

Effects of Inquiry–based Agriscience Instruction on Student Scientific Reasoning

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The purpose of this study was to determine the effect of inquiry–based agriscience instruction on student scientific reasoning. Scientific reasoning is defined as the use of the scientific method, inductive, and deductive reasoning to develop and test hypothesis. Developing scientific reasoning skills can provide learners with a connection to the scientific process by creating knowledge through evidence–based or authentic investigations. Higher reasoning scores indicate the learners’ ability to change a nonscientific belief based on factual evidence. This quasi–experimental study investigated the effect of two teaching methods (inquiry–based instruction and the subject matter approach) on agriscience student scientific reasoning. Fifteen agriscience education classes confined within seven secondary schools across the United States participated in the study. Utilizing univariate analysis of covariance, there was a statistically significant difference between groups based on scientific reasoning. Those students taught through inquiry–based instruction were reported as having higher scientific reasoning than students taught through the subject matter approach.

Keywords: inquiry–based, agriscience, scientific reasoning

Introduction/Literature Review

President Obama’s administration stated a revamped focus of No Child Left Behind (NCLB) that would replace current “inadequate assessments” and adjust “support [for] schools to gain improvement [on assessments], rather than punish those for not improving” scores in science, math, and reading (Obama, 2007). Arne Duncan, United States Secretary of Education stated, “I ask you to join President Obama and me in a new commitment to results that recognizes and rewards success in the classroom...” (Duncan, 2009, p.1). National trends in student science achievement have differed from the gains in math and reading. The stagnant and lowering scores in science achievement have caused concern through the nation (USDE, 2009). Continued efforts to provide research–based evidence have produced research in the areas of teaching and learning with experimental designs based on standardized

testing (Anderson, 2002). In response, the National Research Council (NRC) has pushed for greater hands–on focus in science and inquiry–based instruction (NRC, 1996; 2000). However, a continuous focus on assessments and teaching to cover material as prompted by NCLB, “teaching for the test” can derail science education and shift focus away from “teaching higher–order thinking, amount of time spent on complex assignments, and in the actual amount of high cognitive content in the curriculum” (Valli, 2008, paragraph 6). Lederman (1998) argued less is more, and focusing on in–depth understanding unifies scientific concepts and leads to greater success on achievement exams.

The NRC explained that students benefit by learning science through authentic investigations similar to those conducted by professional scientists. In theory, with the placement of science in a context through inquiry–based instruction, teachers and students begin to develop their approach to science, and this investigative learning leads to greater

understanding (NRC, 2000). The NRC reports and Project 2061 led to the reinvention of the inquiry philosophy and increased interest in the United States educational system in search of producing learners with the ability to apply scientific process skills and to think critically. Inquiry-based instruction continues to focus on the ability to explain the process examined in the development of learner answers (Keil, Haney, Zoffel, 2009). Furthermore, new teaching methods or reinvented ways of instruction must meet the double standard of creating higher student standardized test scores and develop student achievement of high-order thinking. The USDE (2009) stated, "America's teachers must use only research-based teaching methods and the schools must reject unproven fads" (para. 13). Myers (2004) stated agriscience students should exhibit a working knowledge and foundation of science concepts and processes to be successful in the industry and to perform well on achievement tests.

Standardized tests and traditional lecture-based teaching are creating learners that lack the ability to develop arguments with adequate evidence (Baron 1991; Cerbin, 1988; Perkins, Farady, & Bushey, 1991). Learners are now less likely to link evidence with claims (Kuhn, 1992; 1993; Shaw, 1996). Nonetheless, all 50 states have adopted a variety of testing and accountability programs (Council of Chief State School Officers, 2002) based on standardized tests. An examination of these characteristics together led to the NRC (1998) conclusion that learners are not being effectively prepared for postsecondary education or workplace careers.

The acquisition of scientific reasoning does not call for a lack of focus on content knowledge. Means and Voss (1996) stated that reasoning skills and content knowledge are related. As a larger part of this study Thoron and Myers (2011) found students, taught through inquiry-based instruction, scored significantly higher on content knowledge assessments when compared to the subject matter approach. Current teaching methods are not satisfying the needs of individuals entering careers in agriculture, attending major universities, or pursuing other postsecondary education endeavors (NRC, 1998). The NRC (2000) stated that inquiry-based instruction is the optimal tool

to provide students with the ability to transfer knowledge to real-world applications. Educators must focus on creating learners who can think their way through a real-life problem, engage in the curriculum, and ask questions of their peers to expand thinking beyond the context of what they were taught to remember in high school. Continued progress to provide evidence that agriculture contains science in secondary classrooms across the nation must be supported by emerging research that calls attention to this matter. Odden (1991) stated all electives should provide evidence of contributing to the core academics. As agriscience education integrates more science concepts, the teaching methods utilized in science education need to be investigated. This led to the examination of a teaching methodology that will promote higher standardized test scores and scientific reasoning in an agriscience context.

Scientific reasoning (SR) is the connection of the process of producing scientific knowledge through evidence-based reasoning. Scientific reasoning is generally recognized as inductive or deductive. Deductive reasoning has roots back to Aristotle with the creation of prediction and outcome basis. Inductive reasoning was developed by Sir Fances Bacon. Inductive reasoning utilizes evidence to create theories. The best form of SR has been studied in science education research (Schen, 2007), and few studies utilize both inductive and deductive reasoning in the same study (Kuhn & Pearsall, 2000). This study utilizes both deductive and inductive reasoning through the use of Lawson's Classroom Test of Scientific Reasoning (LCTSR). Lawson (1982) identified five factors involved in advancing Piaget's formal reasoning during his scientific reasoning test. Lawson stated that students must generate expectations, control variables, generate causes, determine probabilistic reasoning, and determine proportional reasoning when the goal is advancing scientific reasoning.

Lawson's first scientific reasoning test was completed through a short answer essay type exam, but because of the emphasis on high-stakes testing, he created a multiple-choice test (Lawson, 1992). Schen (2007) utilized this exam with inquiry-based instruction in university introductory biology courses and noted that

reasoning ability was determined and not prior knowledge. Schen's study indicated a positive correlation between achievement scores and reasoning.

Lawson and Weser (1990) investigated the stability of nonscientific beliefs of evolution throughout the semester and its relationship to student levels of reasoning ability. Lawson and Weser hypothesized students with a higher reasoning ability would change their nonscientific beliefs based on the scientific evidence presented. The researchers found that students' nonscientific beliefs had a positive correlation with the evidence presented. The researchers also found that students who had a higher scientific reasoning score changed their nonscientific beliefs the most, which led Lawson and Weser to conclude that skilled learners were better able to adapt their nonscientific beliefs to scientific beliefs.

Lawson, Alkhoury, Benford, Clark, and Falconer (2000) studied college students using the LCTSR by changing the difficulty of the hypothesis presented during quizzes. Lawson et al. found higher level reasoners were better able to transfer problems on an exam. Lawson et al. (2000) conducted a similar study and found the same results. The authors concluded that the greater proficiency in the LCTSR, the greater proficiency in answering questions on achievement exams.

In a study of mathematics instruction, Davis (1990), videotaped two fifth-grade boys solving a problem with pizza slices. After they discussed the problem, sketched the solution, and used pattern blocks they were able to determine the correct answer. Earlier, one boy tried to simply use a paper and pencil method and arrived at an incorrect answer. At the completion of the boy's problem-solving of the pizza slices their teacher was not satisfied with the way they solved the problem. She then directed the students to solve the pizza problem through an easier solution. One year later Davis gave the same boys the same problem and again videotaped the boys creating their solution independently. Each boy indicated he remembered solving the problem and recalled the teacher directing him to an easier method to find the correct answer. However, they could not remember how the teacher solved the problem. Each boy then

solved the pizza problem with his own method based on prior experience. Davis stated that the teacher's solution had no bearing over time. Davis' study illustrated that constructivist theory and inquiry-based instruction seek a deeper understanding and incorporate learning and knowing to develop students who can revisit a similar problem years later and have the ability to use previous experience to obtain successful results (NRC, 2000). In summary, the LCTSR has shown a connection to higher achievement scores. However, there are few studies that examine the development of scientific reasoning through comparing teaching methods.

Theoretical/Conceptual Framework

Constructivism was the guiding philosophical perspective used in this study. The constructivist approach to teaching and learning has been highlighted in research and in practice in numerous educational contexts (Bransford, Brown, & Cocking, 2000; Hamlin, 1992; Lampert, 1992; Myers & Dyer, 2006; Newcomb, McCracken, & Warmbrod, 1993; NRC, 2000; Phipps, Osborne, Dyer, & Ball, 2008; Schunk, 2004). Schunk stated, "...the rise of constructivism has been theory and research in human development, especially the theories of Piaget and Vygotsky" (p. 285). Piaget's (1972) *Theory of Cognitive Development* and Vygotsky's (1978) *Sociocultural Theory* (1978) combined to form the theoretical basis for the study from a constructivist philosophical perspective.

Piaget's (1972) *Theory of Cognitive Development* depends on biological maturation, experience with the physical environment, experience with the social environment, and equilibration. Biological maturation is the factor of a learner maturing with age, experience with the physical environment refers to the learners' interaction and experience within a given learning situation, experience with the social environment refers to the learners' interaction between peer learners and instructors, and equilibration refers to an adaptation between cognitive structures and the environment (Duncan, 1995). Piaget proposed that learners organize their knowledge into schemes and process learning through adapting these schemes

to interpret new experiences. When learners encounter new experiences they attempt to understand by assimilating the new experience into a previous knowledge schema to reach a point of cognitive equilibrium (Phillips, et al., 2008).

Piaget's (1972) theory is accepted to describe the constructivist theory through the belief that people learn by interacting with their environment, peer learners, and instructors, and by transforming those experiences into their schema through assimilation (Phipps, et al., 2008). Constructivism is rooted in the learners' view that interacts with their previous experiences, environment, and people (Fosnot, 1996).

Vygotsky's (1978) Sociocultural Theory is a foundational theory of constructivism that focuses on the social environment as a facilitating portion of learning. Vygotsky argued that humans have the ability to alter their environment for their own purposes (Schunk, 2004) through language and social interaction (Tudge & Scrimsher, 2003). Vygotsky's theory stresses the interaction of interpersonal skills that create meaningful learning and stimulate development of cognitive growth through a context (Schunk, 2004). Meece (2002) suggested that Vygotsky's theory places social interactions in a pivotal role in knowledge construction.

Social interactions may come in the form as student-to-student interactions, teacher-to-student interactions, and student to teacher interactions. In this study, assistance in cognitive development is provided by the agriscience teacher.

Vygotsky's (1978) Sociocultural Theory provides a framework for the constructivist portion of this study. The theory provides a foundation for social learning between individuals in the classroom environment, learning in a context, and the teacher in assuming a facilitating role for the learners. Piaget's theory has similar implications and helps the richness of constructivism through the acknowledgement of learners' experiences and the learners' ability to adopt and adapt new knowledge into their schema.

The model for this study (Figure 1) depicts the interactions that occur in an inquiry-based classroom. Because this study is part of a larger study, there was more than one outcome investigated. Static attributes were variables that would be collected during the investigation, and the teaching and learning process describe the inquiry-based process.

Theoretical Model for the Effects of Inquiry-based Instruction

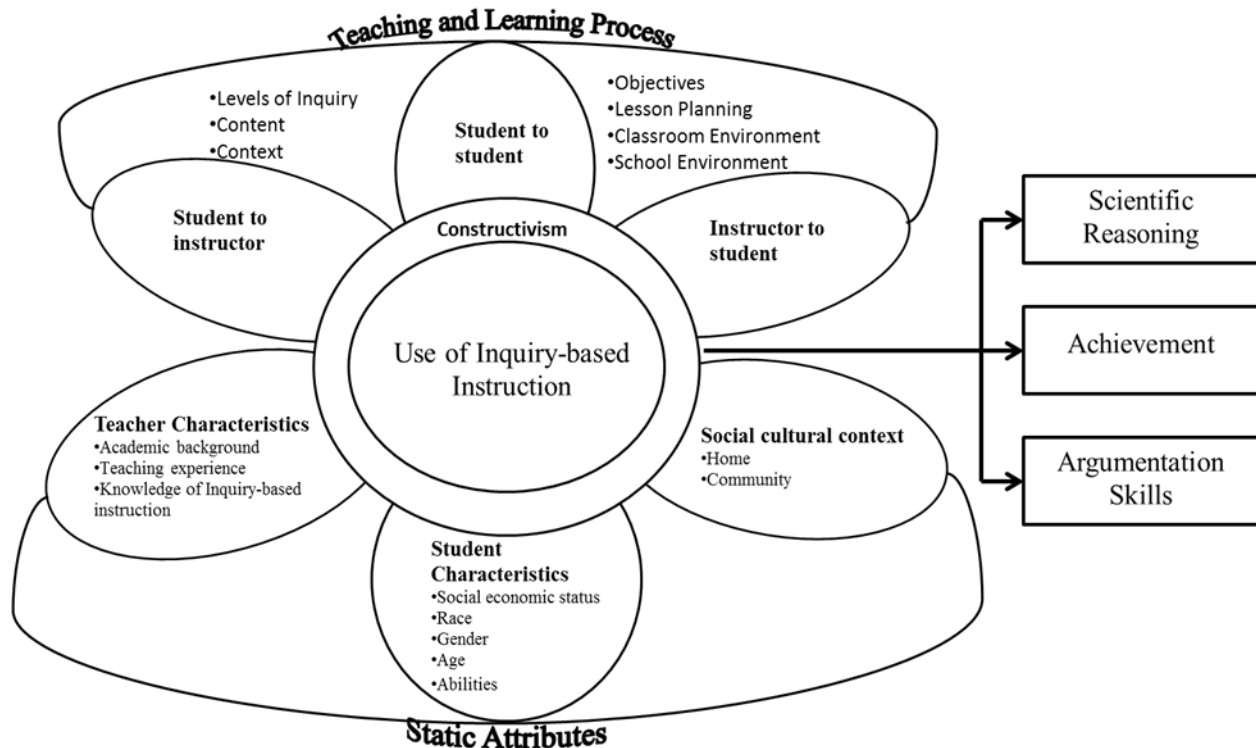


Figure 1. Conceptual model for the effects of inquiry-based instruction.

Purpose/Objectives/Hypotheses

The purpose of this study was to determine the effects of teaching method on scientific reasoning of high school agriscience students. The specific objectives guiding the study were to:

1. Describe the population of the study.
2. Ascertain the effects of inquiry-based instruction on scientific reasoning of high school agriscience students.
3. Examine the relationship between scientific reasoning, ethnicity, sex, year in school, and socio-economic status of high school agriscience students.

The null hypothesis, H_0 : no significant difference in student scientific reasoning based upon the teaching method (inquiry-based

teaching or subject matter approach), guided the analysis of the second objective.

Methods

The population of this quasi-experimental design was composed of students at ten high schools offering agriscience education in the United States ($N = 437$). The accessible population was students of the National Agriscience Teacher Ambassador Academy (NATAA) participants. A purposive sample was selected according to the ability of the teacher to utilize the integrated agriscience curriculum and inquiry-based instruction and subject matter approach to teaching.

The content and context of the lessons for both the subject-matter and inquiry-based lessons were deemed appropriate by a panel of experts. Seven units of instruction that addressed the soil and plant science portion of the National

Agriscience Content Standards for an agriscience course in the United States (CAERT, 2008) were selected by the researcher from the Animal, Plant, and Soil Science curriculum developed by Center for Agricultural and Environmental Research and Training, Inc. (CAERT). The instructional plans were evaluated for content validity by a panel of experts from the Agricultural Education and Communication Department and the School of Teaching and Learning at the University of Florida. The panel determined that the inquiry-based and subject matter lessons were suitable for the grade levels and deemed the lessons appropriate.

The independent variable in this study was the teaching method used in the agriscience classes. Intact treatment groups were randomly selected to receive either inquiry-based instruction or the subject matter approach to learning. The dependent variable in this study was students' level of scientific reasoning. The greatest threat in this design type is that the differences found in the posttest are due to preexisting group differences, rather than due to the treatment (Gall, Borg, & Gall, 1996). The use of multiple classroom settings in this study reduced the risk of interaction of subjects, and the use of pretests of content knowledge addressed these concerns.

To ensure that teachers involved in this study were exhibiting the correct teaching methodology, teachers were asked to audiotape each class period during the duration of the study. The Science Teaching Inquiry Rubric (STIR) (Bodzin & Cates, 2002) was used to analyze the level of inquiry-based instruction. The STIR has been reported to have an overall correlation of $r = .58$ with a perfect correlation between two raters of $r = 1.00$, establishing the STIR as an effective analysis tool (Bodzin & Beerer, 2003). The researcher determined *a priori*, based on a study conducted by Thoron and Myers (2010), that students missing more than 25% of the instructional time during the study would be removed. Additionally, students that did not receive the treatment effectively would be removed from the sample.

All students were administered a pretest to establish a base line before each of the seven replications to measure content knowledge

levels in the subject matter to be taught (soil and plant science). All sections were taught the same content by the same teacher and according to their randomly assigned group were taught one of the two teaching methods (inquiry or Subject-matter) the entire twelve weeks. Pretest instruments were developed by the researcher using content knowledge questions in the form of multiple choice items. The instruments contained a specific number of questions based on the determined percentage of time to be spent teaching each objective of the unit. The testing instruments were validated by a panel of agriscience education and inquiry education experts. Prior to the study, a coefficient alpha for the dichotomous data of the content knowledge achievement exams was calculated through a pilot test to assess reliability of the instruments (Campbell & Stanley, 1963). Reliability coefficients for the content knowledge achievement instruments were calculated using Kuder-Richardson 20 (KR20) for dichotomous data (Gall et al., 1996). The seven instruments were determined to have a coefficient alpha of: .94, .93, .91, .86, .87, .89, and .91 respectively. As such, each instrument was considered reliable.

Lawson's Classroom Test of Scientific Reasoning (LCTSR) (Lawson, 1992) was used to assess scientific reasoning. The LCTSR is considered a reliable and valid instrument that measures levels of formal-operational scientific reasoning in secondary and college-age students. LCTSR is designed to assess scientific reasoning; therefore the instrument requires as little reading and writing as possible. Students are asked questions at Bloom's (1956) cognitive behavior levels of analysis, synthesis, and evaluation. Lawson (1978) stated that the LCTSR measures the learner's ".analysis of possible causal factors (combinatorial reasoning), the weighing of confirming and disconfirming cases (correlational reasoning), the recognition of the probabilistic nature of phenomena (probabilistic reasoning), and the eventual establishment of functional relationships between variables (proportional reasoning)" (p. 12).

The validity of the LCTSR was established by six experts in the area of Piagetian research who unanimously agreed that the test requires

concrete and formal reasoning. In addition, a Cronbach Alpha reliability coefficient of .86 was reported by the developer of the instrument. The Kuder–Richardson 20 reliability estimate for grade levels 8, 9, and 10 was reported as .78 (Lawson, 1978).

Findings

This study is part of a larger study conducted by the researcher. The results address the objectives and hypothesis of the study in determining the influence of teaching method, sex, ethnicity, social economic status, and year in school on student scientific reasoning. Objective one sought to describe the population of the study. The total group consisted of $N = 437$ students from ten different schools across the United States. Three teachers opted out of the study noting health related issues or teaching reassignment. As a result of teachers being unable to deliver instruction, 109 students were removed from the study. Twenty–three students were removed from the study due to missing 25% or more of instruction.

Audio recordings of the administered units were scored using the STIR rubric (Bodzin & Cates, 2002) to determine the level of inquiry investigation by students in the inquiry–based treatment group and that inquiry was not being delivered in the traditional treatment group. It was determined that all seven teachers effectively delivered inquiry–based and subject matter instruction. After removal of participants unable to complete the study and students missing more than 25% of the instructional time, the original sample was reduced to $n = 305$. This equates to a 30.21% mortality rate for this study. Previous experimental studies in agricultural education using intact classes reported similar or higher mortality rates (Boone, 1988; Dyer, 1995; Flowers, 1986; Myers, 2004) and Jurs and Glass (1971) described mortality rates may be as high as 50%.

Participant ethnicity was categorized into the groups of White (non–Hispanic) ($n = 249$, 81.6%), Black ($n = 13$, 4.3%), Hispanic ($n = 31$, 10.2%), and Other ($n = 12$, 3.9%). The ethnicity of each of the treatments was similar to the

ethnicity of the entire sample. The majority of the participants in this study (58.0%) were male. The treatment groups were similar to each other as inquiry–based instruction contained 57.6% male and subject matter (SM) contained 58.5% male participants. Inquiry–based instruction yielded 170 participants and subject matter contained 135 students.

Of the 305 participants who reported grade level data, 48.5% ($n = 148$) were in the ninth grade. The remainder of the participants were either in tenth grade ($n = 134$, 44.0%), or eleventh grade ($n = 23$, 7.5%). There were no twelfth–grade students in the study. Grade level distribution by treatment groups varied little from that of the overall sample. Slightly more than 50% of the students in the inquiry–based group were in the ninth grade as compared to approximately 45% in the subject matter group. Treatment groups were similar in terms of grade level.

Socio–economic status (SES) was determined by eligibility to participate in the national free and reduced school lunch program (Stone & Lane, 2003). Therefore, SES was categorized in the groups of non–eligibility to participate, eligibility to receive reduced lunch, and eligibility to receive free lunch. The majority of the students participating in this study ($n = 221$, 72.5%) were not eligible to participate in the national school lunch program with 16.7% ($n = 51$) eligible to receive a reduced price in the school lunch program and the remainder ($n = 33$), 10.8% eligible to receive free lunch. Treatment groups were similar in terms of SES.

Objective two sought to ascertain the effects of inquiry–based instruction on scientific reasoning of high school agriscience students. Each student’s content knowledge achievement was determined using the researcher–developed content knowledge achievement instruments. The maximum possible score on these instruments was 100. Pretest data were collected from 305 participants (100%). Inquiry–based instruction treatment group achieved similar mean content knowledge pretest scores and similar standard deviations as the subject matter treatment group (see Table 1).

Table 1
Participant Mean Pretest Scores (n = 305)

Content Knowledge Instrument	Treatment Group				Difference	
	IBI		SM		M	SD
	M	SD	M	SD		
1	35.57	11.68	36.64	12.80	1.07	1.12
2	35.72	12.78	36.09	14.20	.37	1.42
3	31.20	11.06	31.79	12.40	.59	1.34
4	36.19	13.88	35.17	12.96	1.02	.92
5	35.82	11.89	35.97	12.77	.15	.88
6	33.72	13.78	35.02	13.83	1.30	.05
7	29.27	11.74	30.07	12.75	.87	1.01

Note. IBI = Inquiry-based instruction; SM = Subject Matter

The LCTSR was used to determine the scientific reasoning of students following the treatments (subject matter and inquiry-based instruction). The LCTSR score of the participants was measured post-treatment using the LCTSR intact. The response rate for the scientific reasoning test was 93.4%. The overall mean score of the LCTSR was 36.77 (SD = 14.36) of a possible 100 (see Table 2). The mean LCTSR score was higher for the inquiry-based instruction (M = 41.44, SD = 14.18) than for subject matter instruction.

Objective three sought to examine the relationship between scientific reasoning, ethnicity, sex, year in school, and socio-

economic status of high school agriscience students. Prior to any inferential analysis of the data, all variables were examined for correlations. For the purpose of discussion, the terminology proposed by Davis (1971) was used to indicate the magnitude of the correlations. Pearson Product Moment correlations were used to determine the relationships between the variables (see Table 3). Negligible correlations between all variables were found with the exception of the correlation between treatment and LCTSR score. The relationship between the LCTSR score and treatment $r = -.37$ was found to be moderate.

Table 2
Participant Mean Scientific Reasoning Scores

Instrument	Treatment Group				Difference (n = 285)	
	IBI (n = 159)		SM (n = 126)		M	SD
	M	SD	M	SD		
LCTSR	41.44	14.18	30.90	12.31	10.54	1.87

Note. IBI = Inquiry-based instruction; SM = Subject Matter; LCTSR = Lawson's Classroom Test of Scientific Reasoning

Table 3
Correlations Between Variables

Variable	1	2	3	4	5	6
1. LCTSR Score	—	.03	-.02	.01	.02	-.37
2. Grade		—	-.03	-.04	-.06	.04
3. Sex			—	.03	.11	-.01
4. Ethnicity				—	.05	.01
5. SES					—	-.05
6. Treatment						—

Note. Treatment = Teaching method utilized

The null hypotheses states there is no significant difference in scientific reasoning based on teaching method. Students' scientific reasoning score was determined by the LCTSR (Lawson, 1992). Students that were taught through inquiry-based instruction achieved a higher mean scientific reasoning score ($M = 41.44$) than students taught using the subject

matter approach. The univariate analysis of covariance [$F(8,496) = 46.34, p \leq .001$] revealed significant differences in scientific reasoning at the alpha level of .05 between students taught by the two teaching methods (see Table 4). Based upon these findings, the null hypothesis of no significant difference in student scientific reasoning between the two groups was rejected.

Table 4
Univariate Analysis of Treatment Effects for Scientific Reasoning

Source	Df	F	p
LCTSR	2	46.34	$\leq .001$

Note. LCTSR = Lawson's Classroom Test of Scientific Reasoning

Conclusions

Based on the results of this study there are three conclusions.

1. *Demographics:* A majority (81.6%) of the students involved in this study were White, non-Hispanic. The majority (58%) of the students in the study were male. Nearly half (48.5%) of the students were in the ninth grade. The second largest grade level represented was the tenth grade (44%) followed by the remainder of the sample in the eleventh grade (7.5%). A majority of the students participating in the study did not qualify for free or reduced lunch programs (72.5%), while just over one-quarter of the students were in a lower socioeconomic group. There were negligible variations across all the demographics for inquiry-based and subject matter treatment groups.

2. *Relationships of variables:* Student demographic variables reported low to negligible relationships with scientific reasoning and treatment. However, treatment and scientific reasoning had a moderate relationship. Based on the findings, the moderate relationship between the treatment and scientific reasoning concludes that treatment has an effect on the students' level of scientific reasoning. It is also concluded that due to the fact that little to no relationship between other variables except the treatment group and scientific reasoning that any differences in students' scientific reasoning ability would be largely attributed to the type of treatment.

3. *Students' scientific reasoning ability:* Student scientific reasoning was determined through Lawson's (1992) Classroom Test of Scientific Reasoning. Students taught using inquiry-based instruction achieved a higher mean LCTSR score ($M = 41.44$) than

students taught through the subject matter approach ($M = 30.90$). The univariate analysis of covariance revealed significant differences in scientific reasoning ability at the alpha level of .05 between students taught by the inquiry-based instruction and subject matter approach, $F(8,496) = 46.34$, $p \leq .001$. Based upon these findings, the null hypothesis of no significant difference in student scientific reasoning between the two groups was rejected.

Discussion/Implications

The finding that inquiry-based instruction (IBI) students achieved higher scientific reasoning scores than their counterparts learning through the subject matter (SM) approach is supportive of IBI containing multiple dimensions of teaching and learning and leading learners to think critically as they continue to focus on the ability to explain the process examined (Keil, Haney, & Zoffel, 2009). Scientific reasoning (SR) is the connection of the process of producing scientific knowledge through evidence-based reasoning (Schen, 2007). Lawson (1992) indicated students with a higher SR score changed their nonscientific beliefs the most. Developing students in agriculture and consumers with a higher scientific reasoning ability may lead to a society that considers factual evidence when making societal decisions.

A continued need exists for all elective subjects, including agriculture, to demonstrate value and contributions to student achievement in core subjects such as science (Odden, 1991). Myers (2004) noted studies have shown that agriscience students are more successful in science courses than students not enrolled in agriscience education. One could purport an expanded effort must be conducted by all elective subjects to document the contributions to student achievement in the areas of math, reading, and science. Results that increase SR through effective teaching in the context of agriculture place the agriscience profession to become integral to the local school-based curriculum.

This study found agreement with Means and Voss (1996) that stated reasoning skills and

content knowledge are related. Students taught through IBI scored significantly higher on content knowledge exams and scientific reasoning (Thoron & Myers, 2011). This study found a moderate relationship between the method used and the scientific reasoning score. The acquisition of scientific reasoning does not call for a lack of focus on content knowledge. The NRC (2000) stated that inquiry-based instruction is a tool to provide students with the ability to transfer knowledge and this study indicated students can transfer IBI into higher scientific reasoning. The combination of Piaget's (1972) theory of Cognitive Development and Vygotsky's (1978) Sociocultural Theory created an interactive environment that allowed for adapting schemes through constructivism, resulting in a richness of knowledge based on scientific reasoning.

Recommendations

This study provides evidence of the effectiveness of inquiry-based instruction for school based agriscience education across the United States. Teacher educators will find the study useful in the selection of teaching methods. The results of this entire study could assist agricultural educators by identifying the key components to adapting curricula to inquiry-based instruction and the role that quality professional development has on scientific reasoning in agriscience. Based on the conclusions of this study, the following recommendations were made for teacher educators, curriculum developers, and practitioners in secondary school education:

1. Based on the finding that inquiry-based instruction is an effective method to deliver agriscience at the secondary school level, teacher educators should model inquiry-based instruction and provide practice in their preservice program.
2. Teacher educators should provide direct instruction for the development of higher scientific reasoning and argumentation skills in their preservice program and provide professional development for in-service teachers.

3. Agriscience courses should include direct instruction on argumentation skills and scientific reasoning.

Recommendations for Further Research

This study provides conclusions regarding its objectives and hypothesis, the study also developed recommendations for further research, including:

1. More experimental studies are needed in agricultural education investigating the most effective methods to teach agriscience education. Replication of this study involving a different group of teachers and

different content focus will add to the body of knowledge for the profession.

2. Replication of this study comparing inquiry-based instruction with other teaching methods may provide insight into how to best teach agriscience.
3. The social cultural context (home and community) and its effects on student content scientific reasoning is warranted.
4. This study did not gather data on teacher perceptions of the two teaching methods under investigation. Further research should be conducted to determine the teachers' perceptions and experiences of utilizing the teaching methods under investigation.

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