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# Socioscientific Issues-based Instruction: An Investigation of Agriscience Students' Content Knowledge based on Student Variables

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**Abstract**

*Numerous researchers in science education have reported student improvement in areas of scientific literacy resulting from socioscientific issues (SSI)-based instruction. The purpose of this study was to describe student agriscience content knowledge following a six-week SSI-based instructional unit focusing on the introduction of cultured meat into the nation's food supply, taking into account students' grade level, socioeconomic status (SES), and experiences in agricultural education. Results indicated that students improved their content knowledge scores from pretest to posttest both proximally and distally; however, the degree of improvement varied based on grade level, SES, number of completed agriculture classes, and FFA involvement.*

Keywords: socioscientific issues; agricultural education; content knowledge

The nation has been experiencing a shortage of qualified agricultural science graduates to fill the estimated 13,000 annual job vacancies in agricultural, food, and natural resources (AFNR) (USDA, 2005). Approximately 40-45% of the industry's applicants have been graduates from "allied higher education programs" (USDA, 2005, p. 3), while just over half of the applicants who have graduated and pursued careers in AFNR did so from agriculturally-based majors (USDA, 2005). The gap between AFNR career needs and agriculture graduates' capabilities has not been without reason; the agriculture industry has changed drastically over the past century, altering the skills and qualifications needed to succeed in AFNR careers. Students receiving education in agriculturally-based fields and principles traditionally have prepared for careers in production agriculture, as farming was previously the most prominent agricultural career (Drache, 1996). Today's agricultural education classroom can provide an appropriate setting for teaching skills and knowledge related to scientific literacy (NRC, 2009), yet the need for curriculum models and educational approaches designed to improve student knowledge and skills in science and agriculture remains (Association of Public and Land-grant Universities, 2009; NRC, 2009; Doerfert, 2011; Shelly-Tolbert, et al., 2000).

Much of scientific literacy focuses on students' awareness of science in society (NRC, 1996). Numerous researchers in science education have reported student improvement in areas of scientific literacy resulting from education through real-world examples and case studies of scientifically-based issues, termed socioscientific-issues (SSI)-based instruction (Albe, 2008; Klosterman & Sadler, 2011; Sadler, 2009; Sadler, 2011; Sadler & Zeidler, 2003). Many of the issues utilized in SSI-based instruction are agriculturally based (Zeidler, Walker, Ackett, & Simmons, 2002), suggesting that SSI-based instruction in secondary school agricultural education classes is a natural fit and may improve students' scientific literacy. While educators were previously criticized for failing to link educational content with real world events (Conroy & Walker, 2000), the National Research Council (2009) posited that agricultural education is "uniquely positioned to respond to students' interest in making the world a better place and in responding to… important societal needs" (p. 99). The problem addressed by this study is the

continuing gap between students' scientific literacy skills and those needed to succeed in the workplace and society, and the search for instructional methods well-suited for secondary agricultural education that show evidence of success for improving student scientific literacy skills (Doerfert, 2011; Harvard Graduate School, 2011; National Research Council, 1996; 2009).

## Theoretical/Conceptual Frameworks

The grand theory supporting this study was constructivism, which states that all learning is the product of the construction of knowledge through experience (Fosnot, 1996). Experiential learning, in true constructivist fashion, combines the aspects of concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) (Kolb, 1984) to apply knowledge and practice in real situations while modeling appropriate behaviors and procedures (Randell, Arrington, & Cheek, 1993). SSI-based instruction improves student learning experiences by allowing students 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).

Socioscientific Issues (SSI) can encompass a variety of concepts and contexts, although all SSIs share two common elements – a connection to science and a level of social significance as identified by the community (Sadler, 2004; 2009; Sadler & Ziedler, 2003). This social significance lends most SSIs to be controversial in nature, and therefore, the subject of debate and concern in everyday life (Sadler, 2009). Modern advances in technology and science, paired with the environmental and economic strains of today's society, "guarantee the prominence of these kinds of issues in the present and future" (Sadler, 2004, p. 513).

Sadler (2011) proposed a framework that highlights considerations when designing SSI-based instruction (Figure 1).

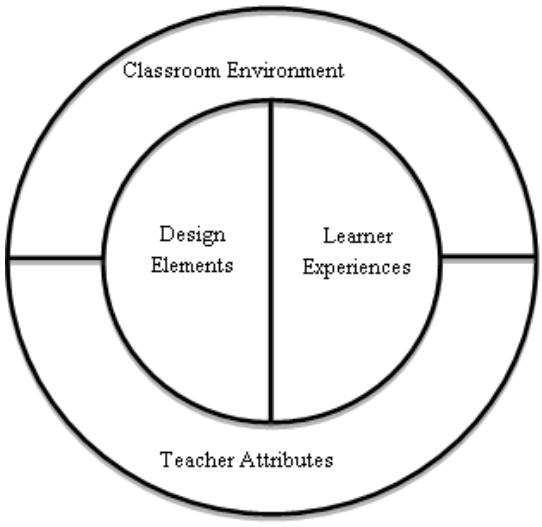


*Figure 1.* Framework for SSI-based Education (Sadler, 2011).

Design elements consist of "considerations that practitioners and curriculum authors should incorporate in their efforts to create units of instruction based on SSI" (Sadler, 2011, p. 361). Learner experiences pertain to the "kinds of experiences that students should have as they are engaged in SSI learning" (Sadler, 2011, p. 362). Classroom environment consists of factors that play a role in the successful implementation of SSIs into student learning experiences related to the class's culture, including high expectations for student participation and a culture of collaboration and respect. Teacher attributes also impact successful implementation of SSIs into en-

riched student learning, and include realistic views of one's limitations and knowledge, and willingness to give up teacher-centered control of the classroom.

This study was guided by the melding of experiential learning and SSI-based instruction theory and Dunkin and Biddle's (1984) model of the theory of classroom teaching in an effort to develop a more holistic concept of SSI-based instruction and its impact on student learning (Figure 2).

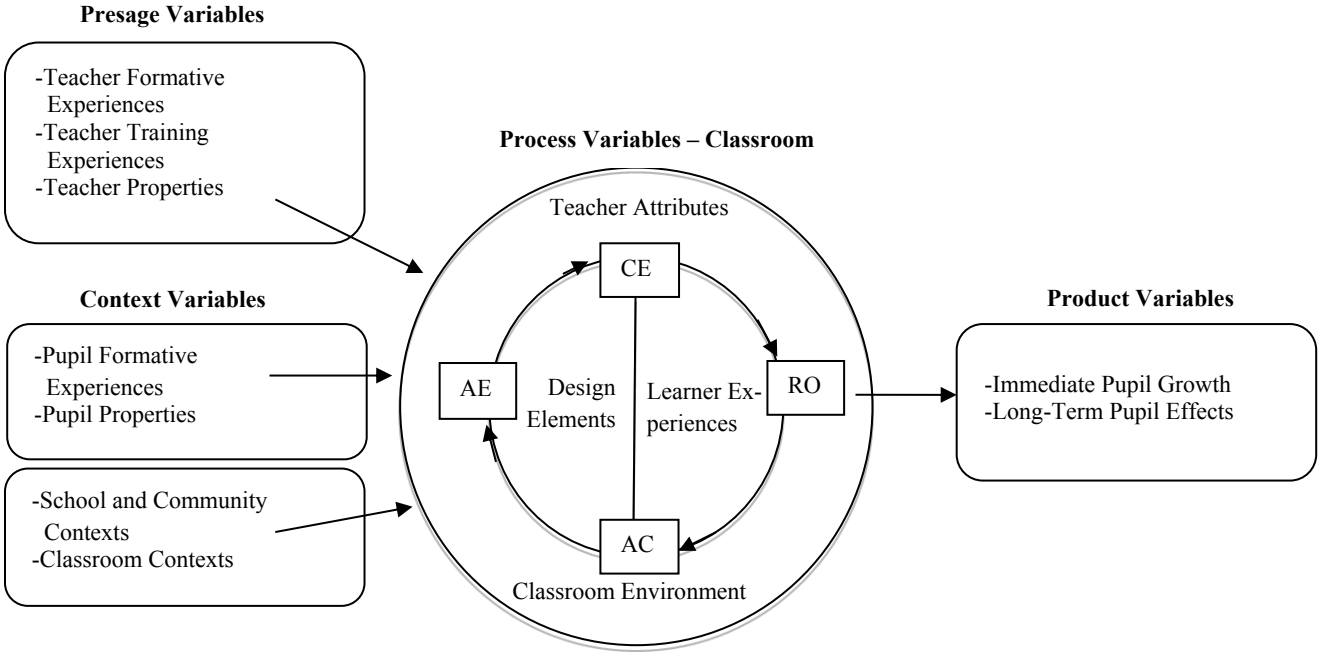


*Figure 2*. Conceptual Model of SSI-based Instruction.

Presage variables and teacher classroom behavior encompass Sadler's teacher attributes, while classroom environment is similar to classroom attributes. The actions of learning experiences in a classroom are accounted for in Dunkin and Biddle's process variables, but can be more accurately framed for use in SSI-based education through both the stages of Kolb's (1984) experiential learning cycle and Sadler's (2011) design elements and learner experiences. Dunkin and Biddle's model incorporates factors and considerations that stem from the community, which may be especially pertinent to SSI-based education due to the societal controversy surrounding the issues introduced into the classroom experiences. Finally, the purpose of teaching is expressed through Dunkin and Biddle's model through product variables, which are omitted from Sadler's framework. Through the combination of the experiential learning cycle (Kolb, 1984), the framework for SSI-based instruction (Sadler, 2011), and the model for the theory of classroom teaching (Dunkin & Biddle, 1974), a holistic model for the evaluation of the SSI-based instruction can be conceptualized (Figure 2).

This study examined how specific context variables are related to desired outcomes following the implementation of a process variable. Context variables, which are those that are uncontrolled by the teacher, are depicted by Dunkin and Biddle (1974) as pupil formative experiences and properties, school and community contexts, and classroom contexts. Students bring formative experiences with them to the classroom, and these can be impacted by aspects such as parents' views and experiences, socioeconomic status, and physical attributes. The social focus of SSI-based instruction implies that students have experiences outside of the classroom that impact their learning through SSI contexts (Sadler, 2011), causing need for research

on the impacts of pupil formative experiences on SSI-based instruction. Cheek, Arrington, Carter, and Randell (1994) found that student achievement was positively correlated with a number of student experiences, including FFA participation and years enrolled in agriscience. However, Ricketts, Duncan, and Peake (2006) found that students enrolled in agriscience programs displayed an average score three points lower than college preparation students on the Georgia High School Graduation Test. Because of the important role parents and experiences in agriculture and agricultural education have on students' decisions to enroll in secondary school agricultural education (Reis & Kahler, 1997; Kotrlik & Harrison, 1987), both of these factors may impact how students learn about specific SSIs in those agricultural education classes.

Pupil properties are commonly measured when examining impacts of teaching. While many studies have discussed the demographic characteristics of students, few have examined how SSI-based instruction impacts students of varying properties differently. In agricultural education, students of varying grade levels enroll in courses together, necessitating investigation of the impact of SSI-based instruction on students of different grade levels. A previous study by Cheek, et al. (1994) found a positive correlation between agriculture students' socioeconomic status and school achievement. Further, the role SSIs have in society and in consumer decisions warrants an examination of the impact of SSI-based instruction with regard to students of different socioeconomic statuses (SES) (Mueller & Zeidler, 2010).

Context variables can alter the impact of process variables, which serve to enable interaction between the teacher and students. The outcomes stemming from classroom interaction are titled product variables. SSI-based instruction has resulted in impacts on numerous student outcomes in science education, including content knowledge, scientific reasoning ability, argumentation skills, and views of the nature of science. This work is a piece of a larger study that examined the impact of SSI-based instruction on each of these outcomes; the present work focused on the impact of SSI-based instruction on student content knowledge.

Barab, Sadler, Heiselt, Hickey, and Zuiker (2007) reported a significant increase in fourth-graders' proximal content knowledge, which aligned directly to the concepts taught in an SSI-based unit focusing on water quality. The study did not find a significant difference in the students' distal content knowledge, which utilized released state science achievement tests. Klosterman and Sadler (2011) found statistically significant differences in eleventh and twelfth grade students' proximal and distal content knowledge following an SSI-based unit focusing on global warming. The opposing results from these two and other studies warrants further examination of how SSI-based instruction may impact proximal and distal content knowledge of students in agricultural education (Sadler, Klosterman, & Topku, 2011; Yager, Lim, & Yager, 2006; Zohar & Nemet, 2002).

## Purpose and Objectives

The purpose of this study was to describe student agriscience content knowledge following a six-week SSI-based instructional unit focusing on the introduction of cultured meat into the nation's food supply, taking into account students' grade level, socioeconomic status, experiences in agricultural education, and parents' experiences in agricultural education. In order to accomplish this purpose, the following objectives were developed:

1. Determine students' proximal and distal content knowledge following an SSI-based instructional unit.
2. Determine students' proximal and distal content knowledge following an SSI-based instructional unit based on enrollment in middle or high school.
3. Determine students' proximal and distal content knowledge following an SSI-based instructional unit based on socioeconomic status, operationally defined as enrollment in the school free or reduced lunch program.
4. Determine students' proximal and distal content knowledge following an SSI-based instructional unit based on number of completed agricultural education classes.

5. Determine students' proximal and distal content knowledge following an SSI-based instructional unit based on membership in the FFA.

## Methods

The study's population was Florida agriscience students. The sampling frame consisted of students of a convenience sample of Florida agriscience teachers. Teachers had to be teaching at least one Agriscience Foundations class during the 2011-2012 year. These classes could be at the middle or high school level.

Teachers were recruited via convenience sampling methods. Those teachers participating in the Florida Association of Agricultural Educators Summer Conference and regional FFA Chapter Officer Leadership Conferences were recruited to attend training sessions related to the study. The teachers attending the summer conference were offered an in-person training session, while those attending the leadership conferences attended one of four online training sessions.

The theory-building nature of this study warranted the use of a preexperimental, single group pretest-posttest design (Campbell & Stanley, 1963), as a true experimental or quasi-experimental design was not deemed appropriate. Theory building, "the purposeful process…by which coherent descriptions, explanations, and representations of observed or experienced phenomena are generated, verified, or refined," (Lynham, 2000, p. 161), is guided in design by the nature and development of the theory rather than by a researcher's preferred method of inquiry (Lynham, 2002). The intervention consisted of lessons which taught agriscience content through an SSI context. The segment was broken down into three instructional units, each examining the SSI (whether cultured meat should be introduced into the nation's food supply) from a different perspective: (a) food safety, (b) economic impacts, and (c) environmental impacts. Thirty lesson plans were developed to accommodate 45-minute classes. All instructional plans were developed according to recommended practices of experiential learning (Kolb, 1984), SSI-based instruction (Sadler, 2011), and inquiry-based instruction (NRC, 2000). Plans were evaluated for content validity by a panel of experts in agricultural education, experiential learning, inquiry-based instruction, and SSI-based instruction from the University of Florida. The content was selected based on 22 Student Performance Standards listed for Agriscience Foundations by the Florida Department of Education. The researcher then grouped these standards by topic and selected content appropriate for the grade level of the students, the course description, the purposes of agricultural education, and the context of a specific SSI.

During the first observation, students were administered pretests that measured their overall agriscience content knowledge. Their knowledge of food safety was also assessed to provide baseline content knowledge data prior to the first treatment unit, Food Safety. Students then experienced the Food Safety treatment unit. Following completion of the first treatment unit, students' knowledge gains in agriscience content related to food safety were measured through a Food Safety posttest. This cycle of pretesting, treatment, and posttesting was repeated through each of the study units. The final observation consisted of posttests to measure students' content knowledge related to environmental impacts and overall agriscience content knowledge.

Researcher-developed instruments were utilized to evaluate students' agriscience content knowledge. Three unit-specific assessments were developed to align with each of the consecutive units taught during the treatment: (a) Food Safety, (b) Economic Impacts, and (c) Environmental Impacts. All tests were similar in design and difficulty. The unit-specific assessments consisted of items appearing on the Florida Agritechnology Industry Certification Exam which aligned with the standards utilized for the intervention. These were supplemented with researcher-developed questions to adequately assess each standard, resulting in a 20-item assessment for each unit. The distal assessment was constructed with questions from the unit assessments, and consisted of 10 items per unit for a total for 30 items.

The students were assessed using identical pretests and posttests; students did not receive feedback on their performance on the pretests before taking the posttests. Content and face

validity were established through an expert panel of faculty members of the University of Florida. A pilot test was conducted utilizing 15 University of Florida juniors in the Department of Agricultural Education and Communication to establish reliability. Removal of identified questions resulted in the following Kuder-Richardson 20 scores, which is the appropriate measure for dichotomous data (Huck, 2008): a) the Food Safety exam had a score of .77, b) the Economic Impacts exam had a score of .66, and c) the Environmental Impacts exam had a score of .72. Data were reported using descriptive statistics, including frequencies, means, and standard deviations.

## Findings

Approximately 40 teachers attended the training sessions, which were provided to inform potential participants about the study. Eleven teachers expressed interest in the study and signed consent forms, leading to a total of 672 students enrolled with signed consent forms. After extensive and repeated communication with the researcher, seven teachers asked to be removed from the study after its start due to complications arising during the school year. Four teachers' classes participated in the entire study; however, after multiple contacts, several teachers failed to send all of the completed instruments. Therefore, the number of students reported for each assessment varied (Table 1). Students were included in each data analysis if they completed a pretest and posttest for that specific instrument; they were not omitted from all data analysis if they were missing a specific pretest or posttest.

### Proximal and Distal Content Knowledge

The study's first objective was to determine students' proximal and distal content knowledge following an SSI-based instructional unit. Descriptive data for each exam are displayed in Table 2.

Table 1

*Number of Students per Objective Variable Completing Each Assessment*

| Objective Variable | *n* | | | | |
|---|---|---|---|---|---|
| | Overall | Distal | Food Safety | Economic Impacts | Environmental Impacts |
| All Students | 66 | 32 | 59 | 63 | 61 |
| Grade Level | | | | | |
| Middle | 56 | 26 | 52 | 56 | 53 |
| High | 9 | 6 | 8 | 7 | 8 |
| Free/Reduced Lunch Status | | | | | |
| Enrolled | 28 | 17 | 25 | 28 | 27 |
| Not Enrolled | 38 | 15 | 34 | 35 | 34 |
| # of Completed Agriculture Classes | | | | | |
| 1 | 6 | 2 | 5 | 5 | 5 |
| 2 | 43 | 26 | 41 | 42 | 41 |
| 3 | 9 | 2 | 8 | 9 | 8 |
| 4 | 5 | 1 | 4 | 5 | 4 |
| FFA Membership | | | | | |
| Member | 37 | 25 | 35 | 37 | 35 |
| Nonmember | 27 | 6 | 23 | 25 | 24 |

Table 2

*Overall Student Exam Scores*

| | | Pretest | | Posttest | | Mean In- | % that increased |
|---|---|---|---|---|---|---|---|
| Assessment | *n* | *M* | SD | *M* | SD | crease | score |
| Distal | 32 | 14.00 | 4.00 | 15.41 | 3.55 | 1.41 | 69 |
| Food Safety | 59 | 11.51 | 2.74 | 13.81 | 2.83 | 2.30 | 75 |
| Economic Impacts | 63 | 9.92 | 2.16 | 11.70 | 2.67 | 1.78 | 63 |
| Environmental Impacts | 61 | 7.56 | 2.16 | 9.41 | 2.82 | 1.85 | 64 |

With regard to the distal exam, students' scores displayed a mean score of less than 50% ($n$ = 32). The mean posttest score was slightly over 50%. Sixty-nine percent ($n$ = 22) scored higher on the distal posttest than on the pretest.

On the proximal assessments measuring student knowledge aligning with the Food Safety unit, students displayed a mean score of slightly over 50% ($n$ = 59). Posttest scores resulted in a higher mean score than the pretest. Seventy-five percent (n = 44) of the students increased their scores from pretest to posttest. With regard to the pretest and posttest aligning with the Economic Impacts unit ($n$ = 63), students displayed a mean score slightly below 50% on the pretest, which increased to slightly over 50% on the posttest. Sixty-three percent ($n$ = 40) of the students scored higher on the posttest than on the pretest. Students' mean pretest and posttest scores on the Environmental Impact unit assessments displayed knowledge improvement, but both mean scores remained below 50% ($n$ = 61). Sixty-four percent of the students ($n$ = 39) displayed increased scores from pretest to posttest.

**Content Knowledge based on Enrollment in Middle or High School**

Table 3 displays students' proximal and distal content knowledge on each exam following an SSI-based instructional unit based on enrollment in middle or high school.

Table 3

*Student Exam Scores based on Middle or High School Enrollment*

| | *n* | Pretest | | Posttest | | Mean Increase | % that increased score |
|---|---|---|---|---|---|---|---|
| Assessment & Group | | *M* | SD | *M* | SD | | |
| Distal | | | | | | | |
| Middle | 26 | 14.35 | 3.60 | 15.69 | 3.69 | 1.34 | 73 |
| High | 6 | 12.50 | 4.37 | 14.17 | 3.49 | 1.67 | 50 |
| Food Safety | | | | | | | |
| Middle | 50 | 11.37 | 2.77 | 13.83 | 2.80 | 2.46 | 78 |
| High | 8 | 12.25 | 2.93 | 13.75 | 3.09 | 1.50 | 88 |
| Economic Impacts | | | | | | | |
| Middle | 56 | 9.73 | 2.78 | 11.45 | 2.66 | 1.72 | 66 |
| High | 6 | 11.28 | 2.93 | 13.83 | 2.88 | 2.55 | 67 |
| Environmental Impacts | | | | | | | |
| Middle | 52 | 7.51 | 2.13 | 9.13 | 2.59 | 1.67 | 67 |
| High | 8 | 7.75 | 2.20 | 11.63 | 2.90 | 3.88 | 75 |

With regard to the distal exam, middle school students ($n$ =26) displayed mean pretest and posttest scores that were above those of high school students ($n$ = 6). All mean scores were below 50%, with the exception of the middle school students' distal exam score, which was slightly over 50%. High school students displayed a higher mean score increase than middle school students. A greater percentage of middle school students displayed an increase in score from pretest to posttest ($n$ = 19) than high school students ($n$ = 3).

With regard to the Food Safety exams, middle school students once again displayed higher mean scores on the pretest and posttest ($n$ = 50) than high school students ($n$ =8). High school students displayed a higher increase in mean score from pretest to posttest. Seventy-eight percent of middle school students displayed increased an increased score from pretest to posttest ($n$ = 39), while 88% of high school students displayed a similar score increase ($n$ = 7).

On the Economic Impacts exam, middle school students ($n$ = 56) displayed lower pretest and posttest mean scores than high school students ($n$ = 6). High school students also displayed a greater increase in mean score from pretest to posttest. The range of scores of high school students on both pretest and posttest were narrower than those of middle school students. Sixty-six percent of the middle school students displayed increased scores from pretest to posttest ($n$ = 37), while 67% of the high school students displayed a similar increase ($n$= 4).

With regard to the Environmental Impacts exam, middle school students ($n$ = 52) displayed mean pretest and posttest scores lower than those of high school students ($n$ = 8). High school students also displayed a greater increase in mean scores from pretest to posttest. Sixty-seven percent of middle school students scored higher on the posttest than on the pretest ($n$ = 35), while 75% of the high school students displayed a similar score increase ($n$ = 6).

**Content Knowledge based on Free/Reduced Lunch Enrollment**

The study's third objective was to determine students' proximal and distal content knowledge following an SSI-based instructional unit based on eligibility for the school free or reduced lunch program. Descriptive data regarding student performance based on enrollment in the free or reduced lunch program are displayed in Table 4.

Table 4

*Students' Mean Scores based on Enrollment in the Free/Reduced Lunch Program*

| Assessment & Group | *n* | Pretest | | Posttest | | Mean Increase | % that increased score |
|---|---|---|---|---|---|---|---|
| | | *M* | SD | *M* | SD | | |
| Distal | | | | | | | |
| Enrolled | 17 | 14.18 | 3.50 | 16.12 | 4.28 | 1.94 | 76 |
| Not Enrolled | 15 | 13.80 | 3.10 | 14.60 | 3.94 | 0.80 | 60 |
| Food Safety Exam | | | | | | | |
| Enrolled | 25 | 11.96 | 2.70 | 13.72 | 2.64 | 1.69 | 72 |
| Not Enrolled | 35 | 11.18 | 2.92 | 13.88 | 3.12 | 2.70 | 80 |
| Economic Impacts Exam | | | | | | | |
| Enrolled | 28 | 10.36 | 2.53 | 11.89 | 2.77 | 1.53 | 61 |
| Not Enrolled | 35 | 9.57 | 2.93 | 11.54 | 2.86 | 1.97 | 71 |
| Environmental Impacts Exam | | | | | | | |
| Enrolled | 27 | 7.59 | 2.00 | 9.67 | 2.72 | 2.08 | 78 |
| Not Enrolled | 34 | 7.53 | 2.23 | 9.21 | 2.90 | 1.68 | 59 |

On the distal exam, students enrolled in the Free or Reduced Lunch Program ($n$ = 17) displayed higher mean pretest and posttest scores than those not enrolled ($n$ = 15). They also displayed a greater increase in scores from pretest to posttest. A greater percentage of enrolled students ($n$ = 13) than those not enrolled ($n$ = 9) increased their score from pretest to posttest.

With regard to the Food Safety unit tests, students enrolled in the Free or Reduced Lunch program ($n$ = 25) displayed a mean pretest score higher than that of students not enrolled ($n$ = 35). However, those that were not enrolled displayed a greater mean score increase, which resulted in a greater mean score on the posttest when compared to that of enrolled students. Seventy-two percent of those enrolled in the free or reduced lunch program increased their score on the food safety test from pretest to posttest ($n$ = 18), while 80% of those not enrolled in the program displayed increased scores from pretest to posttest ($n$ = 28).

With regard to the Economic Impacts exam, students enrolled in the Free or Reduced Lunch program ($n$ = 28) displayed mean pretest and posttest scores higher than those of students that were not enrolled in the program ($n$ = 35). Enrolled students displayed a slightly higher increase in mean score from pretest to posttest than those that were not enrolled. Sixty-one percent of students enrolled in a free or reduced lunch program displayed a score increase between pretest and posttest ($n$ = 17), while 71% of those not enrolled in a program displayed a score increase from pretest to posttest ($n$ = 25).

Students enrolled in the free or reduced lunch program ($n$ = 27) displayed mean scores slightly higher than those of not enrolled students (n = 34) on the Environmental Impact exam. Enrolled students displayed a greater increase in mean score from pretest to posttest. Seventy-eight percent of those enrolled displayed an increase in test score from pretest to posttest ($n$ = 21), while 59% of those not en-

rolled in a program displayed a similar increase ($n = 20$).

**Content Knowledge based on Number of Completed Agricultural Education Classes**

This study sought to determine students' proximal and distal content knowledge following an SSI-based instructional unit based on students' number of completed agricultural education classes though Objective 4. Table 5 displays descriptive data for each exam by the number of agriculture classes students had completed. Because of the small *n* in this study, students were grouped together as completing one or two classes, or three or four classes.

Table 5

*Students' Mean Scores on Exams based on Number of Completed Agriculture Classes*

| Assessment & # of Classes | *n* | Pretest | | Posttest | | Mean Increase | % that increased score |
|---|---|---|---|---|---|---|---|
| | | *M* | SD | *M* | SD | | |
| Distal | | | | | | | |
| 1-2 | 28 | 14.48 | 2.85 | 16.00 | 4.26 | 1.52 | 71 |
| 3-4 | 3 | 10.00 | 3.63 | 11.67 | 4.85 | 1.57 | 33 |
| Food Safety | | | | | | | |
| 1-2 | 45 | 11.09 | 2.89 | 13.73 | 2.95 | 2.64 | 78 |
| 3-4 | 12 | 12.58 | 2.98 | 13.92 | 3.15 | 1.38 | 75 |
| Economic Impacts | | | | | | | |
| 1-2 | 47 | 9.74 | 3.10 | 11.28 | 2.74 | 1.54 | 60 |
| 3-4 | 14 | 10.64 | 2.95 | 13.14 | 2.87 | 2.5 | 93 |
| Environmental Impacts | | | | | | | |
| 1-2 | 46 | 7.43 | 2.28 | 9.33 | 2.81 | 1.9 | 65 |
| 3-4 | 12 | 7.75 | 2.23 | 9.00 | 2.87 | 1.25 | 67 |

Those who had completed one or two agriculture classes ($n = 28$) displayed considerably higher mean pretest and posttest scores on the distal exam than those who had completed 3-4 classes ($n = 3$). However, those with greater class experience displayed a slightly greater increase in mean score from pretest to posttest. Further, a greater percentage of students with more class experience (n = 1) increased their exam score from pretest to posttest, as compared to those with less class experience ($n = 20$).

Students who had completed one or two classes ($n = 45$) displayed lower mean pretest and posttest scores than those who had completed three or four classes ($n = 12$) on the Food Safety pretest. However, these less experienced students displayed a greater mean increase from pretest to posttest. Seventy-eight percent of students whom had completed one or two classes displayed an increase in scores from pretest to posttest ($n = 35$), while 75% of those with three or four completed classes displayed a similar score increase ($n = 9$).

Students with one or two completed agriculture classes ($n = 47$) displayed mean scores lower than those with three or four completed classes ($n = 14$) on both the pretest and posttest for the Economic Impacts unit. Students with more experience also displayed a greater mean score increase from pretest to posttest. Sixty percent of students who had completed one or two classes displayed an increase in scores from pretest to posttest ($n = 28$), while 93% of the students

who had completed three or four classes displayed a similar score increase ($n$ = 13).

Students who had completed one or two agriculture classes ($n$ = 46) displayed a lower mean pretest score than students who had completed three or four classes on the Environmental Impact unit assessment. However, these less experienced students had a greater mean increase from pretest to posttest, and displayed a higher mean posttest score than the more experienced students. Of the students who had one or two completed classes, 65% displayed score increases from pretest to posttest ($n$ = 30), while 67% of those with three or four completed classes displayed a score increase from pretest to posttest ($n$ = 8).

**Content Knowledge based on FFA Membership**

Objective 5 sought to determine students' proximal and distal content knowledge following an SSI-based instructional unit based on students' membership in the FFA. Table 6 displays descriptive data regarding FFA members' and nonmembers' scores on each exam.

Table 6

*Students' Scores on Exams based on FFA Membership*

| Assessment & Group | $n$ | Pretest | | Posttest | | Mean Increase | % that increased score |
|---|---|---|---|---|---|---|---|
| | | *M* | SD | *M* | SD | | |
| Distal | | | | | | | |
| Members | 25 | 14.08 | 3.24 | 15.04 | 4.25 | 0.96 | 64 |
| Nonmembers | 6 | 14.17 | 3.59 | 17.33 | 4.37 | 3.16 | 83 |
| Food Safety Exam | | | | | | | |
| Members | 35 | 11.03 | 2.70 | 13.34 | 2.94 | 2.31 | 74 |
| Nonmembers | 23 | 12.22 | 2.94 | 14.18 | 3.13 | 2.26 | 83 |
| Economic Impacts Exam | | | | | | | |
| Members | 37 | 9.65 | 2.44 | 11.57 | 2.73 | 2.02 | 78 |
| Nonmembers | 25 | 10.32 | 2.96 | 12.00 | 2.86 | 1.68 | 52 |
| Environmental Impacts Exam | | | | | | | |
| Members | 35 | 7.26 | 2.28 | 8.86 | 2.95 | 1.60 | 66 |
| Nonmembers | 24 | 7.96 | 2.26 | 10.04 | 2.91 | 2.08 | 67 |

On the distal exam, FFA members ($n$ = 25) displayed mean pretest and posttest scores lower than those of nonmembers ($n$ = 6). Nonmembers displayed a greater increase in mean score from pretest to posttest. Sixty-four percent of FFA members displayed a score increase from pretest to posttest ($n$ = 16), while 83% of nonmembers displayed a similar increase ($n$ = 5).

With regard to the Food Safety unit, FFA members ($n$ = 35) again displayed mean scores lower than those of nonmembers ($n$ = 23) on both the pretest and posttest. However, members displayed a slightly greater increase in mean score from pretest to posttest. Seventy-four percent of FFA members displayed an increase in score from pretest to posttest ($n$ = 26), while 83% of nonmembers displayed a score increase from pretest to posttest ($n$ = 19).

On the Economic Impacts exam, FFA members ($n$ = 37) displayed mean pretest and posttest scores lower than nonmembers ($n$ = 25). However, members displayed a greater increase in mean score from pretest to posttest. Seventy-eight percent of FFA members displayed a score

increase from pretest to posttest ($n$ = 29), while 52% of nonmembers displayed a similar score increase ($n$ = 13).

With regard to the Environmental Impacts unit tests, FFA members ($n$ = 35) once again displayed mean pretest and posttest scores lower than their nonmember classmates ($n$ = 24). Nonmembers displayed a greater increase in mean score from pretest to posttest. Similar percentages of students from both groups displayed score increases from pretest to posttest. Sixty-six percent of FFA members displayed score increases from pretest to posttest ($n$ = 23), while 67% of nonmembers displayed a similar score increase ($n$ = 16).

## Conclusions and Implications

The above findings yield numerous conclusions regarding the effectiveness of SSI-based instruction in impacting student learning. While these conclusions and accompanying implications and recommendations may prove useful in designing future studies and considering practices in SSI-based instruction, the limitations of this study prevent any meaningful or accurate generalizations to the broader population. Limitations of this study included the low number of teachers and students participating, the low number of teachers and students completing the study, inconsistent group sizes within each objective, confounding variables, such as student and teacher fatigue from a lengthy study, and potential strong relationships between variables, such as number of completed classes and grade level.

Objective 1 examined all students' performance on each of the exams. Students displayed an increase in mean score from pretest to posttest on each of the exams. Further, each exam resulted in over half of the students increasing their score from pretest to posttest. The maximum score earned on each exam increased as well. These findings provide confirmation of existing evidence supporting the use of SSI-based instruction in secondary education, as has been found in numerous studies conducted in science classrooms (Barab, et al., 2007; Klosterman & Sadler, 2011). These score increases imply that SSI-based instruction may be utilized as a method of increasing student learning in agricultural education. While this increased performance may display the potential for SSI-based instruction to positively impact student learning, student scores on pretests and posttests were less optimistic. Students displayed mean scores below 50% on each pretest, and while these mean scores increased, they only did so marginally; students' mean posttest scores were only slightly over 50% on three of the exams, and remained slightly under 50% on one exam. Further, the standard deviations did not consistently decrease among exams, indicating that the variance between student scores on specific exams increased. This increase in score variance implies that student learning was not consistent in certain units. These findings are supported by Ricketts, Duncan, and Peake (2006), who found that students enrolled in agriscience programs achieved to a lesser degree than college preparation students on a graduation test. Low student scores both before and after experiencing SSI-based instruction may be the result of external factors that impact student learning; these external factors may be presage variables that impact teacher actions or context variables that impact student performance, as have been identified by Dunkin and Biddle (1974).

Students displayed the lowest mean score increase on the distal exam. This result contradicts Klosterman and Sadler's (2011) findings which displayed a significant positive impact on distal content knowledge following an SSI-based instructional unit. However, Barab, et al.'s (2007) findings align with those of this study, concluding that SSI-based instruction was more impactful on proximal than on distal content knowledge. Students' knowledge gains were varied according to the content topic on which they were assessed. The greatest increase was displayed on the Food Safety exam, both on the pretest and posttest. The Food Safety exam also yielded the greatest mean increase and greatest percentage of students with an increased score. Students displayed the lowest pretest and posttest mean scores on the Environmental Impacts exam, but displayed the lowest mean score increase on the Economic Impacts exam. Dunkin & Biddle's model for the theory of classroom teaching (1974) cites student formative experiences as a factor impacting student knowledge

acquisition, which may provide some explanation for why students displayed varying levels of achievement on the three content areas in this study.

Objective 2 examined students' performance on each exam based on grade level. Both middle school and high school students displayed mean score increases from pretest to posttest on every exam, implying that SSI-based instruction can have a positive impact on student learning regardless of grade level. This finding is encouraging for agriculture teachers, as courses can have student rosters which combine many grade levels into one class. However, this study displayed how grade level may impact the degree to which students learn; high school students displayed a higher mean score increase than middle school students on each exam, and the amount of improvement on each proximal posttest increased with each exam. Middle school students did not display this same continual increase, implying that high school students may benefit from a longer duration of SSI-based instruction than middle school students. Both Sadler's (2011) framework for SSI-based instruction and the tenets of experiential learning (Kolb, 1984) include the duration of an experience as a factor impacting a learning setting; the difference between middle and high school students' performance on subsequent examinations found in this study may provide evidence of the impact on the duration of SSI-based instructional units on student learning at various levels.

Objective 3 assessed students' scores following the unit based on their enrollment in the free or reduced lunch program. Both groups displayed mean score increases on every exam, implying that SSI-based instruction may be useful in increasing learning regardless of student SES. Students enrolled in the program displayed higher mean scores on all pretests, a finding that stands in contrast to those of Cheek, et al. (1994). Students' performance also varied by group; those enrolled in the program displayed a higher mean score on the distal exam and the Environmental Impacts exam, while those not enrolled displayed higher mean scores on the Food Safety and Economic Impacts exam. Dunkin & Biddle (1974) cite pupil properties, such as SES, as factors that impact student learning, and the role of SSIs in consumer decisions may further impact how background knowledge associated with SES influences student achievement.

Objective 4 sought to examine the impact of SSI-based instruction on students' achievement based on the number of agriculture classes they had completed. Students in both groups (one or two, or three or four completed agriculture classes) displayed mean score increases on all exams, implying that SSI-based instruction can be useful in teaching students with differing levels agricultural knowledge. Students who had completed one or two agriculture classes performed higher on the distal pretest and posttest, as well displayed a higher mean score increase, and greater percentage of students displaying a score increase from pretest to posttest. This finding is inconsistent with those of Cheek, et al. (1994), who concluded that student achievement and number of experiences were positively correlated. However, students with three of four completed agriculture classes displayed higher pretest and posttest scores, a higher increased mean score, and a greater percentage increasing their score on the Economic Impacts exam. This finding may imply that certain topics are better grasped by students with more agricultural background knowledge, which could be supported by Cheek, et al. (1994).

Objective 5 examined student performance before and after an SSI-based instructional unit based on FFA membership. Findings showed that both members and nonmembers increased mean scores from pretest to posttest on all exams, implying that SSI-based instruction can be useful both in conjunction with and in the absence of the influence of FFA. However, nonmembers displayed higher mean pretest and posttest scores than members, which contrast the findings of Cheek, et al. (1994). These differing scores may imply that nonmembers are higher achieving students than members. However, the benefit of FFA involvement may warrant additional FFA recruitment; members displayed a higher increase in mean score on the Economic Impacts exam, implying that FFA experiences may help students learn specific topics.

## Recommendations

SSI-based instruction has been well-established as a useful instructional method in increasing student content knowledge in science education. As this study was the first cited evaluation of SSI-based instruction in agricultural education, the results of this study supporting its use further confirms previous research and provides an opportunity for agricultural educators to enhance their teaching methods. As with any introductory study, further research addressing the study's limitations and exploring its findings is recommended. The findings displayed here imply that teachers should continue to seek methods of improving student learning in order to help them reach a level of mastery. SSI-based instruction may provide an opportunity to improve student learning, but the results of this study imply that alteration of current practices in SSI-based instruction may be warranted. Follow up studies can help agricultural educators gain a better understanding of how teacher variables, student variables, and factors of SSIs and their associated learning experiences can impact student learning during SSI-based instruction in agricultural education. Teacher variables such as previous education, training in SSI-based instruction and associated teaching methods, and experience with the SSI should be examined as factors that could influence the impact of SSI-based instruction on student learning. This study also warrants further examination of student variables, including SES, experience in agricultural education, and FFA involvement. Duration of the SSI unit, number and order of lessons, specific SSIs, and activities included in the lesson can also impact student exam scores, and should therefore be subject to further study.

The findings presented in this study also yield some tentative recommendations to agricultural educators. Both this study and others (Barab et al., 2007) concluded that student achievement can vary based on the distance between content introduction and assessment, both conceptually and during the school year. Agricultural educators should work with preservice and inservice teachers to incorporate methods of transferring knowledge from short-term acquisition to more long-term acquisition. Further, these findings support Sadler's (2011) recommendation of the selection of an appropriate SSI, but clarify that recommendation to include the selection of appropriate aspects of SSIs as well, since students learned at varying degrees according to the Food Safety, Economic Impacts, and Environmental Impacts aspects of cultured meat. Also to be considered when selecting appropriate SSI aspects on which to focus are student factors, such as SES, experience and knowledge in agricultural education, and involvement in FFA, as student scores varied for each SES aspect according to these factors. While further study should be conducted in this area before prescriptive recommendations can be made, the findings of this study support careful consideration of student backgrounds and experiences when selecting appropriate SSIs and accompanying SSI aspects.

Finally, this study led to recommendations regarding FFA recruitment. The benefits of FFA involvement in learning specific aspects of SSI-based units found in this study warrant the incorporation of FFA into SSI-based instruction in agricultural education. In order to maximize its benefits, additional recruitment efforts should be directed toward higher achieving students in agriculture classes, as nonmembers in this study displayed higher mean scores in every area.

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