.7
9. Although large areas of land are brought into cultivation throughout the world each year, large amounts are also rendered useless or are reduced in productive capacity because of the following reasons:	lack of sufficient farm labor	5.0	6.7	3.3

Note. [a] sample of participating students at TTU. [b] sample of participating students at ZU.

Overall, students' mean score of correct answers was 7.6 (*SD* = 2.1) with a median and mode score of 7 (*Mdn* = 7, Mode = 7). ZU students' knowledge mean score was higher (*M* = 7.9; *SD* = 2.0) than TTU students' score (*M* = 7.2; *SD* = 2.2). See Table 3.

Table 3
*Summary of Students' Knowledge of International Agricultural Issues Scores (*N *= 1218)*

Population	*n*	*M*[a]	*Mdn*[a]	*SD*	*Range*
Overall Knowledge Score		7.6	7	2.1	14
TTU	612	7.2	7	2.2	14
ZU	606	7.9	8	2.0	12

Note. [a] total knowledge score on a scale of 0 to 20

Overall, senior students' obtained the highest mean score (*M* = 7.95, *SD* = 2.11), followed by juniors (*M* = 7.93, *SD* = 2.19), sophomores (*M* = 7.48, *SD* = 2.14), and freshmen (*M* = 7.10, *SD* = 2.03). Similar to the overall results, TTU students' highest mean score was obtained by seniors (*M* = 7.58, *SD* = 2.20), whereas junior students at ZU gained the highest mean score (*M* = 8.77, *SD* = 2.07). See Table 4.

Table 4
Summary of Students' Knowledge of International Agricultural Issues by Academic Standing

Characteristic	Total (*n* = 1196)		TTU (*n*[a] =593)		ZU (*n*[b] = 586)	
	M[c]	*SD*	*M*[c]	*SD*	*M*[c]	*SD*
Freshman	7.10	2.03	7.12	2.24	7.06	1.69
Sophomore	7.48	2.14	7.18	2.15	7.85	2.08
Junior	7.93	2.19	7.32	2.25	8.77	2.07
Senior	7.95	2.10	7.58	2.20	8.06	2.02

Note. [a] sample of participating students at TTU. [b] sample of participating students at ZU. [c] total knowledge score on a scale of 0 to 20.

Research objective three focused on determining if there was a significant difference in students' overall knowledge of international agricultural issues by academic institution. An independent *t*-test was used to assess the statistical significance in the students' knowledge of international agricultural issues scores based on their academic institution of enrollment. The null hypothesis stated there would be no difference in the students' knowledge of international agricultural issues (H_o: $\mu_1 = \mu_2$). The alpha level was set at .05 *a priori*. Levene's test for equality of variances was significant (*p* = .03), therefore, the corrected *t*-test was used. This corrected independent *t*-test reported a *t*-value of -5.46 (*p* = .01), therefore the null hypothesis was rejected in favor of the research hypothesis stating that, in the population, there was a significant difference in the participants' knowledge of international agricultural issues depending on where they were enrolled (H_o:$\mu_1 \neq \mu_2$). Cohen's *d* effect size value (*d* = .33) suggest a medium effect size (Kotrlik, Williams, & Jabor, 2011). Table 5 displays the obtained results.

Table 5

*Independent t-test for Students' Knowledge of International Agricultural Issues (*n *= 1196)*

Characteristic	*t*	*df*	*p*	*d*
Knowledge	-5.46	1207.62	.01*	.33

* $p < .05$

Research objective four sought to determine if there was a significant difference in the students' overall knowledge of international agricultural issues by academic standing. A one-way ANOVA was conducted to compare the mean scores of students' knowledge based on their academic standing. The independent variable had four levels based on the students' academic standing: freshman, sophomore, junior, and senior. The dependent variable was the students' knowledge score. The null hypothesis stated there would be no significant difference in the students' knowledge of international agricultural issues by academic standing (H_o: $\mu_1 = \mu_2 = \mu_3 = \mu_4$). The alpha level was set at .05 *a priori*. Based on the findings, the null hypothesis was rejected in favor of the research hypothesis, suggesting there was a significant difference in students' knowledge by academic standing, $F_{(3, 1192)} = 11.49$, $p < .05$. Cohen's *d* effect size value ($d = .17$) suggest a small effect size (Kotrlik et al., 2011). See Table 6. A post hoc analysis was conducted to evaluate differences among the means. The assumption of homogeneity of variance was met $F_{(3, 1192)} = 1.32$, $p = .27$. A Tukey HSD test indicated that freshmen and sophomores are significantly different ($p < .05$) than juniors and seniors.

Table 6

*One-way Analysis of Variance of Students' Knowledge Scores by Academic Standing (*n *= 1196)*

Source	*df*	*SS*	*MS*	*F*	*p*	*d*
Between groups	3	154.04	51.35	11.49	.01*	.17
Within groups	1192	5325.87	4.47			
Total	1195	5479.91				

* $p < .05$

An ANOVA was conducted to assess if there was a significant difference in the students' academic standing by academic institution. In the case of TTU, no significant difference was found among the students' academic standing (H_o: $\mu_1 = \mu_2 = \mu_3 = \mu_4$). In the case of ZU, the results indicate there was a significant difference between students' academic standing, $F_{(3, 588)} = 16.80$, $p < .05$). Cohen's *d* effect size value ($f = .29$) suggest a small to medium effect size (Kotrlik et al., 2011). The Levene's test for homogeneity of variance indicated a significant difference, therefore, based upon the recommendations by Field (2005), the Dunnett's T3 test was used due to its tight control over Type I error. The results confirmed freshmen, juniors and seniors were similar, and significantly different than juniors (H_o: $(\mu_1 = \mu_2 = \mu_4) \neq \mu_3$). See Table 7.

Table 7
*One-way Analysis of Variance of ZU Students' Knowledge Scores by Academic Standing (*n[a] = *592)*

Source	*df*	*SS*	*MS*	*F*	*p*	*d*
Between groups	3	189.66	63.22	16.80	.01*	.29
Within groups	588	2212.66	3.76			
Total	591	2402.32				

Note. [a] sample of participating students at ZU. * $p < .05$

Conclusions/Recommendations/Implications

The results obtained in this study should be taken with caution and should not be generalized to other populations as non-random assignment procedures were used. In addition, data fell outside the bounds of normality, appearing to be positively skewed; the researchers considered this within the parameters of the study design and results were acceptable. These results describe well TTU and ZU students.

Knowledge of international agricultural issues continues to be deficient among students. Only 3.6% of the total population obtained a passing score above 60% as was identified by Wingenbach et al. (2003), 3.5% at TTU and 3.7% at ZU. The overall mean score was 7.6, indicating the average number of correctly answered questions out of the 20 knowledge items on the instrument. These low scores on knowledge items are consistent with previous studies. Hurst (2013) found low mean scores in her study; on average 8 items were correctly answered out of 20, and only 6.5% of her participants obtained a passing score. While, Wingenbach et al. (2003) found only 5% of the students obtained a passing score after taking an international agriculture course.

Freshman students' knowledge mean score at both academic intuitions were fairly similar (TTU = 7.12; ZU = 7.06). A statistically significantly increase in correct answers was observed at both academic institutions, based on the students' academic standing. Overall, these results suggests freshmen and sophomore students are similar, while junior and seniors are similar. Junior and Senior students have been in school for a longer period time, expose to more coursework and international infusion compared to freshman and sophomore students. These two groups were significantly different but still, a low proportion of students' obtained a passing score. Students' means scores by academic standing were between 7 and 8 points out of 20 in both academic institutions. These are below the passing score and imply a lack of understanding of international agricultural issues. In addition, due to nature of this study – convenience sample – the proportion of students at each academic institution and at each grade level was not equivalent, therefore differences in knowledge observed may have been influenced by the proportion of students.

Wingenbach et al. (2003) suggested students may not be able to connect the course information and media to the instrument, consequently accounting for the obtained results. This can possibly be the case in this study as well. The lack of knowledge may be disadvantageous for students entering a labor force that demands skillful employees, able to apply their technical knowledge and to be internationally proficient. Olson et al. (2007) suggested that "students' should be able to think, work, and operate across boundaries" (2007, p. 14). Students' lacking knowledge may interfere with their ability to engage in a global context if entering the professional world immediately. This lack of knowledge, specifically in terms of international agriculture, is not uncommon among U.S. students as was concluded by Wingenbach et al. (2003).

Both academic institutions should provide students with the needed knowledge of international agricultural issues by further internationalizing their curriculums to effectively engage students in an understanding of global issues and their implications to the world. The internationalization of the higher education curriculum goes beyond the commercialization of education as a commodity and beyond the curriculum (Olson et al., 2007). It involves faculty engaging with the world (Whigham & Ackers, 2003), developing partnerships to conduct research and encourage educational opportunities for students and faculty, as well as the potential recruitment of international students and faculty to foster a multicultural environment on campuses around the globe (Altbach & Knight, 2007; Olson et al., 2007; Whigham & Ackers, 2003). The internationalization and globalization of education will remain as a central force in future years and will most likely be affected by multiple factors such as, the global political realities, policy, cost of study, domestic capacity, expansion of the English language, e-learning initiatives, private sector, quality assurance, and the internationalization of curriculum itself (Altbach, 2015; Altbach & Knight, 2007). It is recommended to further explore students' knowledge of international agricultural issues by identifying courses with international dimensions that may expand students' knowledge to an international context, as well as other factors that may potentially influence their understanding, such as study abroad programs. This can potentially position graduates as skillful and competitive employees in a constantly evolving world.

In addition, further research is needed to identify the most appropriate instrumentation to measure accurate knowledge of international agricultural issues held by students. The reliability analyses conducted to assess the instrument internal consistency in the pilot test and at post-hoc found were negligible (KR-20 = .23; KR-20 = .14). Frisbie (1988) indicates low reliability coefficients found in knowledge instruments can be attributed to the independence of items explored in the instrumentation. Furthermore, he suggested to researchers obtaining low reliability coefficients to not use results with confidence to make conclusions. However, it is important to highlight findings by previous researchers whom have also analyzed reliability, finding low coefficients on knowledge tests (Hurst, 2013), as well as others that have opted not to reported reliability analyses (Wingenbach et al., 2003).

References

Acker, D. (1999). Improving the quality of higher education in agriculture globally in the 21st century: constraints and opportunities. *Journal of International Agricultural and Extension Education, 6*(2). doi:10.5191/jiaee.1999.06206

Ajzen, I. (1985). From intentions to actions: a theory of planned behavior. In j. Kuhl & j. Beckman (Eds.), *Action-control: From cognition to behavior* (pp. 11- 39). Heidelberg, Germany: Springer

Ajzen, I. (2006). Constructing a tpb questionnaire: conceptual and methodological considerations. Retrieved January 23, 2015 from http://www.people.umass.edu/aizen/pdf/tpb.measurement.pdf.

Altbach, P. (2015). Perspectives on internationalizing higher education. *International Higher Education*, (27).

Altbach, P. G. (2004). Globalisation and the university: Myths and realities in an unequal world. *Tertiary Education & Management, 10*(1), 3-25. doi:10.1080/13583883.2004.9967114

Altbach, P. G., & Knight, J. (2007). The internationalization of higher education: Motivations and realities. *Journal of Studies in International Education, 11*(3-4), 290-305. doi:10.1177/1028315307303542

Anthony, D., Bederman Miller, P., & Yarrish, K. K. (2013). An analysis of initial global citizenship in a liberal arts college in northeastern Pennsylvania. *Journal of International Education Research (JIER), 10*(1), 23-28. doi:10.19030/jier.v10i1.8346

Bartlett, J., Kotrlik, J., & Higgins, C. (2001). Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal, 19*(1), 43. Retrieved from ftp://149.222-62-69.ftth.swbr.surewest.net/TreePDF/Determing%20Appropriate%20Sample%20Size%20in%20Survey%20Research.pdf

Bonfiglio, O. (1999). The difficulties of internationalizing the American undergraduate curriculum. *Journal of Studies in International Education, 3*(2), 3-18. doi:10.1177/102831539900300202

Christiaensen, L., Demery, L., & Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction - an empirical perspective. *Journal of development economics, 96*(2), 239-254. doi:10.1016/j.jdeveco.2010.10.006

Coers, N., Rodriguez, M. T., Roberts, T. G., Emerson, H. C., & Barrick, R. K. (2012). Examining the student impacts of three international capstone experiences. *NACTA Journal, 56*(2), 55.

De Wit, H. (Ed.). (2005). *Higher education in Latin America: The international dimension* (Vol. 638). World Bank Publications

Frisbie, D. A. (1988). Reliability of scores from teacher-made tests. *Educational Measurement: Issues and Practice, 7*(1), 25-35. doi:10.1111/j.1745-3992.1988.tb00422.x

Food and Agriculture Organization of the United Nations [FAO]. (2014, March). Post 2015 and SDGs: nourishing people, nurturing the planet (Issue Brief), Rome: FAO

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: an introduction*. Boston: Pearson

Holm-Nielsen, L. B., Thorn, K., Brunner, J. J., & Balán, J. (2005). Regional and international challenges to higher education in Latin America. In H. de Wit, I. Jaramillo, J. Gacel-Ávila & J. Knight. (eds.), *Higher Education in Latin America. The International Dimension* (21-38), doi: 10.1787/9789264209992-4-en

Hurst, S. (2013). *Knowledge, perceptions, and experiences of secondary agriculture teachers and 4-h agents regarding global agricultural issues* (Master's thesis, University of Florida). Retrieved from http://ufdc.ufl.edu/UFE0045533/00001

Hurst, S. & Roberts, T. (2013). *Factors associated with integration of global agricultural issues in 4H programs*. Paper presented at the Association for International Agricultural and Extension Education conference, Fort Worth, TX. Abstract retrieved from https://www.aiaee.org/attachments/article/1522/jiaee 20(2).pdf

Institute of International Education. (2014). *Americans study abroad in increasing numbers* [Press Release]. Retrieved from http://www.iie.org/Research-and-Publications/Open-Doors/Data

Kotrlik, J., W., Williams, H. A., & Jabor, M. K. (2011). Reporting and interpreting effect size in quantitative agricultural education research. *Journal of Agricultural Education, 52*(1), 132-142. doi: 10.5032/jae.2011.01132

McIntyre, B. D., Herren, H. R., Wakhungu, J., & Watson, R. T. (2009). *Agriculture at a Crossroads. International assessment of agricultural knowledge, science and technology for development (IAASTD): global report*. Synthesis Report. Washington DC: Island Press. Retrieved from FAO website: http://www.fao.org/fileadmin/templates/est/Investment/Agriculture_at_a_Crossroads_Global_Report_IAASTD.pdf

Moriba, S. (2011). *Investigating the international awareness and global competence of students meeting their international dimension requirement through course offerings in a college of agricultural sciences and natural resources: a descriptive and comparative study* (Doctoral dissertation, Oklahoma State University). Retrieved from https://shareok.org/handle/11244/6567

Radhakrishna, R., & Dominguez, D. (1999). Global awareness and understanding of governor school scholars: a four-year study. *Journal of International Agricultural and Extension Education*, *6*(3), 19-25. doi:10.5191/jiaee.1999.06303

Rio, F. (1964). Agricultural education in Latin America and its promise for the future. *The Phi Delta Kappan, 45*(4), 202-207. Retrieved from http://www.jstor.org/stable/20343088

Sax, L. J., Gilmartin, S. K., & Bryant, A. N. (2003). Assessing response rates and nonresponse bias in web and paper surveys. *Research in higher education*, *44*(4), 409-432. doi:10.1023/a:1024232915870

Stripling, C., & Ricketts, J. (2016). Research priority 3: sufficient scientific and professional workforce that addresses the challenges of the 21st century. In Roberts, T. G., Harder, A., & Brashears, M. T. (Eds), *American Association for Agricultural Education national research agenda: 2016-2020* (pp. 29-35). Gainesville, FL: Department of Agricultural Education and Communication.

Stromquist, N., & Monkman, K. (Eds.). (2014). *Globalization & education: integration and contestation across cultures*. United Kingdom: Rowman & Littlefield Education.

Spring, J. (2008). Research on globalization and education. *Review of Educational Research,* 78(2), 330-363. doi:10.3102/0034654308317846

Sweetland, S. R. (1996). Human capital theory: foundations of a field of inquiry. *Review of Educational Research*, *66*(3), 341–359. doi:10.3102/00346543066003341

Olson, C. L., Evans, R., & Shoenberg, R. E. (2007). *At home in the world: Bridging the gap between internationalization and multicultural education*. Washington, DC: American Council on Education.

Torres, C. A., & Schugurensky, D. (2002). The political economy of higher education in the era of neoliberal globalization: Latin America in comparative perspective. *Higher Education, 43*(4), 429-455. doi:10.4324/9780203478691_chapter_2

Whigham, K., & Acker, D. (2003). Globalization of agriculture. *South African Journal of Plant and Soil, 20*(4), 209-214. doi:10.1080/02571862.2003.10634938

Wingenbach, G., Boyd, B., Linder, J., Dick, S., Arispe, S., & Haba, S. (2003). Students´ knowledge and attitudes about international agricultural issues. *Journal of International Agricultural and Extension Education, 10*(3), 25-35.doi: 10.5191/jiaee.2003.10304

Benchmarking Self-Efficacy of Early-Career Agricultural Science Teachers in [State]

Bodie Carroll, Keller ISD

John Rayfield, Texas Tech University

Tim Murphy, Texas A&M University

Agricultural Education and Communications

Texas Tech University

Box 42131

Lubbock, TX 79409-2131

Quantitative

Teacher Education

Benchmarking Self-Efficacy of Early-Career Agricultural Science Teachers in Texas

Abstract

*The purpose of this study was to determine the self-efficacy of early-career agricultural science teachers from Texas, in the three domains of agricultural education: classroom instruction, FFA, and supervised agricultural experience (SAE). This descriptive study was conducted using a random sample of first, second, and third year agricultural science teachers. A response rate of 50.6% was achieved (*N*=168,* n*=85). The respondents completed an online survey using the Qualtrics™ system. The survey included 49 likert scale items, as well as demographic items. Teachers in this study reported the lowest self-efficacy in the categories of utilize a program advisory board, manage a horticulture/greenhouse laboratory, and assist students in preparing FFA proficiency applications. Teachers reported the highest self-efficacy in the categories of supervise students during FFA trips and activities and assist students in planning FFA chapter activities. Additionally, this study examined the relationship between demographic variables and self-efficacy in each of the three domains.*

Introduction

Agricultural education at the secondary level faces a major shortage of teachers (Wolf, 2011). Foster, Lawver and Smith (2014) estimated a teacher deficit of 287 teachers for 2015. It is estimated that there will be hundreds of unfilled positions this year (Teach Ag, 2013). Hovatter (2002) found that 50% or more of qualified graduates were employed in a career field other than teaching. Croasmun, Hampton, and Hermann (1999) discovered teacher attrition to be the largest factor when determining the demand for teachers in the United States. According to Boone and Boone (2009), attrition is often linked to the number and type of problems teachers face, and their success or failure could depend on their ability to address these problems.

The first goal of the National Strategic Plan and Action Agenda for Agricultural Education is, “An abundance of highly motivated, well-educated teachers in all disciplines, pre-kindergarten through adult, providing agriculture, food, fiber and natural resources systems education” (National Council for Agricultural Education, 2000, p.4). Wolf (2011) cited that in order to retain teachers they must be competent in the tasks they are required to perform as agricultural educators. Wolf goes on to say assessing an educator’s self-efficacy in tasks specific to agricultural education will inform teacher preparation programs about the areas in which additional professional development is required.

Previous research has been conducted to investigate the self-efficacy of student teachers from Texas, primarily in the classroom instruction domain (Edgar, Roberts, & Murphy, 2009; Roberts, Harlin, & Briers, 2008; Stripling, Ricketts, Roberts, & Harlin, 2008; Roberts, Mowen, Edgar, Harlin, & Briers, 2007; Harlin, Roberts, Briers, Mowen, & Edgar, 2007; Roberts, Harlin, & Ricketts, 2006; Edgar, Murphy, & Roberts, 2011). Additionally, Burris, McLaughlin, McCullough, Brashears, & Fraze, (2010) conducted a study examining the differences in general efficacy among first and fifth year teachers. Roberts, Harlin, and Briers (2008) stated research in the area of self-efficacy has mostly been conducted by only a few researchers in very few states. The need for this study arises from the lack of research dealing with self-efficacy of early-career agricultural science teachers in the state of Texas and the effect self-efficacy has on teacher attrition. The research objectives of this study are as follows:

1. Determine the self-efficacy of early-career agricultural science teachers in the domains of classroom instruction, FFA, and supervised agricultural experience (SAE).
2. Determine if demographic characteristics of early-career agricultural science teachers are correlated with self-efficacy.

Literature Review/Theoretical Framework

Teachers leave the profession for a variety of reasons. Fulton, Yoon, and Lee (2005) stated teachers leave due to personal reasons, a change in career, retire, or move schools, which is sometimes considered a type of attrition. Another leading reason for leaving the teaching profession is salary (Ingersoll, 2001). Attrition is often linked to the number and type of problems that a teacher faces (Boone & Boone, 2009). Boone and Boone posit that a teacher's success or failure depends on their ability to overcome and solve these problems. It is crucial to retain educators because student achievement is directly linked to teacher retention (Darling-Hammond, 2000). Each year, 15% to 33% of teachers change careers, which is higher than most other careers (Ingersoll, 2004; 2001). Having a teacher shortage is not a new phenomenon; in fact, Kantrovich (2007) stated there has been a teacher shortage in agricultural education for the past 40 years. Wolf (2011) stated the study of self-efficacy could be a potential solution to the current shortage of teachers.

Bandura (1994) defines self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 1). Furthermore, Bandura (1997) asserted perceived self-efficacy is an individual's belief in their ability to systematize and perform the sequence of actions needed to complete a task or achieve an outcome. Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) defined self-efficacy as "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 223).

Individuals derive self-efficacy from four main sources: mastery experiences, psychological and emotional states, vicarious experiences, and social persuasion (Bandura, 1994). Bandura goes on to state mastery experience is the most successful way to cultivate a strong sense of self-efficacy. This is most easily understood by the rationale that successfully completing a task promotes self-efficacy, but failure at a task weakens a person's self-efficacy (Wolf, 2011). Swan, Wolf, and Cano (2011) cited mastery experiences are considered to be the most effective of the four components of Bandura's self-efficacy theory. Bandura (1977) states physiological and emotional arousal is an important aspect of self-efficacy because it adds the component of individuals showing how they deal with stressful situations, vulnerability, and anxiety. According to Swan et al. (2011), vicarious experiences involve viewing others doing well at a task, which may cause the viewer to believe they could also do well at the task. Social persuasion occurs when an individual is convinced or persuaded that they can complete a task successfully.

Self-efficacy makes a distinction in the way people think, feel, and act (Schwarzer & Hallum, 2008). In fact, Schwarzer and Hallum go on to state a low self-efficacy is associated with depression, anxiety, helplessness, low self-esteem, and pessimistic thoughts. Bandura (1993) stated that a person's beliefs influence how they feel, think, behave, and motivate themselves. In addition, Bandura (1993) stated that self-efficacy aids people in succeeding at tasks. Furthermore, Bandura (1982) stated that a person's belief in their ability to achieve a task would lead to competent performance of that task. The guiding theoretical framework for this study is derived from Woolfolk Hoy & Hoy's (2009) model in Figure 1, which was derived from Bandura's (1994) self-efficacy theory.

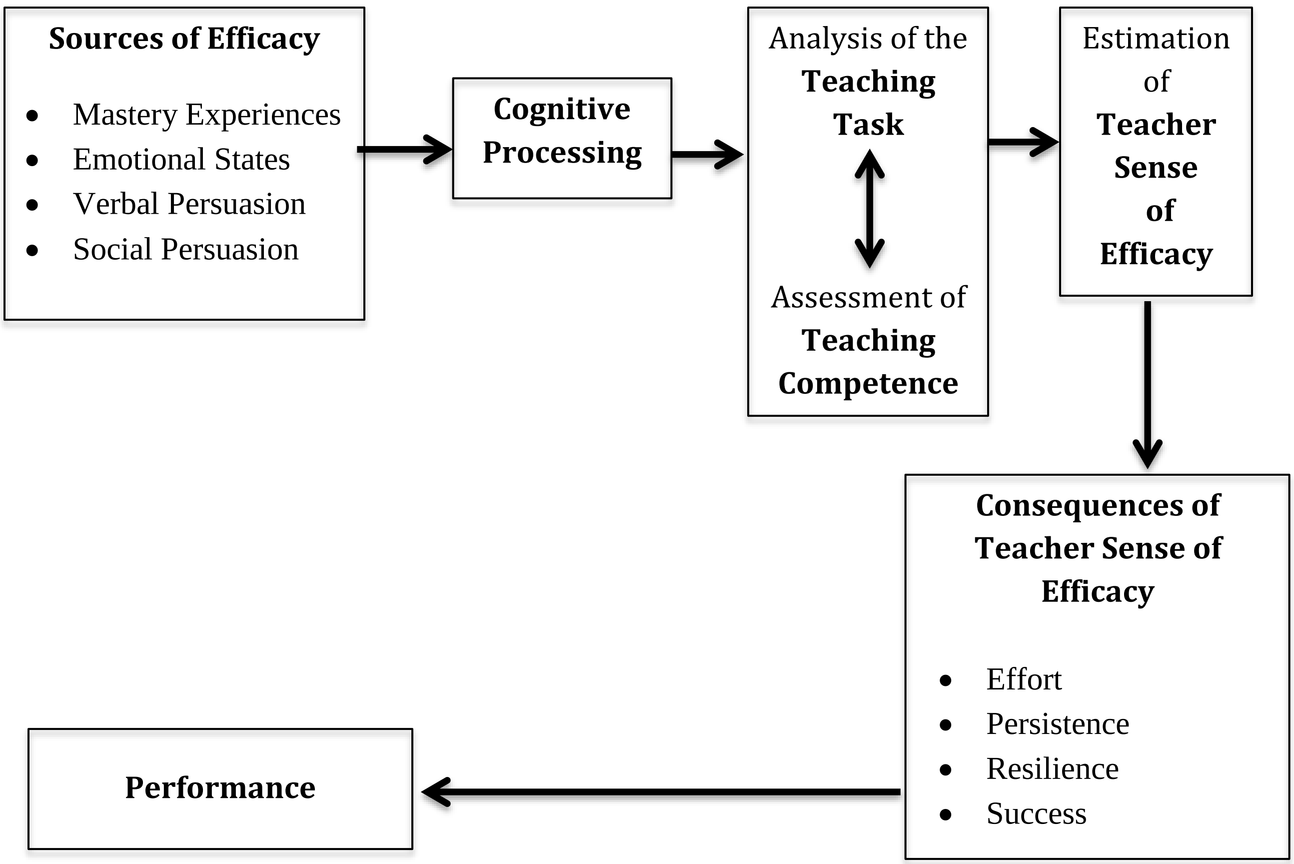

Figure 1: A model of teacher's perceived efficacy. (Woolfolk Hoy & Hoy, 2009)

The framework for this study is embedded in the idea that a teacher must be self-efficacious in order to perform and teach effectively. Teachers with a high sense of self-efficacy believe in their ability to overcome problems through time and effort, while teachers with low self-efficacy are typically overrun with classroom problems (Swan, Wolf, & Cano, 2011). Novice, or beginning teachers, who are more efficacious, tend to stay in the teaching field because they have a stronger commitment to the field (Whittington, McConnell, & Knobloch, 2003). Previous research has shown that individuals who leave the teaching field are less efficacious than those who choose to stay in the field (Glickman & Tamashiro, 1982).

A teacher's self-efficacy has been determined by previous research to be one of the most important variables that determines a teacher's effectiveness and performance in the classroom (Calik, Sezgin, Kavgaci, & Cagatay Killnic, 2012; Cooper, 2010; Mackenzie, 2000). Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) go on to state teacher efficacy has been found to have a relationship with a teacher's behavior, effort, enthusiasm, innovation, planning, perseverance, resilience, willingness to work with difficult students, and their commitment to the teaching profession. Additionally, Woolfolk Hoy and Davis (2006) stated that a teacher's sense of self-efficacy is closely related to student achievement.

Teachers with a high sense of self-efficacy have a belief they can reach students who are unmotivated through extra effort and help from parents or other teachers (Wolf, 2011). Additionally, a teacher with high self-efficacy is more open, willing, and likely to create dynamic student-centered learning environments (Wolf, 2011). Coldarci (1992) found that efficacy is a significant predictor indicative of an individual's commitment to the profession. Additionally, Bruinsma and Jansen (2010) found that the quality of an individual's teacher preparation program is related to teacher commitment to the profession.

Teacher efficacy in the field of agricultural education is unique due to the additional competencies and skills required not typical to other fields of education (Harper, Weiser, & Armstrong, 1990). Phipps and Osborne (1988) stated agricultural education programs are unique and require leadership development and experiential learning, not typically found in other areas of education. According to Wolf (2011), teachers must believe they are competent in tasks they are required to perform as agricultural educators. To overcome the shortage of teachers the profession is facing, future teachers must be prepared and have a belief of success (Swan, Wolf, & Cano, 2011). This can help fight teacher attrition, and therefore keep a higher amount of teachers in the field (Swan, Wolf, & Cano, 2011). Bandura (1977) proposed self-efficacy is most influential during the early part of learning, which is why this study aims to study the self-efficacy of early-career teachers. Although there has been research in the field of agricultural education, there has been no consensus of the data collected (Wolf, 2011). Wolf (2011) also stated the literature base for self-efficacy of agricultural science teachers is not extensive.

Agricultural education has always placed an emphasis on producing highly qualified teachers who have a high sense of self-efficacy. Teachers who have a higher sense of self-efficacy are more likely to stay in the teaching field and have a greater ability to perform their expected tasks (Swan, Wolf, and Cano, 2011). Several studies have examined the self-efficacy of early-career teachers, but few studies examine the self-efficacy of early-career teachers in the state of Texas in all three domains of agricultural education (classroom instruction, FFA, and SAE).

Methods

This study was descriptive in nature with a cross-sectional design. Fraenkel and Wallen (2009) explain that a descriptive study should attempt to fully explain a state of affairs fully and carefully. Gay, Mills, and Airasian (2012) describe a cross-sectional design as a method in which data is collected at a single point in time. The dependent variable for this study was teacher self-efficacy. The independent variables were the individual's ability to perform key tasks in the fields of FFA, SAE, and classroom instruction as well as demographic characteristics (gender, years of teaching experience, number of teaching partners, community size, education, age, likeliness to teach until retirement, certification method, high school FFA involvement, highest FFA degree, and FFA membership). To address the research objectives for this study an online survey was utilized as the means of data collection.

The population of interest for this study was all early-career agricultural science teachers in the state of Texas during the 2012-2013 school year. An early-career teacher was defined as a teacher who was in their first, second, or third year of teaching during the respective school year. A list of all early-career teachers (N = 302) was obtained from the membership services department of the Vocational Agriculture Science Teachers Association of Texas. Once the list was obtained, a simple random sample was taken from the population. The researcher determined a sample size of 168 participants was adequate for this study based on a confidence interval of 5 and a confidence level of 95%. A total of 85 respondents completed the survey resulting in a 50.6% response rate.

The instrument for this study was adapted from an instrument used to study self-efficacy of agricultural science teachers across the country in the three domains of agricultural education: classroom instruction, SAE, and FFA (Wolf, 2011). Once the instrument was acquired it was edited and reviewed by a panel of experts in order to make the instrument Texas specific. This was done because in Texas some events fall into different categories on the state level than they would on a national level. A primary example of this is leadership development events (LDEs) and career development events (CDEs). Therefore, the panel of experts was assigned the task of making the instrument more specific to Texas agricultural science teachers. Overall, five items were amended on the instrument. Wolf (2011) reported reliabilities for the instrument ranging from .94 to .98 for the overall instrument. Reliability was analyzed and calculated post hoc for this study and a reliability estimate of .97 was calculated using Cronbach's alpha. Wolf (2011) reported a panel of experts in the field of agricultural education determined the content validity of the instrument. There were no known threats to internal validity.

The instrument contained 49 likert scale items that allowed participants to rank their level of capability to complete a task on a scale of one (No capability) to nine (A great deal of capability). To account for non-response error the researcher used a comparison of early to late respondents (Linder, Murphy, Briers, 2001). An early respondent is defined as someone who responded by February 7th and a late respondent is anyone who responded after this point. No statistically significant differences were found between early and late responses; therefore, non-response error should not be considered a threat to internal validity. In addition to the 49-likert scale items, the researcher created 11 demographic questions to address the research objectives for this study. A panel of experts in agricultural education and instrument development then validated these questions.

Dillman, Smyth, and Christian's (2009) tailored design method was followed for the data collection procedures used during this study. The survey was uploaded to Qualtrics™ and all emails were sent and collected using the Qualtrics™ system. Qualtrics™ is an online survey system that allows researchers to create surveys, distribute them electronically, and collect/download data. Dillman et al. (2009) recommended using multiple contacts and to vary the message used in each email. For this study, the researcher used five points of contact, an initial email including the survey link, and four follow-up emails. Each email was sent out in one-week intervals over a five-week period. As recommended by Dillman et al. (2009), the four follow up emails were varied and contained different information in order to maximize response rate.

The data collected from this survey was analyzed using the Statistical Package for Social Sciences (SPSS). The data was exported directly from Qualtrics™ into an SPSS spreadsheet. Means and standard deviations were calculated for each of the Likert-scale items to determine self-efficacy. Percentages and frequencies were calculated for the demographic questions. Pearson correlations were calculated to determine relationships between demographic items and Likert-scale items.

Findings

Demographic data were collected for participants in the online Qualtrics™ survey. Frequencies and percentages are reported for number of years taught, gender, size of community, highest degree obtained, likeliness to teach until retirement, age, certification method, high school agriculture class experience, FFA membership, and highest FFA degree obtained.

The respondents were all in their first (n = 32), second (n = 36), or third (n = 17) year of teaching. The majority of participants (n = 58) reported their highest degree obtained as a Bachelor's degree. The size of the community in which the participants taught in was determined by categorizing each participant's school according to population density. These could be either rural, less than 2,500 people, suburban, between 2,500 and 50,000 people, or urban, more than 50,000 people, as identified by the U.S. Census Bureau (2011). The majority of teachers came from a suburban (n = 39) or rural community (n = 29). Over 29% (n = 25) of respondents reported they were undecided when asked how likely they were to teach until retirement. Additionally, 9.4% (n = 8) and 7.1% (n = 6) of participants said they were unlikely or very unlikely to teach until retirement, respectively. The majority of participants (82.4%; n = 70) reported they were traditionally certified in agricultural science.

The purpose of research objective one was to assess the self-efficacy of early-career agricultural science teachers in the state of Texas in the domains of classroom instruction, FFA, and SAE. The data are reported in Tables 1, 2, and 3 using means and standard deviations. The instrument ranged from a score of one (No capability) to a score of nine (Great Deal of Capability). Furthermore, mean scores ranging from 1.0 - 3.9 are considered low, scores between 4.0 - 6.9 are moderate, and scores between 7.0 - 9.0 are high.

The first part of research objective one sought to determine the self-efficacy of early-career teachers in the classroom instruction domain. The two lowest means were, "Manage a horticulture laboratory/greenhouse," and "Teach students with special needs." Additionally, the two highest mean scores were, "Use computers in my teaching" and "Use multimedia in my teaching."

Table 1

*Self-Efficacy of Early-Career Teachers in the Classroom Instruction Domain (*N = *85)*

What is your level of capability to:	*M*	*SD*
Utilize computers in my teaching	7.53	1.53
Utilize multimedia in my teaching	7.53	1.42
Respond to difficult questions from my students	7.27	1.13
Evaluate student learning	7.20	1.28
Motivate students to learn	7.12	1.17
Manage student behavior	6.99	1.44
Implement new curriculum into the agriculture program	6.95	1.26
Gauge student comprehension of what I have taught	6.94	1.23
Develop good questions for my students	6.91	1.22
Teach students to think critically	6.82	1.22
Effectively conduct field trips	6.82	1.90
Provide appropriate challenges for very capable students	6.80	1.40
Create lesson plans for instruction	6.65	1.92
Use a variety of assessment strategies	6.60	1.56
Manage an agricultural mechanics laboratory	6.56	2.14
Adjust my lessons to the proper level for individual students	6.49	1.44
Implement alternative strategies in my classroom	6.49	1.45
Teach students with special needs	6.48	1.80
Manage a horticulture laboratory/greenhouse	5.64	2.14

Note: 1= No Capability to 9 = A Great Deal of Capability. Low = 1.0-3.9, Moderate = 4.0-6.9, High = 7.0-9.0.

The second section of research objective one sought to determine the self-efficacy of early-career teachers in the FFA domain. There were no items that fell into the low range, seven in the moderate range, and nine in the high range. The two lowest mean scores were in the constructs of, “Assist students in preparing FFA proficiency applications” and “Utilize a program advisory board.” The two highest mean scores were in the competencies of, “Supervise students during FFA trips and activities” and “Assist students in planning FFA chapter activities.”

Table 2

*Self-Efficacy of Early-Career Teachers in the FFA Domain (*N*=85)*

What is your level of capability to:	*M*	*SD*
Supervise students during FFA trips and activities	7.94	1.30
Assist students in planning FFA chapter activities	7.58	1.71
Assist students planning FFA banquets	7.48	1.73
Assist students in facilitating FFA fundraising activities	7.46	1.64
Recruit new FFA members	7.41	1.22
Prepare CDE teams	7.36	1.51
Assist students in recruiting new FFA members	7.25	1.37
Prepare LDE teams	7.08	1.90
Train a chapter officer team	7.01	2.04
Assist students in preparing for public speaking events	6.94	1.74
Assist students in preparing a Program of Activities	6.67	1.76
Assist students in developing an effective public relations program for the FFA chapter	6.61	1.85
Assist students in preparing FFA degree applications	6.16	2.06
Utilize the FFA Alumni	6.01	2.20
Assist students in preparing FFA proficiency applications	5.69	2.03
Utilize a Program Advisory Board	5.29	1.47

Note: 1= No Capability to 9 = A Great Deal of Capability. Low = 1.0-3.9, Moderate = 4.0-6.9, High = 7.0-9.0.

The third and final part of research objective one sought to determine the self-efficacy of early-career teachers in the SAE domain. There were no items that fell into the low range, seven in the moderate range, and six in the high range. The two lowest mean scores were in the items, “Supervise student placement SAE programs” and “Utilize the community to develop SAE opportunities for students.” The two highest mean scores were in the constructs of, “Conduct home/SAE visits” and “Utilize resources to make recommendations to students’ SAE projects.”

Table 3

*Self-Efficacy of Early-Career Teachers in the SAE Domain (*N*=85)*

What is your level of capability to:	*M*	*SD*
Conduct home/SAE visits	7.36	1.67
Utilize resources to make recommendations to students' SAE projects	7.26	1.43
Make recommendations for students' SAE projects	7.24	1.50
Show students the value of SAE programs	7.15	1.38
Provide career exploration opportunities for students	7.09	1.30
Supervise student entrepreneurship SAE programs	7.06	1.65
Develop SAE opportunities for students	6.93	1.65
Assist students in keeping SAE records	6.87	1.63
Assist students in receiving recognition for SAE projects	6.76	1.66
Motivate students to have an SAE program	6.73	1.71
Supervise student production SAE programs	6.66	1.81
Utilize the community to develop SAE opportunities for students	6.40	1.65
Supervise student placement SAE programs	6.35	1.67

Note: 1= No Capability to 9 = A Great Deal of Capability. Low = 1.0-3.9, Moderate = 4.0-6.9, High = 7.0-9.0.

The mean scores for each domain were averaged to calculate grand means per construct. The highest summated mean score was a score of 6.91 in the SAE domain. The next highest mean score was a score of 6.87 in the FFA domain and the lowest mean score was 6.14 in the classroom instruction domain.

The purpose of research objective two was to determine if there is a relationship between teacher self-efficacy in the three domains of agricultural education and demographic characteristics of early-career agricultural science teachers in the state of Texas. A Pearson product moment correlation was calculated to determine if there was a relationship between demographic characteristics and self-efficacy. Correlation scores ranging from .01 to .09 are considered negligible, .10 to .29 are considered low, .30 to .49 are considered moderate, .50 to .69 are considered substantial, and scores of .70 or higher are considered very high (Davis, 1971).

The highest correlation score was between the demographic characteristic, years of experience, and the domain of FFA, with an $r = .49$, which according to Davis (1971) is a moderate correlation. There were five more correlation scores that fell into the moderate category. In order of highest to lowest correlation score, the five correlations were between likeliness to teach until retirement and SAE ($r = .40$), likeliness to teach until retirement and FFA ($r = -.37$), number of teachers in program and SAE ($r = -.36$), highest FFA degree obtained and SAE ($r = .34$), and high school agriculture class experience and SAE ($r = .31$). The remaining correlation scores were either low or negligible. A negative correlation between likeliness to teach until retirement and FFA indicated that the less likely an individual is to teach until retirement the higher their self-efficacy is within the FFA domain. In addition, the negative correlation between number of teachers in a program and the SAE domain indicated that the fewer teachers there are in a program the higher an individual's self-efficacy is in the SAE domain. A summary of the findings are presented in Table 4.

Table 4

*Correlations between Demographic Characteristics and Self-Efficacy (*N*=85)*

Demographic Characteristic	Classroom Domain	FFA Domain	SAE Domain
Years of Experience	-.17	.49	-.15
Number of Teachers in Program	-.07	.11	-.36
Population of Community	-.01	-.24	.26
Likeliness to teach until retirement	-.28	-.37	.40
Age	.10	.05	-.04
Teaching Certification	.22	-.15	-.12
High School Agriculture Class Experience	.24	-.26	.31
Highest FFA Degree Obtained	-.04	.08	.34

Note: .01 to .09 = Negligible, .10 to .29 = Low, .30 to .49 = Moderate, .50 to .69 = Substantial, .70 or Higher = Very Strong (Davis, 1971).

Summary, Conclusions, and Recommendations

According to the data, 42.4% of the respondents are second year teachers, 37.6% are first year teachers, and 20% are third year teachers. The breakdown of gender was fairly evenly distributed with males accounting for 52.9% of the sample and females 47.1% of the population. In what was once a male driven profession, females are quickly catching up to the number of males. Data also suggests 45.9% of respondents teach in a suburban community (between 2,501 and 50,000 people) and 34.1% teach in a rural community (less than 2,500 people).

About 54.1% (n = 46) of the respondents reported they were likely or very likely to teach until retirement. Consequently, 29.4% of respondents were undecided and 16.5% are unlikely or very unlikely to teach until retirement. This finding requires further investigation. Are teachers burning out at a faster rate than in the past or are they simply finding other careers? In regards to age, 52 respondents reported being between 21 and 25, and 25 individuals reported being between 26 and 30. The majority of the sample was traditionally certified in agricultural science (n = 70). Additionally, 72 respondents reported completing between 3 and 4 years of agricultural science courses while in high school and 80 individuals reported they were FFA members in high school.

In the classroom instruction domain, early-career agricultural science teachers reported having a summated mean self-efficacy score of 6.14. The classroom instruction domain had the lowest summated mean score of the three domains, although, each of the three domains fell into the moderate self-efficacy category with a score ranging from 4.0 to 6.9. Respondents reported the lowest self-efficacy for the classroom instruction domain on the skill of managing a horticulture laboratory/greenhouse (M = 5.64). Consequently, early-career teachers may struggle to provide the appropriate guidance and instruction to students in this area of education. Additionally, early-career teachers in this study reported moderate self-efficacy in regards to teaching students with special needs (*M* = 6.48). We recommend higher emphasis be placed on preparing teachers for the classroom instruction domain as data indicated teachers were the least efficacious in this domain.

In the classroom instruction domain, there were two constructs that respondents scored very highly. A mean score of 7.53 was reported for both of the following variables: utilize computers in my teaching and utilize multimedia in my teaching. As a result, early-career agricultural science teachers should be able to provide an adequate education in this area due to their high self-efficacy. Additionally, technology integration and use of technology in the classroom should be a smooth, interactive, and positive experience for both teachers and students due to high teacher self-efficacy. This may result in students receiving higher quality instruction in this area of agricultural education, and it could ultimately lead to student successes.

In the FFA domain, teachers in this study reported a summated mean score of 6.87, which was the second highest mean score out of the three domains. Respondents reported the lowest mean score in the construct of utilize a program advisory board with a score 5.29. It is important to note this is the lowest mean self-efficacy score from all three domains. Early-career agricultural science teachers may struggle to involve their local community, parents, past members, and businesses due to a low self-efficacy in this category. Teachers are missing out on a crucial resource by not utilizing an advisory board to guide their chapter and its goals. The data also indicated teachers reported a low self-efficacy in the area of assisting students in preparing FFA proficiency applications. As a result, early-career agricultural science teachers may struggle to help students apply for and prepare proficiency applications. A possible solution is to increase education and professional development for teachers in this area. Additionally, it would most likely be useful for inexperienced teachers to partner and learn from teachers who are more experienced with award applications.

In the domain of FFA, early-career agricultural science teachers reported a high self-efficacy in regards to the construct of supervising students during FFA trips and activities. A mean score of 7.94 was calculated for this construct, which was the highest mean self-efficacy score from all three domains. As a result, teachers from this study feel more comfortable supervising students on trips, which could lead to more students participating and traveling to FFA events. This could have a positive impact on FFA programs and students. Additionally, data indicated a high mean score for the construct of assisting students in planning FFA chapter activities. Consequently, this could lead to better organized and more impactful opportunities for students in the FFA.

In the third and final domain of agricultural education, SAE, early-career agricultural science teachers reported a summated mean score of 6.91. This was the highest summated mean score from the three domains. Teachers reporting the highest self-efficacy in the SAE domain could result in greater SAE projects and opportunities for students. In the domain of SAE, the lowest reported self-efficacy was in the construct of supervising student placement SAE programs. As a result of a low self-efficacy in this category, teachers could potentially steer students away from placement SAE programs or fail to recognize placement as a viable SAE project altogether. Consequently, agricultural science teachers could lose opportunities from community members and businesses, which could greatly benefit students and their SAE projects. We recommend continuing education and teacher preparation programs spend time developing teacher knowledge in these two areas.

Data indicated the highest mean score was in the category of conducting home/SAE visits with a mean score of 7.36. This may translate into a greater amount of guidance for students when receiving home visits for their SAE projects. The next highest mean score was in the competency of utilizing resources to make recommendations to students' SAE projects. Similarly to the previously mentioned competency, possessing a high amount of self-efficacy in this domain could result in students receiving better guidance and instruction with their SAE projects.

Prior research (Wolf, 2011) indicated that the study of self-efficacy could be a potential solution to the shortage of agricultural education teachers. It can be concluded from this study most early-career agricultural education teachers have a moderate amount of self-efficacy in each of the three domains of agricultural education, classroom instruction, FFA, and SAE. These three categories had reported summated mean self-efficacy scores of 6.14, 6.87, and 6.91, respectively. Continued improvement in teacher education and professional development could lead to more competencies falling into the high self-efficacy range.

A similar study of self-efficacy in the state of Ohio reported having summated mean self-efficacy scores of 7.15, 7.04, and 6.96 in the domains of classroom instruction, FFA, and SAE, respectively (Wolf, 2011). The mean self-efficacy scores for this study were lower in all three domains of agricultural education. The lowest summated mean score in the study was in the classroom instruction domain, whereas, Wolf (2011) reported the classroom instruction domain was the highest. Classroom instruction should become a higher priority for early-career teachers and the organizations and universities responsible for educating prospective teachers in agricultural education. It is important for agricultural education teachers to be well rounded in all three domains.

The purpose of research objective two was to determine if there was a relationship between demographic variables and self-efficacy in each of the three domains of agricultural education. Correlations ranging from .01 to .09 are considered negligible, .10 to .29 are considered low, .30 to .49 are considered moderate, .50 to .69 are considered substantial, and scores of .70 or higher are considered very high (Davis, 1971). The highest six correlations were all considered to be moderate correlations.

The highest correlation was between the demographic variable, years of experience, and the FFA domain ($r = .49$). This indicated that in this study the greater the years of experience the higher degree of self-efficacy a teacher possesses. As a result, early-career agricultural science teachers should become more successful and have greater results within the FFA domain the more experienced they become. It is recommended early-career teachers and prospective teachers be given more opportunities to be prepared for teaching in the FFA domain so they start out with a higher degree of self-efficacy.

The second highest correlation ($r = .40$) is between the demographic variable, likeliness to teach until retirement, and the SAE domain. This indicated the more likely an early-career agricultural science teacher is to teach until retirement the higher their self-efficacy in the SAE domain. As a result, teachers who are more dedicated to staying in the profession will most likely be better equipped at providing SAE opportunities. It is recommended early-career teachers be better prepared for this domain because some teachers could be choosing to leave the profession early due to their low self-efficacy in the SAE domain.

The results of this study provide researchers with several opportunities for further research within the area of agricultural science teacher self-efficacy. Not only should this study be replicated in other states to compare self-efficacy of agricultural science teachers across the nation, but also a follow up study should be conducted in Texas. A longitudinal study could help researchers understand more accurately the self-efficacy of early-career teachers and how it changes over time. A study comparing early-career and experienced agricultural science teachers could help illustrate changes in self-efficacy over time, as well as identify areas for professional development.

Wolf (2011) reported self-efficacy was highest in the classroom instruction domain for early-career agricultural science teachers in the state of Ohio. In this study, classroom instruction received the lowest summated mean self-efficacy score. Further research should be conducted to understand why the classroom instruction domain is lower and potential solutions to this problem. Additionally, Wolf (2011) reported higher summated self-efficacy scores in all three domain of agricultural education. Further research and investigation of self-efficacy in the state of Texas and across the nation could help researchers better understand this issue.

Only 54.1% of respondents in this study reported they are likely or very likely to teach until retirement. With a shortage of agricultural education teachers in the state and nation already, this should be of immediate concern to individuals related to the field of agricultural education. Further research should be conducted to examine what role self-efficacy plays in determining if an individual chooses to teach until retirement.

References

Bandura, A. (1977). Self–efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215.

Bandura, A. (1993). Perceived self–efficacy in cognitive development and functioning [Electronic Version]. *Educational Psychologist, 28*(2), 117–148.

Bandura, A. (1994). Self-efficacy. In V.S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, 99. 77-81). New York, NY: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health.* San Diego, CA: Academic Press, 1998).

Bandura, A. (1997). *Self–efficacy: The exercise of control.* New York, NY: Freeman.

Boone, H. N., & Boone, D. A. (2009). An assessment of problems faced by high school agricultural education teachers. *Journal of Agricultural Education, 50*(1), 21-32. doi: 10.5032/jae.2009.01021

Bruinsma, M., & Jansen, E. P. W. A. (2010). Is the motivation to become a teacher related to pre–service teachers' intentions to remain in the profession? *European Journal of Teacher Education, 33*(2), 185–200. doi: 10.1080/02619760903512927

Burris, S., McLaughlin, E. K., McCullogh, A., Brashears, T., Fraze, S. (2010). A comparison of first and fifth year agriculture teachers on personal teaching efficacy, general teaching efficacy and content efficacy. *Journal of Agricultural Education, 51*(1), 22-31. doi:10.5032/jae.2010.01022

Calik, T., Sezgin, F., Kavgaci, H., & Cagatay Kilinc, A. (2012). Examination of relationships between instructional leadership of school principals and self-efficacy of teachers and collective teacher efficacy. *Educational Sciences: Theory and Practice, 12*(4), 2498-2504.

Coladarci, T. (1992). Teachers' sense of efficacy and commitment to teaching. *Journal of Experimental Education, 60*(4), 323–337.

Cooper, J. D. (2010). Collective efficacy, organizational citizenship behavior, and school effectiveness in Alabama public high schools (Doctoral dissertation). Retrieved from ProQuest Dissertations and Thesis database (UMI: 3422943).

Croasmun, J., Hampton, D., & Hermann, S. (1999). Teacher attrition: Is time running out? University of North Carolina, Chapel Hill, North Carolina. Retrieved May 18, 2013 from http://horizon.unc.edu/projects/issues/papers/hampton.asp

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. Educational Policy Analysis Archives, 8(1), Retrieved from http://epaa.asu.edu/ojs/issue/view/8

Davis, J. A. (1971). *Elementary survey analysis.* Englewood Cliff, NJ: Prentice-Hall.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed-mode surveys: The tailored design method* (3rd ed.). New York, NY: Wiley and Sons.

Edgar, D. W., Roberts, T. G., Murphy, T. H. (2009). Structured communication: Effects on teaching efficacy of student teachers. *Journal of Agricultural Education, 50*(1), 33-44. doi:10.5032/jae.2009.01033

Fraenkel, J. R., & Wallen, N. E. (2009). How to design and evaluate research in education. New York, NY: McGraw-Hill.

Foster, D. D., Lawver R. G., & Smith, Amy R. (2014). *National agricultural education supply & demand. 2014 Executive Summary.* Retrieved http://aaaeonline.org/Resources/Documents/NSDSummary_3_1_2015_Final.pdf.

Fulton, K., Yoon, I., & Lee, C. (2005). Induction into learning communities. National Commission of Teaching and America's Future. Washington, DC. Retrieved from: http://eric.ed.gov/PDFS/ED494581.pdf

Gay, L. R., Mills, G. E., Airasian, P. (2012). Educational research: Competencies for analysis and applications (10th ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Glickman, C. D., & Tamashiro, R. T. (1982). A comparison of first year, fifth year, and former teachers on efficacy, ego development, and problem solving. *Psychology in Schools, 19*(4), 558-562.

Harlin, J. F., Roberts, T. G., Briers, G. E., Mowen, D. L., & Edgar, D. W. (2007). A longitudinal examination of teaching efficacy of agricultural science student teachers at four different institutions. *Journal of Agricultural Education, 48*(3), 78–90. doi:10.5032/jae.2007.03078.

Harper, J. G., Weiser, R. G., & Armstrong, R. F. (1990). Factors associated with western region agriculture teachers' perceptions of teaching effectiveness. *Journal of Agricultural Education, 31*(4), 22-26. doi: 10.5032/jae.1990.04022.

Hovatter, G. A. (2002). Impact of student teaching experiences, personal demographics, and selected factors on the decisions of pre-service agricultural education teachers to enter into teaching. Unpublished master's thesis, West Virginia University, Morgantown.

Ingersoll, R. M. (2001). Teacher turnover, teacher shortages, and the organization of schools. University of Washington: Center for the Study of Teaching and Policy.

Ingersoll, R. (2004). Four myths about America's teacher quality problems. In M. Smylie & D. Miretzky (Eds.), Developing the teacher workforce: The 103rd Yearbook of the National Society for the Study of Education, 1–33. Chicago: University of Chicago Press. Retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7984.2004. tb00029.x/abstract

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

Mackenzie, S. V. (2000). Collective efficacy and collaborative climate in Maine high schools (Doctoral dissertation). Retrieved from ProQuest Dissertations and Thesis database (UMI No: 9986550).

National Council for Agricultural Education. (2000). *The national strategic plan and action agenda for agricultural education: Reinventing agricultural education for the year 2020.* Alexandria, VA: Author.

Phipps, L. J., & Osborne, E. W. (1988). *Handbook on agricultural education in public school.* Danville, IL: Interstate.

Roberts, T. G., Harlin, J. F., Briers, G. E. (2008). Peer modeling and teaching efficacy: The influence of two student teachers at one time. *Journal of Agricultural Education, 49*(2), 13-26. doi: 10.5032/jae.2008.02013

Roberts, T. G., Mowen, D. L., Edgar, D. W., Harlin, J. F., & Briers, G. E. (2007). Relationship between personality type and teaching efficacy of student teachers. *Journal of Agricultural Education, 48*(2), 103–113. doi: 10.5032/jae.2006.02081

Schwarzer, R., & Hallum, S. (2008). Perceived teacher self-efficacy as a predictor of job stress and burnout: Mediation analyses. *Applied Psychology, 57*(1), 152-171. doi:10.1111/j.1464-0597.2008.00359.x

Stripling, C., Ricketts, J. C. Roberts, T. G., & Harlin, J. F. (2008). Preservice agriculture education teachers' sense of teaching self–efficacy. *Journal of Agricultural Education, 49*(4), 120–130. doi:10.5032/jae.2008.04120

Swan, B. G., Wolf, K. J., & Cano, J. (2011). Changes in teacher self-efficacy form the student teaching experience through the third year of teaching. *Journal of Agricultural Education, 52*(2), 128-139. doi: 10.5032/jae.2011.02128

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*, 202-248.

U. S. Census Bureau, Department of Commerce. (2011). Urban area criteria for the 2010 Census. Retrieved from http://www.census.gov/geo/www/ua/fedregv76n164.pdf

Whittington, M. S., McConnell, E. A., & Knobloch, N. A. (2003). Teacher efficacy of novice teachers in agricultural education at the end of the school year. *Proceedings of the 30th Annual National Agricultural Education Research Conference,* Orlando, FL, 204-215.

Wolf, K. J. (2011). Agricultural education perceived teacher self-efficacy: A descriptive study of beginning agricultural education teachers. *Journal of Agricultural Education, 52*(2), 163-176. doi: 10.5032/jae.2011.02163

Woolfolk Hoy, A. E., & Davis, H. A. (2006). Teacher self-efficacy and its influence on the achievement of adolescents. *Self-efficacy beliefs of adolescents*, 117-137.

Woolfolk Hoy, A. E., & Hoy, W. K. (2009). Instructional leadership: A research–based guide to learning in schools. Boston, MA: Allyn and Bacon.

Effect of the Inquiry-Based Teaching Method on Students' Content Knowledge and Motivation to Learn about Biofuels

Carmelita E. Goossen
Oklahoma State University
439 Ag Hall
Stillwater, OK 74078
P: 405-744-8036
E: carmelita.goossen@okstate.edu

F. Richie Roberts
Oklahoma State University
439 Ag Hall
Stillwater, OK 74078
P: 405-744-8036
E: richie.roberts@okstate.edu

Amanda Kacal
Oklahoma State University
439 Ag Hall
Stillwater, OK 74078
P: 405-744-8036
E: carmelita.goossen@okstate.edu

Ashley S. Whiddon
Oklahoma State University
439 Ag Hall
Stillwater, OK 74078
P: 405-744-8036
E: carmelita.goossen@okstate.edu

J. Shane Robinson
Oklahoma State University
100 ITLE
Stillwater, OK 74078
P: 405-744-3094
E: shane.robinson@okstate.edu

Quantitative Research

Teaching and Learning in Undergraduate Academic Programs

Effect of the Inquiry-Based Teaching Method on Students' Content Knowledge and Motivation to Learn about Biofuels

Carmelita Goossen, Southwestern Heights High School, Kismet, KS
F. Richie Roberts, North Carolina A&T University
Amanda Kacal, Cinco Ranch High School, Katy, TX
Ashley Whiddon, Perry Middle School, Perry, GA
J. Shane Robinson, Oklahoma State University

Abstract

Students in secondary education are failing in science and are not prepared adequately for college. This deficit has led to the use of innovative teaching methods, including inquiry-based instruction. Inquiry-based instruction has gained popularity because of its realistic and problem-based strategy. The purpose of this study was to determine the effect of inquiry-based instruction, compared to lecture, on the content knowledge and motivation for completing a science-based laboratory activity of pre-service agricultural education teachers (N = 41) at Oklahoma State University. Students were assigned randomly to either an inquiry group or lecture group in the completely randomized 2x2 design. A biofuels unit containing a fully developed classroom kit developed by Lab Aids® served as the content for the treatment. The findings of the study revealed a statistically significant increase in biofuels content knowledge for those who received inquiry-based instruction when compared to those who received lecture. However, no effects were detected regarding the treatment on students' motivation for completing the activity. As this study was exploratory in nature, it is recommended that it be replicated with a larger sample size to increase generalizability.

This work has been funded, partially, by the NSF EPSCoR award EPS 0814361.

Introduction

American secondary students are failing in the area of science (Kuenzi, 2008) and are not ready for college (Cavanagh, 2004). Unfortunately, the progress of science aptitudes of American students in secondary school systems has been stagnant for years (National Center for Education Statistics, 2005; Provasnik, Gonzales, & Miller, 2009). The report, *A Nation at Risk: The Imperative for Educational Reform* (1983), stated, "the educational foundations of our society are being eroded by a rising tide of mediocrity" (p. 5).

The lack of science proficiency has led to an educational change in how science is taught (Lloyd, 1992). Science educators have turned their attention to the inquiry teaching method (Karukstis & Elgren, 2007). Inquiry-based instruction is "the creation of a classroom where students are engaged in essentially open-ended, student-centered, hands-on activities" (Colburn, 2000, p. 42). With inquiry, students are allowed to explore the learning situation, develop hypotheses about the outcome of activities, and test solutions (Colburn, 2000).

Historically, inquiry-based education has been celebrated as an instrumental pedagogy for both the mathematics and science disciplines (National Research Council, 1996), which has strong ties to agriculture. Additionally, empirical evidence supporting inquiry-based teaching methods has been documented well throughout science, technology, engineering, and mathematics (STEM) education (Bransford, Brown, & Cocking, 1999; Bybee et al., 2006; Llewellyn, 2002; National Commission on Excellence in Education, 1983; National Commission on Mathematics and Science Teaching, 2000; National Council of Teachers of Mathematics, 2000).

Efforts to connect science and agriculture better have been observed throughout the years. For instance, in some states, students who enroll in agriscience classes receive science credit for graduation (Connors & Elliot, 1995; Thoron & Myers, 2011). Attempts to update the equipment and technology necessary for teaching laboratory science in agricultural settings has improved and become *commonplace* in agriscience programs (Shoulders & Myers, 2012). Also, agricultural instructors have reported having positive experiences teaching science-based laboratory activities (Myers & Dyer, 2006; Myers, Washburn, & Dyer, 2004; Osborne & Dyer, 2000). In addition, numerous agricultural educators have the necessary desire to integrate more science into their program's curricula (Washburn & Meyers, 2010); yet, they do not always have the knowledge to do so appropriately (Scales, Terry, & Torres, 2009).

Agricultural education and science have a longstanding history. Agricultural education has been referred to as the oldest science in the world (Ricketts, Duncan, & Peake, 2006). The National Research Council (1988) initially called for agriculture to integrate more science into its courses by urging that, "ongoing efforts should be expanded to upgrade the scientific and technical content of vocational agricultural education class" (p. 35). The relation of the two fields was described further by Buriak (1992) in his definition of agriscience, "Instruction in agriculture emphasizing the principles, concepts, and laws of science and their mathematical relationships supporting, describing and explaining agriculture" (p. 4).

Agricultural education has been a good medium for teaching students science skills and proficiencies (Thompson & Balschweid, 2000). The reverse is true also. When teachers employed a science-enhanced curriculum to teach agricultural competencies, students' learned agricultural concepts better than students whose teachers used an agricultural curriculum (Haynes, Robinson, Edwards, & Key, 2012a). Interestingly, though, a similar study yielded no statistically significant differences regarding students' science aptitudes (Haynes, Robinson, Edwards, & Key, 2012b). That study (Haynes et al., 2012b) recommended that professional development should focus on assisting agricultural education teachers in learning how to integrate science concepts better. One strategy could be to emphasize how to use the inquiry-based instructional method.

Inquiry is a method of instruction that has become a popular teaching strategy in agricultural education due to its unique realistic, problem-based method of instruction (Phipps, Osborne, Dyer, & Ball, 2008). Inquiry-based teaching places individuals "in-action" to solve problems instead of learning "out-of-context" (Applebee, 1996, p. 130). This method also is a natural complement for the integration of STEM education into agricultural education instruction because encouraging cognitive retention requires that students' prior preconceptions be engaged early and often throughout the learning process (Bybee et al., 2006). Therefore, students go beyond obtaining a fact-based education and instead utilize deep cognitive processing skills more readily (Donovan & Bransford, 2005; Willingham, 2003) to deepen their science capacities.

Employing students to think actively about the content and participate in hands-on activities enables them to develop a stronger conceptual understanding of science (Minner, Levy, & Century, 2010). Therefore, the science discipline has placed a large emphasis on using inquiry-based teaching when delivering its course content (Dormody, 1993)

Despite this strong track record, numerous educators avoid implementing inquiry instruction into their classrooms because of its complexity and intensity during the instructional process (Puntambekar, Stylianou, & Goldstein, 2007). Additional reasons explaining why teachers are hesitant to utilize this teaching method relates to their lack of training and experience with constructivist style teaching (Llewellyn, 2002).

What is more, the research has been somewhat conflicting regarding the effectiveness of inquiry as a pedagogy. Specifically, controversy exists regarding how science should be taught (Kirschner, Sweller, & Clark, 2006; Furtak, Seidel, Iverson, & Briggs, 2012). Evidence supporting the use of inquiry for teaching science is strong; however, not everyone involved in public school systems believes science should be taught through inquiry-based approaches (Crawford, 2007) mostly because a lack of empirical validation exists suggesting that it affects student learning positively (Kirschner et al., 2006). In fact, Kirschner et al. (2006) stated, "minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process" (p. 75).

Unlike inquiry-based learning, lecture is usually organized by the teacher and can sometimes lack interaction (Akkus, Gunel, & Hand, 2007; Yore, 2001). Typically, the teacher tries to drill the information into the student so that he or she can memorize the desired facts (Moore & Moore, 1984). Some researchers claim that science should be offered by way of teacher-centric methods, such as lecture (Klahr & Nigam, 2004). What is more, teachers are more confident in their ability to use lecture than any other method, and therefore do so more frequently, when teaching science, technology, engineering, and mathematics (STEM) principles (Smith, Rayfield, & McKim, 2015). Others claim that the only way to learn science is through student-centric pedagogies, such as inquiry (Granger et al., 2012). Recent inquiry studies, however, suggest that this method of teaching has a positive effect on learning outcomes (Easterly III & Meyers, 2011; Friedel et. al, 2008; Parr & Edwards, 2004; Thoron & Myers, 2011).

Inquiry-based teaching often is advertised as a fun and engaging method of teaching that motivates students to learn science at a higher level by exploring their own learning (Minner et al., 2010). Therefore, students have positive perceptions of inquiry (Washburn & Myers, 2010; Wolf & Fraser, 2008). However, additional research is warranted regarded how motivation is affected by inquiry teaching (Pintrich, 2003). Specifically, Smith et al. (2015) recommended that

> Teacher educators should make sure that instruction is included for preservice teachers in effective lecture techniques, and instruction should be given to allow novice teachers to make appropriate decision[s] related to when it is appropriate to substitute student-centered alternatives to traditional methods. (pp. 197-198)

Furtak et al. (2012) stated that, "while the debate between inquiry-based and traditional instructional approaches has continued to simmer, researchers have investigated inquiry-based teaching reforms with particular interest in the specific features that appear to lead to increased student learning" (p. 301). Additionally, Hu, Kuh, and Li (2008) called for research "to take into account the fit between the nature or inquiry-oriented activities and students' interests, competencies, and motivation . . . ." (p. 78). Therefore, what effect does the type of instruction have on students' content knowledge and perceived motivation to complete a science-based, laboratory activity in the context of agriculture?

This study was grounded in the expectancy-value theory (Schunk, Pintrich, & Meece, 2008). People have expectations regarding their abilities to perform a task and place value on the reasons "they might engage in a task" (Schunk et al., 2008, p. 44). Ultimately, the expectancy-value theory depends on peoples' aspirations for participating in an activity (Eccles, 2007). If people have a solid motive for participating, believe they have a realistic opportunity to achieve success, and are offered a meaningful incentive, their motivation for participating increases (Schunk et al., 2008). How much value a person has for an activity depends on the personal importance they place on the activity (also known as attainment value), their intrinsic motivation, their perceived usefulness of the activity (also known as utility value), and the cost of participating (Eccles, 2007). Answering this study's research question will provide a response to the American Association for Agricultural Education's priority number four (Doerfert, 2011). Specifically, a key outcome to that priority is that learners will be " . . . actively and emotionally engaged in learning, leading to high levels of achievement . . ." (p. 21).

Purpose and Objectives

The purpose of this study was to determine the effect of inquiry-based instruction, compared to lecture, on students' content knowledge and motivation for completing a science-based laboratory activity. The following research objectives guided the study.

1. Determine the effect of inquiry-based instruction and lecture on students' content knowledge.
2. Determine the effect of inquiry-based instruction and lecture on students' overall perception of the activity.
3. Determine the effect of inquiry-based instruction and lecture on students' perceived interest and enjoyment regarding the activity.
4. Determine the effect of inquiry-based instruction and lecture on students' perceived value and usefulness of the activity.
5. Determine the effect of inquiry-based instruction and lecture on students' perceived choice of the activity.

The following null hypotheses guided the statistical analysis of the study.

$H_0$1: There is no statistically significant difference between students' content knowledge due to the effect of inquiry-based instruction and lecture.

$H_0$2: There is no statistically significant difference in overall activity perception of students due to the effect of inquiry-based instruction and lecture.

$H_0$3: There is no statistically significant difference in interest and enjoyment of the activity due to the effect of inquiry-based instruction and lecture.

H_04: There is no statistically significant difference in value and usefulness of the activity due to the effect of inquiry-based instruction and lecture.

H_05: There is no statistically significant difference in perceived choice of the activity due to the effect of inquiry-based instruction and lecture.

Methods and Procedures

This exploratory, experimental study employed an independent variable with two levels to assess two treatment groups. The independent variable of this study was laboratory instruction method. The two levels were inquiry-based instruction and lecture. The dependent variables were students' content knowledge, and their motivation for participating in and completing the activity. Content knowledge was measured utilizing a 10-item criterion-referenced test. Student activity perceptions were measured using the Intrinsic Motivation Inventory (IMI), a 25-item activity perception questionnaire (Intrinsic Motivation Inventory, n.d.). The IMI is a self-regulated perception instrument in which participants determine their level of motivation for completing laboratory experiments.

The population of interest was all students (*N* = 41) enrolled in a junior-level foundations course in agricultural education at Oklahoma State University. Although 41 students were enrolled in the course, originally, not all were present for the duration of the treatment. Therefore, if any student missed a class meeting during the treatment period, he or she was omitted from the study. As a result of this, 37 students participated fully in all experimental conditions.

This research study was conducted to provide students' evidence as to which pedagogy (i.e., lecture versus inquiry-based teaching) is most useful in teaching content related to agriscience. This study followed the exact protocol of two similar studies regarding similar populations of interest at Oklahoma State University (Baker, Brown, Blackburn, & Robinson, 2014; Blackburn, Robinson, & Kacal, 2015). The biofuels unit was chosen due to its connection to agriculture and because of its scarcity within the state's curriculum. As such, the researchers felt as though students would not have been exposed to the curriculum before; thus, no bias would affect pre-test scores.

Because the population consisted of pre-service teachers, this study was presented to the students within the course topic of teaching and managing an agriscience laboratory and was included in the course syllabus. At the beginning of the semester, students were informed of this research study, by way of the course syllabus, and how its findings might impact them as future teachers.

Following Institutional Review Board approval, students were assigned randomly to two groups as a means for controlling threats to internal validity (Gay, Mills, & Airasian, 2009). The treatment group consisted of students who were assigned to receive content via the inquiry-based teaching section (*n* = 19). The counterfactual group consisted of students who were assigned to receive the content via lecture (*n* = 17) (see Figure 1).

Method of Instruction		Repeated Measures: Pre-Test	Repeated Measures: Post-Test
	Lecture	Treatment Group A *n* = 17	Treatment Group A *n* =17
	Inquiry-based Instruction	Treatment Group B *n* = 19	Treatment Group B *n* = 19

Figure 1. Random Assignment to a SPF 2x2 design.

To ensure that both groups were equal prior to instruction, a one-way ANOVA was utilized to determine if statistically significant differences existed between students' pre-test and post-test scores based on treatment group. Prior to employing ANOVA, Levene's test for equality of error variances was calculated to ensure error variances were equal (Field, 2009). The Levene's test indicated no statistically significant differences $p = .196$; therefore, equality of error variances was assumed. It was found that no statistically significant differences ($p > .05$) existed between the two groups (i.e., inquiry-based instruction and the lecture) (see Table 1). Thus, both groups were deemed to be equal in their content knowledge of biofuels prior to the experiment.

Table 1

Lecture Versus Inquiry Based Learning on Pre-test Scores

Type of Instruction	*M*	*SD*	*F*	*p*
Lecture (*N* = 17)	5.53	1.42	2.53	.12[a]
Inquiry (*N* = 19)	4.74	1.52		

Note. [a]Effect size = 0.54 (*medium*, per Cohen's *d*, Kirk, 1995)

Following the pre-test, students relocated to their assigned laboratory setting to experience a 30-minute lesson on course content related to biofuels. Both groups received instruction consisting of the same objectives, basic concepts, and terminology of biofuels. A kit developed by the Science Education for Public Understanding Program (SEPUP) supplied laboratory procedures and protocols used to conduct the biofuels experiment employed in this study. Students completed investigation two titled, *Comparing the Energy Stored in Two Fuels.* This investigation is part of a larger kit produced by Lab-Aids® Incorporated titled, *Biofuels: Investigating Ethanol Production and Combustion* – Kit 39S (Lab-Aids® Incorporated, 2007). In this investigation, students compared the energy levels of two fuels – ethanol and kerosene. Students formulated hypotheses based on their current knowledge and prior experiences and then completed the experimental investigation. The students used mathematical formulae and calculations for testing their hypotheses. The major scientific and mathematical concepts within this investigation included the chemical make-up of fuels, pollutants, experimental design and control, converting units of measurement, and averaging. The Lab-Aids® Incorporated biofuels kit utilized in this investigation also was employed by two similar studies conducted at Oklahoma State University (Baker et al., 2014; Blackburn et al., 2015). Biofuels kits and supplies used in the study were supported partially by the NSF EPSCoR award EPS 0814361.

Although the content was held consistent, the delivery of the content was altered. Content was delivered using the assigned teaching method for the respective treatment groups. In the treatment group, content was delivered through the inquiry-based method (i.e., student-centered teaching), and in the counterfactual group, the content was delivered through the lecture method (i.e., teacher-centered teaching).

Inquiry-Based Instruction Treatment

The National Research Council (1996) reinforced inquiry based instruction as a student-centered teaching approach stating, “inquiry teaching requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science” (p. 6). During the biofuels laboratory experiment, students in the inquiry-based instruction treatment group employed their prior knowledge to develop their experimental procedures using the laboratory materials they were provided. The laboratory procedures and protocols supplied for the Lab-Aids® Biofuels investigation two were adapted for this treatment group using the Science Teacher Inquiry Rubric (STIR) (National Research Council, 2000) to increase inquiry and enhance learner-centered teaching methods to guide instruction. The STIR was developed based on the National Science Education Standards’ essential features of inquiry instruction (National Research Council, 2000, p. 6).

> The five essential features of inquiry include: (a) learners are engaged by scientifically oriented questions, (b) learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions, (c) learners formulate explanations from evidence to address scientifically oriented questions, (d) learners evaluate their explanations in light of alternate explanations, particularly those reflecting scientific understanding, (e) learners communicate and justify their proposed explanations. (National Research Council, 2000, p. 14)

The STIR places these essential features on a continuum to assist teachers in implementing inquiry-based instruction through curriculum adaptation. One side of the continuum describes teacher-centered teaching methods, while the other side of the continuum describes student-centered teaching methods (National Research Council, 2000).

In the inquiry-based group, students were expected to develop their own hypothesis related to the outcome of the experiment. They were encouraged to obtain approval from the instructor at multiple checkpoints throughout the experiment to validate that their hypotheses, data collection, and procedures aligned with experiment protocols. The laboratory instructor's role was to facilitate the process, not teach the content. When students were confused, the instructor was allowed to ask questions to the students, answer questions asked by students, and provide pertinent and timely information to get students progressing again.

Lecture Treatment
In contrast, students in the lecture treatment were taught the concepts of biofuels with a PowerPoint® presentation. In addition, students were provided laboratory procedures and protocols supplied for the Lab-Aids® Biofuels investigation two. Laboratory instructors provided these procedures at the beginning of the experiment; therefore, students simply followed the step-by-step protocol instead of developing their own data collection procedure to conduct the experiment. The Lab-Aids® curriculum comes with a booklet of scripted laboratory exercises in which students are to complete. Students received the step-by-step procedures included in the Lab-Aids® Biofuels kits. The instructors leading this group followed the scripted exercises exactly as they were printed in the booklets.

The three instructors (one in the treatment room and two in the counterfactual room) who led both treatment and counterfactual groups were graduate students in agricultural education at Oklahoma State University. These instructors were formerly certified agricultural education teachers and had been trained to use their respective teaching methods, as assigned. In all, the instructors had a combined 12 years of secondary teaching experience in three different states. Specifically, the instructor who led the inquiry-based teaching treatment group is a National Agriscience Teacher Ambassador specially trained in inquiry methods with more than 90 hours of training in inquiry-based teaching techniques to improve agriscience curriculum.

Instrumentation
The content and questions found in the Lab-Aids ® curriculum was used to develop the criterion-referenced test that served as the dependent variable of the study. The test was assessed, previously, for face and content validity by a panel of experts consisting of pedagogical and content experts (Baker et al., 2014). It also was deemed to be reliable (Blackburn et al., 2015) as a result of procedures outlined by Wiersma and Jurs (1990). Therefore, the test was used in this study without any modification.

In addition, the researchers employed a 25-item activity perception questionnaire that is part of the Intrinsic Motivation Inventory (IMI, n.d.). The IMI "is a multidimensional measurement device" that has been used in numerous experiments related to intrinsic motivation and self-regulation through the assessment of participants' subjective experiences "related to a target activity in laboratory experiments" (IMI, n.d., para. 1). The activity perception questionnaire assessed three constructs including "interest/enjoyment, value/usefulness, and perceived choice" (IMI, n.d., p. 8).

Findings

The first objective was to determine the effect the type of instruction had on students' knowledge, as confirmed by post-test scores. Out of ten possible points, the group that received lecture (N = 17) had an average score of 5.76 (SD = 1.89) and those in the inquiry group (N = 19) had an average score of 7.21 (SD = 1.27), which was determined to be statistically significant at the .05 level, $F(1, 34) = 7.39$, $p = .01$ (see Table 2). Prior to analyzing the data, Levene's test of equality of error variances was employed to ensure that homogeneity of variances was not violated. Levene's test was determined to be nonsignificant at the .05 level $F(1, 34) = 1.74$, $p = .196$. Accordingly, the researchers rejected the null hypothesis.

Table 2

Lecture Versus Inquiry Based Learning on Students' Post-test Scores

Type of Instruction	*M*	*SD*	*F*	*p*
Lecture (*N* = 17)	5.76	1.89	7.39*	.01[a]
Inquiry (*N* = 19)	7.21	1.27		

Note. *Statistically significant at the .05 level; [a]effect size = 0.90 (*large*, per Cohen's *d*, Kirk, 1995)

A test of simple main effects was necessary due to the statistically significant interaction effect between time and instructional method. Simple main effects are employed to understand the interaction effects better (Kirk, 1995). Table 3 depicts the results of the simple main effects test. It was found that there was a simple main effect regarding the duration of the experiment (i.e., time from pre-test to post-test) and the type of instruction received.

Table 3

Simple Main Effects Table for the Effect of Time on Instructional Method

Source	*SS*	*df*	*MS*	*F*	*p*	*Partial* η^2
Time	32.92	1	32.92	19.01	.00	.36
Instruction	1.91	1	1.91	.64	.43	.02
Time*Instruction	22.48	1	22.48	12.98	.00*	.28
Error	58.90	34	1.73			
Total		37				

Note. *Statistically significant at the .05 level

Contrast was employed to test the simple effects of instruction within each level combination of the dependent variable. A statistically significant difference (p = .01) in post-test score was found for the lecture group (see Table 4). The contrast revealed that 18% of the dependent variable is related to the method of instruction.

Table 4

Contrast for Time Repeated Measures

Time		*SS*	*df*	*MS*	*F*	*p*	*Partial* η^2
Pre-test	Contrast	5.64	1	5.64	2.59	.12	.07
	Error	73.92	34	2.17			
Post-test	Contrast	18.76	1	18.76	7.40	.01*	.18
	Error	86.22	34	2.54			

Note. *Statistically significant at the .05 level

The purpose of objective two was to determine the effect of the type of instruction on students' perceptions of completing the assignments in the activity. It was found that those in the lecture group (N = 14) had a mean score of 4.64 (SD = .71), and those in the inquiry group (N = 18) had a mean score of 4.47 (SD = .81). A between groups analysis deemed non-significant results, and the researchers failed to reject the second null hypothesis (see Table 5).

Table 5

Effects of Activity Perceptions on the Activity Between Groups

Construct	*SS*	*df*	*MS*	*F*	*p*	*Partial* η^2
Activity Perception Total	.24	1	.24	.40	.53	.02
Interest/Enjoyment	.45	1	.45	.56	.46	.00
Value/Usefulness	.42	1	.42	.57	.46	.02
Perceived Choice	.01	1	.02	.02	.90	.01

Note. *Statistically significant at the .05 level

The purpose of objective three was to determine the effect of the type of instruction on students' perceptions of interest/enjoyment of the activity. It was found that those in the lecture group (N = 16) had a mean score of 5.02 (SD = .90), and those in the inquiry group (N = 19) had a mean score of 4.80 (SD = .89). A between groups analysis deemed non-significant results, and the researchers failed to reject the third null hypothesis (see Table 5).

The purpose of objective four was to determine the effect of the type of instruction on students' perceptions of value/usefulness of the activity. It was found that those in the lecture group (N = 16) had a mean score of 4.94 (SD = .80), and those in the inquiry group (N = 19) had a mean score of 4.73 (SD = .90). A between groups analysis deemed non-significant results, and the researchers failed to reject the fourth null hypothesis (see Table 5).

The purpose of objective five was to determine the effect of the type of instruction on students' perceptions of perceived choice of the activity. It was found that those in the lecture group (*N* = 15) had a mean score of 4.11 (*SD* = .99), and those in the inquiry group (*N* = 18) had a mean score of 4.06 (*SD* = 1.16). A between groups analysis deemed non-significant results, and the researchers failed to reject the fifth null hypothesis (see Table 5).

Conclusions

The inquiry-based teaching method affected students' biofuel content knowledge positively, as measured on the criterion-referenced test. Not only was this finding statistically significant, but it also had a large practical effect on students' ability to learn biofuels content. This finding supports the notion that students perform better on knowledge-based examinations when content is delivered with student-centered methods, which is consistent with other seminal works in the literature (Crawford, 2007; Easterly III & Myers, 2011; Friedel et. al, 2008; Parr & Edwards, 2004; Furtak et al., 2012; Thoron & Myers, 2011).

A simple main effects test revealed a statistically significant difference in time to type of instruction between the students who were in the inquiry-based instruction group based on post-test scores. Students in the inquiry-based group gained more content knowledge than did their counterparts in the lecture group. There was a statistically significant increase in post-test scores of the students in the inquiry-based groups as 18% of post-test scores were attributed to the inquiry method. This is consistent with studies that suggested that inquiry could have a positive effect on students' learning outcomes (Easterly III & Myers, 2011; Friedel et. al, 2008; Parr & Edwards, 2004; Thoron & Myers, 2011).

The IMI activity perception instrument was utilized to measure the overall experience of the specific method used in the group and the content taught. There were no statistically significant differences between groups in the constructs of *interest/enjoyment*, *value/usefulness,* and *choice* of the activity; thus, the type of pedagogy used did not impact student motivation. Collectively, students reported that they found the activity to be interesting and useful, and they felt like their choice to participate in the activity was at least *somewhat true*. Because both groups were deemed to be motivated to participate in the activity, this finding is consistent with previous studies that reported students having a positive perception toward inquiry as a method of instruction (Washburn & Myers, 2010; Wolf & Fraser, 2008). Additionally, the findings reveal that students were intrinsically motivated to participate in the activity, which is part of the expectancy-value theory (Eccles, 2007; Schunk et al., 2008).

Recommendations for Research

This study's findings indicate that content knowledge increased for those who received instruction through inquiry-based teaching as opposed to those who received instruction through lecture. However, because this study was exploratory in nature and employed a small sample size (*N* = 41) with low power, further research is needed (Kirk, 1995). It is recommended that the study be replicated with a larger sample size among both secondary and post secondary students. Specifically, the same procedures and protocol should be replicated with similar groups, and the data should be combined with the current study to increase the study's overall power and ability to yield more reliable results regarding the inquiry method's effect on students' content knowledge and motivation for completing the activity.

Researchers have conflicting views regarding inquiry-based instruction (Easterly III & Myers, 2011; Friedel et. al, 2008; Kirschner et al., 2006; Parr & Edwards, 2004; Puntambekar et al., 2007; Thoron & Myers, 2011). However, this study indicated an increase in content knowledge utilizing the inquiry-based method. This could be due to the differences in teaching styles of the instructors delivering the methods. It is possible that *teacher effect* may have impacted the study. To control for the possibility of teacher effect, a similar study should be replicated in which the same teacher instructs both groups.

Since documentation regarding the use of the IMI in agricultural education is limited, it is recommended that further research should be conducted utilizing the instrument to assess students' perceptions with other, various activities. Such studies would help validate the instrument for agricultural education.

Finally, future studies should include qualitative research methods to follow up with students regarding their thoughts of the two interventions to understand additional and more in-depth details regarding the study's findings. Specifically, a qualitative study focusing on what students liked and disliked and valued and devalued (Eccles, 2007) about the inquiry and lecture teaching methods would help inform aspiring teachers regarding the selection of appropriate pedagogies to implement in their own teaching and learning environments in the future (Smith et al., 2015).

Recommendations for Practice

Considering the small sample size and power attributed to this study, the findings are especially encouraging for inquiry-based teaching. Therefore, it is recommended that additional preparation be devoted to developing pre-service students' efficacies to utilize the inquiry-based teaching method at Oklahoma State University. Information taught through science-enhanced curriculum increases students' agricultural knowledge (Haynes et al., 2012a) and inquiry often is revered as a fun and engaging method that motivates students to learn at a higher level (Minner et al., 2010). Therefore, it is recommended that secondary agricultural education teachers employ inquiry-based teaching methods when teaching science-enhanced curriculum.

Researchers have recommended that professional development should be offered to assist teachers in learning how to integrate science concepts within the agricultural education curriculum more effectively (Haynes et al., 2012a). An implementation strategy could include employing inquiry-based teaching methods. Researchers have indicated that teachers avoid using inquiry because of its complexity and intensity during instruction (Puntambekar et al., 2007), and the avoidance could be related to their confidence in using lecture (Smith et al., 2015) and inexperience and discomfort with using constructivist-teaching methods (Llewellyn, 2002), such as inquiry. It is recommended that agricultural education teachers participate in professional development opportunities regarding inquiry-based teaching when delivering science-enhanced agricultural education curriculum. Also, it was evident from this study that content understanding was lacking. As such, additional effort should be made to help pre-service teachers expand their horizons regarding science competencies that have an agricultural undertone.

Discussion

This study targeted pre-service teachers regarding their ability to teach science more effectively could have positive implications for future secondary students. Robinson, Kelsey, and Terry (2013) found that pre-service teachers in agriculture at Oklahoma State University do not perceive teaching STEM concepts as an important aspect of their job initially; however, they did begin perceiving it positively once they were introduced to the curriculum. Therefore, the ultimate goal of the researchers is to improve the science literacy of secondary students by improving the competencies of pre-service teachers. One potential approach is to increase pre-service teachers' experiences with STEM-based laboratories in agricultural contexts.

References

Applebee, A. N. (1996). *Curriculum as conversation: Transforming traditions of teaching and learning*. Chicago, IL: University of Chicago Press

Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? *International Journal of Science Education, 29*(14), 1745–1765. doi:10.1080/09500690601075629

Baker, M. A., Brown, N. R., Blackburn, J. J., & Robinson, J. S. (2014). Determining the effects that the order of abstraction and type of reflection have on content knowledge when teaching experientially: An exploratory experiment. *Journal of Agricultural Education, 55*(2), 106–119. doi:10.5032/jae.2014.02106

Blackburn, J. J., Robinson, J. S., & Kacal, A. (2015). Determining the effects of reflection type and cognitive style on students' content knowledge. *Journal of Agricultural Education, 56*(3), 195–209. doi:10.5032/jae.2015.03195

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). How people learn: Brain, mind, experience, and school. Washington, DC: National Academies Press.

Buriak, P. (1992). Filling the gap in agriculture. *The Agricultural Education Magazine, 64*(9), 4, 23.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A., & Landes, N. (2006). The BSCS 5E instructional model: Origins and effectiveness. *Colorado Springs, CO: BSCS.*

Cavanagh, S. (2004). Students ill-prepared for college, ACT warns. *Education Week, 24*(8). Retrieved from http://www.edweek.org/ew/articles/2004/10/20/08act.h24.html

Colburn, A. (2000). An inquiry primer. *Science Scope, 23*(6), 42–44. Retrieved from http://www.experientiallearning.ucdavis.edu/module2/el2-60-primer.pdf

Connors, J. J., & Elliot, J. F. (1995). The influence of agriscience and natural resources curriculum on students' science achievement scores. *Journal of Agricultural Education*, *36*(3), 57–63. doi:10.5032/jae.1995.03057

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching, 44*(4), 613–642. doi:10.1002/tea.20157

Doerfert, D. L. (Ed.) (2011). *National research agenda: American Association for Agricultural Eductaion's research priority areas for 2011-2015*. Lubbock, TX: Texas Tech University, Department of Agricultural Education and Communications.

Donovan, S. M., & Bransford, J. D. (2005). How students learn: History, mathematics, and science in the classroom. Washington, DC: National Academies Press.

Dormody, T. J. (1993). Science credentialing and science credit in secondary school agricultural education. *Journal of Agricultural Education*, *34*(2), 63–70. doi:10.5032/jae.1993.02063

Easterly III, R. G., & Myers, B. E. (2011). Inquiry–based instruction for students with special needs in school based agricultural education. *Journal of Agricultural Education, 52*(2), 36–46. doi:10.5032/jae.2011.02036

Eccles, J. (2007). *Subjective task value and Eccles et al. model of achievement-related choices*. New York: The Guildford Press.

Field, A. (2009). *Discovering statistics using SPSS (3rd ed.)*. Thousand Oaks, CA: Sage Publications, Inc.

Friedel, C., Irani, T., Rudd, R., Gallo, M., Eckhardt, E., & Ricketts, J. (2008). Overtly teaching critical thinking and inquiry-based learning: A comparison of two undergraduate biotechnology classes. *Journal of Agricultural Education*, *49*(1), 72–84. doi:10.5032/jae.2008.01072

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of Educational Research, 82*(3), 300–329. doi:10.3102/003465431247206

Gay, L. R., Mills, G. E., & Airasian, P. (2009). *Educational research: Competencies for analysis and applications*. Upper Saddle River, NJ: Pearson.

Granger, E. M., Bevis, T. H., Saska, Y., Southerland, A., Sampson, V., & Tate, R. L. (2012). The efficacy of student-centered instruction in supporting science learning. *Science, 338*(5), 105–108. doi:10.1126/science.1223709

Haynes, J. C., Robinson, J. S., Edwards, M. C., & Key, J. P. (2012a). Determining the effect of a science-enhanced curriculum on agricultural content knowledge: A causal comparative study. *Proceedings of the 2012 AAAE Conference, Asheville, NC.* Retrieved at http://aaaeonline.org/uploads/allconferences/5-23-2012_23_abstracts2012.pdf

Haynes, J. C., Robinson, J. S., Edwards, M. C., & Key, J. P. (2012b). Assessing the effect of using a science-enhanced curriculum to improve agriculture students' science scores: A causal comparative study. *Journal of Agricultural Education, 53*(2), 15–27. doi:10.5032/jae.2012.02015

Intrinsic Motivation Inventory (n.d.). Self-determination theory: An approach to human motivation & personality. Retrieved from http://www.selfdeterminationtheory.org/questionnaires/10-questionnaires/50

Karukstis, K. K., & Elgren, T. E. (2007). *Developing and sustaining a research-supportive curriculum: A compendium of successful practices.* Washington, DC: Council on Undergraduate Research.

Kirk, R. E. (1995). *Experimental design: Procedures for the behavioral sciences (3rd ed.).* Pacific Grove, CA: Brooks/Cole Publishing Co.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. doi:10.1207/s15326985ep4102_1

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*(10), 661–667. doi:10.1111/j.0956-7976.2004.00737.x

Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action*. Congressional Research Service Reports. Retrieved from http://digitalcommons.unl.edu/crsdocs/35/

Lab-Aids, Incorporated (2007). *Biofuels: Investigating ethanol production and combustion (39S).* Ronkonoma, NY: Lab-Aids, Inc.

Llewellyn, D. (2002). Inquiry within: Implementing inquiry-based science standards. Thousand Oaks, CA: Corwin Press.

Lloyd, B. W. (1992). A review of curricular changes in the general chemistry course during the twentieth century. *Journal of Chemical Education, 69*(8), 633–636. doi:10.1021/ed069p633

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction – What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47,* 474–496. doi:10.1002/tea.20347

Moore, G. E., & Moore, B. A. (1984). The problem solving approach to teaching: Has it outlived its usefulness? *Journal of the American Association of Teacher Educators in Agriculture, 25*(2), 3–10. doi:10.5032/jaatea.1984.02003

Myers, B. E., & Dyer, J. E. (2006). Effects of investigative laboratory instruction on student content knowledge and science process skill achievement across learning styles. *Journal of Agricultural Education, 47*(4), 52–63. doi:10.5032/jae.2006.04052

Myers, B. E., Washburn, S. G., & Dyer, J. E. (2004). Assessing agriculture teachers' capacity for teaching science integrated process skills. *Journal of Southern Agricultural Education Research*, *54*(1), 74–85. Retrieved from http://www.jsaer.org/pdf/vol54Whole.pdf

National Center for Education Statistics (2005). *NAEP state comparisons–data table*. Retrieved from http://nces.ed.gov/nationsreportcard/statecomparisons/withinyear.aspx?usrSelections+1%2cSCI%2c0%2c2%2cwithin%2c0%2c0

National Commission on Excellence in Education. (1983). *A nation at risk: An imperative for educational reform*. Washington, DC: U.S. Department of Education.

National Commission on Mathematics and Science Teaching. (2000). *Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. Washington, DC: U.S. Department of Education.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM, Inc.

National Research Council. (1988). *Understanding agriculture: New directions for education*. Danville, IL: The Interstate Printers and Publishers.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington DC: National Academy Press.

Osborne, E. W., & Dyer, J. E. (2000). Attitudes of Illinois agriscience students and their parents toward agriculture and agricultural education programs. *Journal of Agricultural Education*, *41*(3), 50–59. doi:10.5032/jae.2000.03050

Parr, B., & Edwards, M. C. (2004). Inquiry-based instruction in secondary agricultural education: Problem-solving – An old friend revisited. *Journal of Agricultural Education, 45*(4), 106–117. doi:10.5032/jae.2004.04106

Phipps, L. J., Osborne, E. W., Dyer, J. E., & Ball, A. (2008). *Handbook on agricultural education in public schools.* Clifton Park, NY: Thomson Delmar Learning.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95*(4), 667–686. doi:10.1037/0022-0663.95.4.667

Provasnik, S., Gonzales, P., & Miller, D. (2009). *U.S. performance across international assessments of student achievement: Special supplement to the condition of education 2009*. NCES 2009–083: National Center for Education Statistics.

Puntambekar, S., Stylianou, A., & Goldstein, J. (2007). Comparing classroom enactments of an inquiry curriculum: Lessons learned from two teachers. *Journal of the Learning Sciences, 16*(1), 81–130. doi:10.1080/1050840070933694

Ricketts, J. C., Duncan, D. D., & Peake, J. B. (2006). Science achievement of high school students in complete programs of agriscience education. *Journal of Agricultural Education, 47*(2), 48–55. doi:10.5032/jae.2006.02048

Scales, J., Terry, Jr., 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

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research, and applications* (3rd ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Shoulders, C. W., & Myers, B. E. (2012). Teachers' use of agricultural laboratories in secondary agricultural education. *Journal of Agricultural Education, 53*(2), 124–138. doi:10.5032/jae.2012.02124

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective practices in STEM integration: Describing teacher perceptions and instructional method use. *Journal of Agricultural Education, 56*(4), 182–201. doi:10.5032/jae.2015.04183

Thompson, G. W., & Balschweid, M. M. (2000). Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs. *Journal of Agricultural Education, 41*(2), 73–80. doi:10.5032/jae.2000.02073

Thoron, A. C., & Myers, B. E. (2011). Effects of inquiry-based agriscience instruction on student achievement. *Journal of Agricultural Education*, *52*(4), 175–187. doi:10.5032/jae.2011.04175

Washburn, S. G., & Myers, B. E. (2010). Agriculture teacher perceptions of preparation to integrate science and their current use of inquiry based learning. *Journal of Agricultural Education, 51*(1), 88–98. doi:10.5032/jae.2010.01088

Wiersma, W., & Jurs, S. G. (1990). *Educational measurement and testing*. Boston, MA: Allyn and Bacon.

Willingham, D. (2003). Why students think they understand when they don't. *American Educator*, 38–41, 48.

Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education*, *38*(3), 321–341. doi:10.1007/s11165-007-9052-y

Yore, L. D. (2001). What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal of Science Education*, *5*(4). Retrieved from http://unr.edu/homepage/crowther/ejse.