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Effects of Inquiry–based Agriscience Instruction on Student Achievement

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Testing to build research–based evidence to support teaching methodologies that promote student learning has become increasingly important in a standards–based educational system in the United States. One challenge is the lack of studies that support specific methodologies so teachers and administers can make professional development and curricular decisions. This quasi–experimental study investigated the effect of two teaching methods on student content knowledge achievement. Inquiry–based instruction was compared to the subject matter approach in 15 agriscience education classes found within seven different secondary schools across the United States. Utilizing student pretest score as a covariate, there was a statistically significant difference between groups on the posttest. Those students taught through inquiry–based instruction were reported as having higher content knowledge achievement than students taught through the subject matter approach.

Keywords: agriscience, inquiry, inquiry–based, quasi–experimental, student achievement

Introduction

National trends of student achievement in the United States have been recorded by the federal government through the National Center for Education Statistics (NCES) since 1969. The NCES assesses students in the areas of science, math, and reading at ages 9, 13, and 17. Throughout the 1970s the NCES reported declining scores in each area that led to a renewed focus on academics through what was referred to as a back–to–the–basics approach. The back–to–the–basics agenda progressed through the 1980s (NCES, 2000). In response to *A Nation at Risk* (NCEE, 1983), secondary schools adopted higher graduation requirements in the areas of English, math and science. Progression of student–driven achievement during the 1990s led to the establishment of academic standards and goals, and the NCES (2000) reported stable performance in the science and math subjects and modest gains in reading for all learners. In the early twenty–first century, No Child Left Behind (NCLB) legislation was passed and has remained a driving factor in measuring student achievement (USDE, 2009). Math and reading scores continue to increase among children, and achievement gaps show trends of closing across race and gender (NCES, 2008). Meanwhile science achievement has become stagnant and has even declined since 1996 (USDE, 2009). In 2000, 82% of the nation's 12th graders performed below the proficient level on the NAEP science assessment. According to the International Mathematics & Science Study, "the longer students stay in the current system the worse they do" (USDE, 2009, paragraph 3).

The USDE (2009) has called for scientific studies that prove the best ways to teach science and have indicated America's teachers must use only research–supported teaching methods. 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). Previous studies conducted that compared teaching methodologies in the agricultural education profession have reported mixed results. Boone (1990), Dyer (1995), Enderlin and Osborne (1992), Flowers (1986), Myers (2004), and Roegge and Russell (1990) all reported either low student achievement scores or inconsistent treatment effects from their studies, leading to mixed findings.

The National Research Council (NRC) reports (1996; 2000) called for inquiry–based methods that led to current reforms and an increased emphasis on inquiry in science curricula. Inquiry has been identified as a teaching and learning method that provides learners with motivation to learn and develop skills to be successful throughout life (Dewey, 1910; Lederman, 1998). 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 National Research Agenda (NRA) (Osborne, 2007) for agricultural education addressed the call by the NRC and outlined areas of research importance. The NRA's fifth research priority area in the section of agricultural education in schools is to "determine the effects of agricultural instruction" (p. 21). When enhancing agricultural education programs and student achievement and performance, the goals of science education must be considered. Improved programs and student achievement will allow agriscience classrooms to implement curricula that are better suited for changing student needs.

Common ground exists between agricultural education and science education in addition to enhanced student science achievement. Student enrollment in agriscience courses provides an additional science–based course. Agricultural classes commonly receive science credit toward high school graduation (Connors & Elliot, 1995; Thoron & Myers, 2008). Thompson (1998) studied the results of agriscience in public schools and concluded that the integration of science will "academically strengthen vocational courses and make academic courses more relevant" (p. 77). 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). Studies have shown that agriscience students are more successful in state science exams than students not enrolled in agriscience education (Conners & Elliot 1995; Chiasson & Burnett 2001).

Traditional teaching methods are not satisfying the needs of individuals entering careers in agriculture, attending major universities, or pursuing other postsecondary education endeavors (NRC, 1996, 2009). 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. 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. As agriscience education highlights its science concepts, the teaching methods utilized in science education need to be investigated. The problem investigated in this study was the continuing lag in student science achievement scores (USDE, 2009) by secondary school students in the United States. There remains a need to determine if and how secondary agricultural education programs can help address this national concern.

Theoretical/Conceptual Framework

Figure 1 depicts the conceptual model used to guide this study and explain inquiry–based instruction. The model represents the interactions taking place in an inquiry–based classroom. There is a significant amount of student–to–student interaction during inquiry–based instruction (IBI). Students will draw upon each other's experiences during the inquiry. There is also the social and cultural context that occurs during inquiry–based instruction. When using IBI learners will develop a better understating of how to communicate with peer learners who have a different background than theirs (NRC, 2000). The social–cultural interactions that students have during this teaching method may lead to better communication skill sets and appreciation for different opinions.

Inquiry–based instruction promotes student–to–teacher contact. As in many cases, the teacher will act as the facilitator and aid the learners' thinking, thus explaining the instructor–to–student role seen in Figure 1. Another portion of the model is teacher preparation, skill, and knowledge. During inquiry–based instruction the teacher does not need to be aware of all the potentially correct answers. The teacher does need to facilitate learning, have a strong foundation, and know where to guide students to

find the required information during their inquiry (NRC, 2000). Finally, a goal of the study was to utilize all interactions of inquiry–based instruction of the model and measure the effectiveness of the inquiry method in knowledge–based achievement.

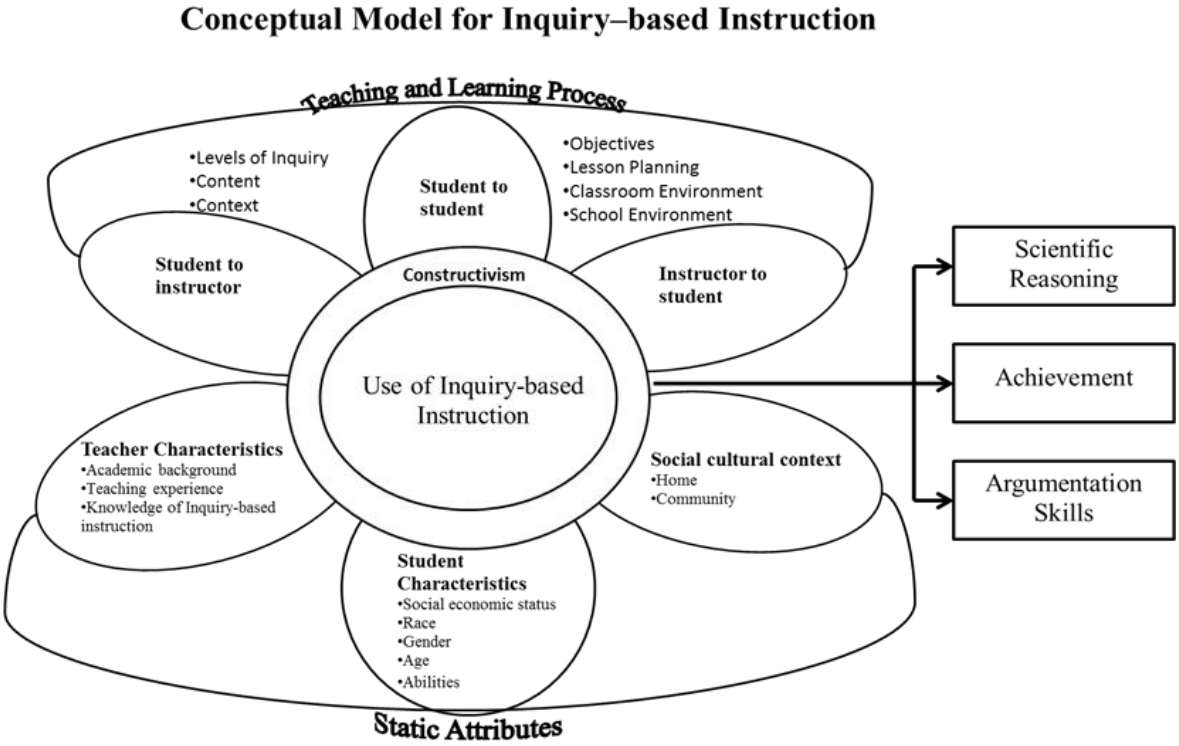

Figure 1. Conceptual model for the effects of inquiry–based instruction.

Purpose/Objectives/Hypotheses

The purpose of this study was to determine the effects of teaching method on student content knowledge achievement of high school agriscience students. Content knowledge is defined as students' ability measures on a standardized assessment. The specific objectives guiding the study were to:

1. Ascertain the effects of inquiry–based instruction on content knowledge achievement of high school agriscience students.
2. Examine the relationship between content knowledge achievement, ethnicity, gender, year in school, and socio–economic status of high school agriscience students.

The null hypothesis, H_o: no significant difference, at the .05 level, in student content knowledge achievement based upon the teaching method (inquiry–based teaching or subject matter approach), guided the analysis of the first objective.

Methods

Population and Sample

The population for this study was United States secondary school agriscience students. The accessible population was students of National Agriscience Teacher Ambassador Academy (NATAA) participants. A purposive sample was selected according to the ability of the teacher to effectively deliver both teaching methodologies under investigation, familiarity with the content of the units of instruction, and

having two sections of the same class for investigation.

All teachers were identified as highly qualified teachers prior to being selected to participate in the NATAA. Each teacher was selected to participate in the NATAA professional development by their state's FFA executive secretary and/or their state's agricultural education specialist (L. Gossen, personal communication, October, 26, 2008). The population of this study was composed of students (N = 437) at ten schools taught by NATTA participants.

Research Design

The independent variable in this study was the teaching method used in the agricultural education classes. Treatment groups utilized a subject matter approach or inquiry approach to learning. The dependent variable in this study was student content knowledge achievement. Covariates were used to adjust group means in order to compensate for previous knowledge in the subject matter. These covariate measures included pretests for the unit of instruction. This study utilized a quasi–experimental design because random assignment of subjects to treatment groups was not possible (Campbell & Stanley, 1963). Additionally, intact groups were used. Gall, Borg, and Gall (1996) stated that all groups may receive a treatment in the nonequivalent control group design. Gall et al. stated that the only essential features of this type of design are nonrandom assignment of subjects to groups and administration of a pretest and posttest to all groups.

Campbell and Stanley (1963) noted regression as a concern but explained that the risk of regression during a pretest–posttest procedure can be minimized if subjects are not selected on extreme scores. To address Campbell and Stanley's concern the teaching methods were randomly assigned to the intact groups (classes). The greatest threat of interaction 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 et al., 1996). The use of multiple classroom settings in this study reduced the risk of interaction of subjects, and the use of covariates of content knowledge achievement pretest scores to statistically adjust the means on the posttest and randomization of pretest and posttest questions addressed the interaction concern. Students in the agriscience classes included in the study were taught all lessons with the same method. Students completed the pretest assessment for the upcoming content that followed over the next two weeks. Each student then took a posttest immediately following the instruction, followed by the pretest for the next segment of the content taught. The units were designed to require a total of 12 weeks to complete. There were a total of 7 pretests and posttests.

IBI	O_1	X_1	O_2	O_3	X_2	$O_4 \ldots O_7$
SM	O_1	X_1	O_2	O_3	X_2	$O_4 \ldots O_7$

Unit of Instruction Plans

Content selection is also a concern with conducting a study utilizing specific teaching methods (Myers, 2004). The content and context of the lessons for both the subject-matter and inquiry–based lessons were deemed appropriate by a panel of teaching and learning 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). For the subject–matter approach (control) the CAERT lesson plans were utilized. For the inquiry–based approach (treatment) the CAERT lesson plans were adapted by the researcher to provide for inquiry–based instructional methods. The instructional plans were evaluated for content validity by a panel of experts from the University of Florida. The panel determined that the inquiry–based and subject matter lessons were appropriate for the grade levels and deemed the lessons appropriate for inquiry and subject matter approaches.

Procedures

Boone (1988) suggested that when conducting teaching methodological studies and teachers are delivering the treatments, precautions need to be taken to ensure conformity to teaching the approach under investigation. Boone recommended professional development to prepare teachers to properly

deliver the treatment. This study addressed Boone's recommendation by selecting from among teachers who were involved in NATAA professional development program. The NATAA is a five–day intensive professional development training on the inquiry–based instructional method. In addition to the five–day professional development in–service training, each teacher participating in the study received a researcher–developed audio tutorial that further explained the teaching methods and general information for participation in the study. Teachers were provided lesson plans, handouts, assessment instruments, worksheets, and supplemental items by the researcher so that the teacher could deliver the assigned treatments effectively.

To ensure utilization and adherence to the assigned treatment, each teacher presentation was audio taped and analyzed by the researcher. The Science Teaching Inquiry Rubric (STIR) (Bodzin & Cates, 2002) was used to determine the level at which inquiry was utilized. Following Dyer (1995) and Myers' (2004) procedures, the first class period and two other randomly selected classes were evaluated. The level of STIR was determined *a priori* that a mean greater than 2.5 on a 5 point scale would be essential to ensure that each treatment was delivered using the prescribed method. Students attending classes, in which the teaching method was not appropriately delivered, as determined by the STIR, would be removed from the sample. 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 from the sample.

Instrumentation

In order to measure student prior content knowledge and establish base–line knowledge for each group, the researcher designed a content knowledge pretest and posttest for each unit of instruction. All tests were similar in design and difficulty based on Bloom (1956). Pretests and posttests for each achievement measurement remained the same, and questions were randomly ordered for each student each time the assessment was proctored. Teaching objectives were used as the basis for constructing the instruments. Lesson matrices were developed to verify that each objective included in the lesson plans was properly assessed in the instruments. A panel of experts from the University of Florida was used to determine face and content validity of the instruments. The instruments were determined to be valid. Data were collected electronically through student–completed assessments using the MYCAERT electronic testing system. The assessments were immediately scored by the computer system. Correct and incorrect answers and scores on the pretests were withheld from the students.

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. The posttest questions were asked in a randomly selected order to reduce testing effect (Campbell & Stanley, 1963). Test–retest reliability was calculated with a summated test score mean of 49.4% for content knowledge achievement (CKA) one, 50.0% for CKA two, 47.8% for CKA three, 48.2% for CKA four, 56.9% for CKA five, 45.3% for CKA six, and 57.5% for CKA seven. Reliability coefficients for the content knowledge achievement instruments were calculated using Kuder–Richardson 20 (KR20) for dichotomous data (Gall et al., 1996). The instruments were determined to have a coefficient alpha of .94, .93, .91, .86, .87, .89, and .91 respectively.

Findings

The results address the objectives and hypothesis of the study in determining the influence of teaching method, gender, ethnicity, social economic status, and year in school on student achievement. The total group consisted of 437 students from ten different schools across the United States. Two teachers sustained health issues (one personal and one family) and another teacher was reassigned a new teaching role after the first week of the study, therefore 109 students were removed from the study due to non–participation or inability to complete the study. Twenty–three students were removed from the study due to missing 25% or more of the instructional sessions. Audio recordings of the administered units were scored using the scientific teaching inquiry rubric (STIR) 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. 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). It was determined that all seven teachers effectively delivered both forms of 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), Black, Hispanic, and Other. The majority of students participating in this study were categorized as White (81.6%). The ethnicity of each of the treatments was similar to the ethnicity of the entire sample (see Table 1). The majority of the participants in this study (58.0%) were male. The treatment groups were similar to each other as inquiry–based instruction (IBI) 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 (Table 1).

Socio–economic status (SES) was determined by ability to participate in the national free and reduced school lunch program (Stone & Lane, 2003). Therefore, SES was categorized in the groups of non–ability to participate, ability to receive reduced lunch, and ability to receive free lunch. The majority of the students participating in this study (72.5%) were not able to participate in the national school lunch program with 16.7% able to receive a reduced price in the school lunch program (Table 1). Treatment groups were similar in terms of SES.

Table 1
Participant Ethnicity, Grade Level, and Socio–Economic Status (n = 305)

	Treatment Group					
	IBI		SM		Total	
	n	%	*N*	%	*N*	%
Ethnicity						
White, non–Hispanic	139	81.8	110	81.5	249	81.6
Black	8	4.7	5	3.7	13	4.3
Hispanic	16	9.4	15	11.1	31	10.2
Other	7	4.1	5	3.7	12	3.9
Grade Level						
Ninth	87	51.2	61	45.2	148	48.5
Tenth	69	40.6	65	48.1	134	44.0
Eleventh	14	8.2	9	6.7	23	7.5
SES						
Not a participant	122	71.8	99	73.3	221	72.5
Reduced lunch	26	15.3	25	18.5	51	16.7
Free lunch	22	12.9	11	8.1	33	10.8

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

The first objective sought to ascertain the effects of inquiry–based instruction on student content knowledge achievement 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%) with an overall mean of 36.04 (*SD* = 12.18) for instrument one; 35.88 (*SD* = 13.41) for instrument two; 31.46 (*SD* = 11.66) for instrument three; 35.74 (*SD* = 13.47) for instrument four; 35.89 (*SD* = 12.27) for instrument five; 34.30 (*SD* = 13.79) for instrument six; 29.63 (*SD* = 12.18) for instrument seven (see Table 2). Although the IBI treatment group achieved similar mean content knowledge scores and similar standard deviations as the SM treatment group, the subject matter group achieved higher pretest mean scores and standard deviations on all instruments with the exception of instrument four.

Table 2
Participant Mean Pretest Scores (n = 305)

Content Knowledge Instrument	Treatment Group				Total	
	IBI		SM			
	M	*SD*	*M*	*SD*	*M*	*SD*
1	35.57	11.68	36.64	12.80	36.04	12.18
2	35.72	12.78	36.09	14.20	35.88	13.41
3	31.20	11.06	31.79	12.40	31.46	11.66
4	36.19	13.88	35.17	12.96	35.74	13.47
5	35.82	11.89	35.97	12.77	35.89	12.27
6	33.72	13.78	35.02	13.83	34.30	13.79
7	29.27	11.74	30.07	12.75	29.63	12.18

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

Posttest data were collected from 305 students. The overall mean of content knowledge achievement posttest was 62.13 (*SD* = 17.71) for instrument one; 63.15 (*SD* = 16.94) for instrument two; 64.77 (*SD* = 16.86) for instrument three; 70.66 (*SD* = 15.70) for instrument four; 70.66 (*SD* = 17.28) for instrument five; 72.07 (*SD* = 17.11) for instrument six; 72.63 (*SD* = 16.59) for instrument seven. IBI recorded consistently higher mean scores on all content knowledge achievement instruments and lower standard deviations on six of the seven content knowledge achievement instruments than SM instruction (see Table 3).

Table 3
Participant Mean Posttest Scores (n = 305)

Content Knowledge Instrument	Treatment Group				Total (*n* = 305)	
	IBI (*n* = 170)		SM (*n* = 135)			
	M	*SD*	*M*	*SD*	*M*	*SD*
1	63.49	17.86	60.43	17.44	62.13	17.71
2	66.24	14.86	59.26	18.57	63.15	16.94
3	68.26	15.86	60.39	17.11	64.77	16.86
4	76.82	13.67	62.90	14.66	70.66	15.70
5	79.04	12.74	60.10	16.48	70.66	17.28
6	81.64	10.32	60.00	16.35	72.07	17.11
7	80.68	10.61	62.49	17.23	72.63	16.59

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

Objective two examined the relationship between content knowledge achievement, ethnicity, gender, 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 4).

Content knowledge posttest scores were found to have moderate to substantial relationships with other posttests ranging from r = .34 to r = .59 with the exception of posttest one. Posttest one had negligible to low correlations with all variables. The treatment variable was found to have moderate or substantial correlation with four of the seven content knowledge posttests. The demographic variables of year in school (grade), gender, ethnicity, and SES contained negligible relationships with posttests and type of treatment (inquiry–based instruction and subject–matter approach). One relationship was determined to be low between Posttest two and year in school.

Table 4
Correlations of variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Posttest 1	--	.05	.18	.07	.17	.16	.10	.11	-.02	-.05	.01	-.09
2. Posttest 2		--	.34	.28	.35	.37	.30	.26	-.00	-.08	.02	-.21
3. Posttest 3			--	.41	.42	.37	.43	-.03	-.01	-.10	.00	-.23
4. Posttest 4				--	.59	.45	.35	.08	.05	-.12	.01	-.44
5. Posttest 5					--	.54	.49	.08	-.01	-.07	.05	-.55
6. Posttest 6						--	.46	.03	.00	-.08	.07	-.63
7. Posttest 7							--	.17	-.05	-.03	.03	-.55
8. Grade								--	-.03	-.04	-.06	.04
9. Gender									--	.03	.11	-.01
10. Ethnicity										--	.05	.01
11. SES											--	-.05
12. Treatment												--

Note. Posttest = Content Knowledge Achievement Exams; Treatment = Teaching method utilized.

The null hypotheses stated there is no significant difference in student content knowledge achievement based upon the teaching method. Student content mean scores were analyzed between groups through analysis of covariance technique. Student pretest score was utilized as a covariate to adjust for achievement prior to the treatment. Following the first instructional period (the first two weeks of the study), students who were taught through inquiry–based instruction (IBI) reported a mean posttest score of 63.49 (SD = 17.86) and those taught through the subject matter (SM) had a mean score of 60.43 (SD = 17.44) (see Table 5). Table 6 illustrates posttest scores were found to not be statistically significant, $F(4,334) = 2.82$, $p = .09$, $r^2 = .09$.

During the second instruction period, students in the group that was taught through IBI achieved a mean posttest score of 66.24 (SD = 14.86) with the SM group having a mean of 59.26 (SD = 18.57). This difference in posttest scores was found to be statistically significant, $F(19,550) = 17.30$, $p \leq .001$, $r^2 = .20$. For the third instruction period, students in the IBI group recorded a mean score of 68.26 (SD = 15.86) and the SM group recorded a mean score of 63.39 (SD = 17.11). This difference in posttest scores was also found to be a statistically significant, $F(17,256) = 22.08$, $p \leq .001$, $r^2 = .15$. During the fourth session of content students in the IBI group had a mean score of 76.82 (SD = 13.67) and the SM group scored a mean score of 62.90 (SD = 14.66). This difference in mean posttest scores was statistically significant, $F(16,849) = 73.43$, $p \leq .001$, $r^2 = .44$ During the fifth portion of the study, IBI students reported a mean score of 79.04 (SD = 12.74) while students learning under SM reported a mean score of 60.10 (SD = 16.35). The difference in posttest scores for the fifth assessment were found to be statistically significant, $F(27,956) = 129.94$, $p \leq .001$, $r^2 = .54$. For the sixth instructional unit, students in

the group that was taught through IBI had a mean posttest score of 81.64 (*SD* = 10.32) and the SM group having a mean of 60.00 (SD = 16.35). This difference in posttest scores was found to be statistically significant, $F(41,219) = 230.72$, $p \leq .001$, $r^2 = .62$. Finally, the seventh instructional unit, students in the IBI group recorded a mean score of 80.68 (SD= 10.61) and the SM group recorded a mean score of 62.49 (SD = 17.23). This difference in posttest scores was also found to be a statistically significant, $F(26,626) = 133.96$, $p \leq .001$, $r^2 = .54$. Based upon these findings, the null hypothesis of no difference in content knowledge achievement due to teaching method was rejected.

Table 5
Content Knowledge Posttest Scores by Treatment (n = 305)

Content Knowledge Instrument	Treatment Group			
	IBI		SM	
	M	*SD*	*M*	*SD*
1	63.49	17.86	60.43	17.44
2	66.24	14.86	59.26	18.57
3	68.26	15.86	60.39	17.11
4	76.82	13.67	62.90	14.66
5	79.04	12.74	60.10	16.48
6	81.64	10.32	60.00	16.35
7	80.68	10.61	62.49	17.23

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

Table 6
Univariate Analysis of Treatment Effects for Content Knowledge

Source	*df*	*F*	*P*
CKP 1	2	2.82	.09
CKP 2	2	17.30	≤.001
CKP 3	2	22.08	≤.001
CKP 4	2	73.43	≤.001
CKP 5	2	129.94	≤.001
CKP 6	2	230.72	≤.001
CKP 7	2	133.96	≤.001

Note. CKP = Content Knowledge Posttest

Conclusions

Based on the results of this study, there are four conclusions: (a) participants were primarily White (81.6%), male (58%), enrolled in the ninth grade (48.5%), and did not qualify for free or reduced lunch programs (72.5%). Minorities comprised 18.4%, tenth graders encompassed 44%, and 27.5% of the participants qualified for some form of meal support; (b) IBI and SM group's ethnicity, gender, grade level, and socio–economic status were similar when taught using either IBI or SM approaches; (c) When taught with either teaching approach students showed gains in content knowledge on assessments. Inquiry–based instruction reported increased scores over students taught through the subject matter approach; and (d) Students taught using inquiry–based instruction scored higher on content knowledge assessments as compared to students taught using the subject matter approach.

Discussion/Implications

This study presents findings which indicate this form of inquiry–based instruction is effective in the agriscience classroom in increasing student content knowledge achievement. Previous studies conducted that compared teaching methodologies in the agricultural education profession have reported

mixed results. Boone (1990), Dyer (1995), Enderlin and Osborne (1999), Flowers (1986), Myers (2004), and Roegge and Russell (1990) all reported either low student achievement scores or inconsistent treatment effects from their studies, leading to mixed findings. This study differs from the previously mentioned studies based on the following: (a) the preparation the teachers received prior to implementation of the study, (b) the length of the study, (c) the method of data collection, and (d) how the study was managed.

The preparation the teachers in the study received was an intense week of professional development through the NATAA. Teachers were taught the basics of inquiry–based instruction, were able to apply their skills through hands–on application of the method, and reflected and related the content to the curriculum they currently teach. Following the preparation NATAA teachers presented workshops at the National FFA Convention and NAAE conference. This form of professional development is ideal to focus the teachers' attention on the topic, allow them to utilize and experiment with the curriculum, and provide reflection with peers on effective utilization in their local curriculum. The NATAA teachers then taught at least one school year utilizing inquiry–based instruction before this study was conducted. Previous studies addressed professional development in a variety of ways, from asking teachers if they could teach the method, to conducting a one–day workshop on the specific teaching strategy. The amount of time spent in professional development and allowing teachers to experiment and become comfortable with the teaching method likely impacted the results of this study.

The length of this study is another factor that differed from previous studies that investigated teaching methods in a quasi–experimental design. Previous studies ranged from four to eight weeks of treatment. Had the treatment included only the two weeks of instruction prior to the beginning of this study (four weeks total), this study would probably not found a treatment effect. By expanding the study to eight weeks, the researcher would have had to conclude mixed results at best, perhaps reporting four weeks of no significant difference in student achievement and four weeks (2 assessments each) of significant difference in student achievement scores. The delay in starting the study for two weeks to allow for students to adjust to inquiry–based instruction is an important consideration for future research that investigates teaching methodology. Finally, over the course of the twelve–week investigation, scores for the inquiry–based instruction increased at a faster pace than scores for students in the subject matter group. Examination of ways to expedite the transition for the students will lead to stronger studies in the future.

Data collection was conducted electronically. Electronic forms of assessments and instant data delivered to the researcher allowed for the researcher to gauge the progress of the teachers as lessons were taught. Instant feedback to the researcher was important in keeping teachers on task and troubleshooting any problems that may have occurred. Teachers found the grading system effective, and the electronic format provided students with instant feedback on scores.

The continuous contact with the teachers was also vital to achieving high–quality results. Communication with teachers through a weekly message and supplying contact information for around the clock communication allowed for mentoring the teachers throughout the study, kept them apprised of the steps involved in the process, and provided encouragement and feedback on their teaching. Strong professional development coupled with encouragement and mentorship provided for clear results of this study.

Inquiry–based instruction is a teaching method that advances student achievement and supplies the profession with a sound template for future investigations. In summary, students learn more when teachers are well–prepared to teach the lessons, use a variety of instructional strategies, are given guidance and feedback on their teaching, and promote opportunity for students to spend time–on–task.

Recommendations

Based on the findings of this study, four recommendations were made for teacher educators and curriculum developers in secondary school education: (a) 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 similar to that of the NATAA; (b) Teacher educators should provide in–service education opportunities for current teachers on inquiry–based instruction; (c) Inquiry–based curricula and lesson plans that utilize this form of instruction should be developed to further the use of this teaching method; and (d) teacher educators should provide mentorship to teachers through guidance and feedback on their inquiry–based teaching, using a variety of instructional strategies, developing and teaching well–prepared lessons, and helping promote time–on–task for students.

Based on the findings of this study, three recommendations were made for practitioners in secondary school agriscience education: (a) Strong consideration should be given to attend the NATAA professional development workshops and learn inquiry–based instruction. Efforts to expand NATAA program opportunities nationally for more agriscience teachers are needed, utilizing NATAA teachers as state–wide leaders who can provide professional development at the state level; (b) IBI should be utilized in the agriscience classroom. At least four weeks of instruction or four unique lesson plans should be utilized to allow students to adjust to the new method of instruction; (c) Agriscience teachers with experience and sound knowledge of IBI should mentor teachers who are learning to teach inquiry–based instruction by providing feedback, clarity of content, thinking through potential questions and pitfalls, and sharing ideas.

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