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Comparing Experiential Learning Techniques and Direct Instruction on Student Knowledge of Agriculture in Private School Students

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Abstract

Currently, less than 3% of the U.S. population lives on a farm (Riedel, 2006). Technological advances and mechanization coupled with other societal factors, have led to the decline of an agriculturally literate population (Kovar & Ball, 2013). Blair (2009) identified one strategy for increasing agricultural literacy as implementing education that promotes agricultural activities via experience. This quantitative study was conducted at three private schools in Mississippi during the spring of 2015. The primary investigator (PI) taught six (6) lessons contextualized in agriculture to tenth grade students enrolled in advanced biology courses. The study consisted of a control group (no instruction), and two experimental groups; one received direct instruction only, and one was led through various experiences relevant to plant science and agricultural production with a high-tunnel greenhouse. Pre and post-tests assessed knowledge gain. Participants' knowledge scores increased significantly among experimental groups ($p < .001$). Multivariate analysis revealed post-test scores between experimental groups were significantly different ($p = .016$). Further analysis of the data displayed that 67% of the variance in scores was attributed to method of instruction and a strong correlation existed between post-test scores and treatment group ($R = .820$).

Keywords: experiential learning, direct instruction, agricultural literacy

Introduction

The lack of perceived importance of agriculture today has contributed to the gradual decline of agricultural literacy from generation to subsequent generation. Due to a variety of factors, the United States has drastically shifted from a once dominantly agrarian society to the opposite end of the spectrum (Riedel, 2006). The United States Environmental Protection Agency (EPA) reported that now, only 2% of the U.S. population lives on farms as compared to 43% in 1953 (Tarmann, 2003; EPA, 2013). Birkenholz, Harris, and Pry (1994) acknowledged advancements in plant genetics and other agriculture technology have made production more efficient than ever, resulting in larger but fewer farming enterprises. The technological advances, coupled with urbanization, have created a substantial chasm of knowledge between the farm and

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the table. This has significantly contributed to the decline of agricultural literacy in our population (Kovar & Ball, 2013).

Agricultural literacy is a vast concept, including agriculture's relationship with the environment and natural resources, agricultural policies, plant and animal production, and the economic impacts of agriculture (Frick, Kahler, & Miller, 1991). Many people tend to associate the term "agriculture" with farming or ranching only (Terry, Herring, & Larke, 1992). This misconception, combined with conflicting opinions in mainstream media regarding agricultural production, food labeling, and biotechnology, have contributed to a growing negative perception of agriculture within society (Balschweid, Thompson, & Cole, 1998). An agriculturally literate society will be able to decipher fact from fiction in regard to the onslaught of emotional negativity produced through various media outlets concerning agriculture (Kovar & Ball, 2013).

A strategy for altering perceptions and increasing agricultural literacy is implementing agricultural centered, school-based lessons (Fisher-Maltese, 2014). Agriculture and education have changed significantly since the National Research Council's (NRC) publication (1988) *Understanding Agriculture: New Directions for Education* where it was stated "agriculture is too important a topic to be taught only to the relatively small percentage of students considering careers in agriculture and pursuing vocational agriculture studies" (p. 1). Blair (2009) pointed to the many benefits of teaching lessons focused on agriculture. "[In agriculture,] food can no longer be viewed as a mere commodity for consumption; we are brought into the ritual of communal goodness that is found at the intersection of people and plants" (Blair, 2009, p. 18). Exposure to agriculture can change student perceptions and these lessons help contextualize science within the natural world and promote linkages with nature and concepts that relate to other subject matter (Blair, 2009).

Experiential learning is an effective pedagogical approach in teaching agriculture as well as other closely related scientific fields. Although not a new approach, experiential learning is recognized to be effective in assisting students with solving real- world problems (Kolb, 1984). Experiential learning is widely championed because of its challenging nature and the complexity of integrating different aspects of learning by doing (Penny, Frankel, & Mothersill, 2012; Baker & Robinson, 2016). Penny et al. (2011) concluded:

> (…) lecture format for transmitting knowledge can no longer be the only pedagogical approach used in academic settings. Experiential learning opportunities that promote the use of cognitive, affective, psychomotor (…) ways of knowing are more reflective of learners in the new millennium. (p. 7)

Experiential learning also makes the case for critical thinking and a deeper understanding of the subject matter by being heavily centered on student involvement and reflection rather than memorization (Baker & Robinson, 2016).

Literature Review

Declining profitability of American farms and decreasing agricultural education enrollment led to a serious assessment of agricultural education (Kovar & Ball, 2013). The NRC's (1988) publication is widely accepted as the foundation of agricultural literacy concepts. The goal of the report was assessing and improving secondary agricultural education programs in the United States (Kovar & Ball, 2013). Based on the NRC's publication, a three-part definition was introduced pertaining to competencies an agriculturally literate person should possess. First, "[agriculture's] history and its current economic, social, and environmental significance" (pp. 8-9), second, enough knowledge to make informed decisions regarding diet and health, and finally, "[possess enough] practical knowledge needed to care for their outdoor environments, which include lawns, gardens, recreational areas, and parks". (p. 9)

Since the introduction of agricultural literacy by the NRC, many studies have assessed knowledge of agriculture among teacher and student populations, with most emphasis being elementary-aged student populations (Kovar & Ball, 2013). Birkenholz et al. (1994) investigated agricultural literacy among college students. The survey instrument included an assessment of agricultural knowledge, perceptions of agriculture, and demographics. Birkenholz et al. (1994) reported participants were somewhat knowledgeable about agriculture.

Frick, Birkenholz, Gardner, and Machtmes (1995) and Pense and Leising (2004) further examined agricultural knowledge of students. Frick et al. (1995) assessed Midwest rural and urban inner-city students' agricultural knowledge and perceptions. Their study included 1,121 respondents with 668 from rural Indiana and 453 from urban Michigan. They found that rural students answered 65% of the knowledge items correctly and the urban student group answered 47.9% of the knowledge questions correctly. Their numbers indicated both rural and urban student groups were not very knowledgeable of agricultural practices, but rural students had more knowledge of agricultural practices than urban students.

Pense and Leising (2004) conducted a similar study with a population of 12th graders in Oklahoma. They sought to determine knowledge of the food and fiber systems based on the Food and Fiber Systems Literacy Framework benchmarks for grades 9-12. Using an ex post facto research design and purposive sampling, they assessed 330 general education and agricultural students from five different high schools. Their study also included students in urban, rural, and suburban schools. Their results indicated that, overall, the students exhibited similar levels of knowledge and were not agriculturally literate because no school achieved a mean score higher than 49%.

Experiential learning builds on the foundation set by John Dewey, Carl Rodgers, and David Kolb and is identified as a process of learning which focuses on engaging students through active experimentation and reflection (Baker, Robinson, & Kolb, 2012). The famous quip 'tell me and I forget, teach me and I remember, involve me and I will learn' has been attributed to many individuals; however, it provides a basis for experiential learning. In Dewey's 1938 publication *Experience & Education*, he pointed out the need for experiential learning and expressed that experience can lead to genuine education. Dewey (1938) stated, "education in order to accomplish its ends both for the individual learner and for society must be based upon experience, which is always the actual life-experience of some individual" (p. 39). David Kolb stated "learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (1984, p. 38). Kolb's definition of learning has strengthened the foundation provided by Dewey from the experiential learning perspective.

Wozencroft, Pate, and Griffiths (2014) explained additional benefits associated with experiential learning, stating it "[promotes] student engagement, [promotes] an improved atmosphere for making ethical decisions, and the promotion of critical-thinking and problem-solving skills" (p. 4). The promotion of critical thinking within experiential learning is furthered by intentional and deliberate reflections that stem from the concrete experiences involved with the process (Baker & Robinson, 2016). Although many definitions and observational objectives for experiential learning exist, Penny et al. (2011) gave a very appropriate definition contending its effectiveness in teaching across disciplines:

> The objective of experiential learning is to provide an education that attends in some balanced manner to the student's need to advance knowledge acquisition and critical judgment, thinking and acting, reflection and engagement, career development and

informed citizenship, growth as an individual, and greater connectivity with the larger community. (p. 2)

Arnold, Warner, and Osborne (2006) sought to examine the use of experiential learning in secondary agricultural education classrooms. Their qualitative study investigated secondary agriculture teachers' familiarity with and implementation of Kolb's (1984) ELT. They found teachers lacked formal knowledge about ELT but recognized the benefits of experiential learning. Some benefits the participants identified were students retained subject matter better, students were more engaged, and students performed better academically (Arnold et al., 2008).

Theoretical and Conceptual Framework

The agricultural literacy model presented by Elliot (1999) served as the theoretical model for this study and depicts how knowledge and opinions of agriculture are shaped (Figure 1). The agricultural literacy framework consists of three constructs; education, personal characteristics, and participation in agricultural activities. Education illustrates how individuals receive agricultural information and knowledge. This can be gathered via formal and structured educational approaches, non-formal approaches such as extension activities and field days, or from various news media outlets. Personal characteristics including gender, ethnicity, home location, and family/friends, provide a basis for familiarity of agriculture due to factors beyond the control of the individual. Finally, participation in agricultural activities includes participation in FFA, 4-H, growing plants, or raising animals. Participating in agricultural activities results in more genuine perceptions of agriculture.

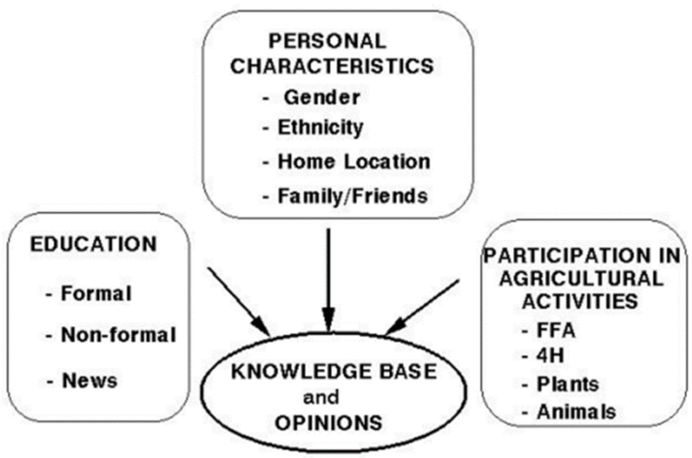

Figure 1. Framework of influences that determine agricultural knowledge and perceptions (Elliot, 1999).

Elliot (1999) used this model when assessing the awareness and knowledge base of agriculture in Arizona public school teachers. He found that teachers who received an agricultural literacy education treatment were more agriculturally literate than those who did not and concluded that agricultural education can positively affect a target population's knowledge and perceptions of agriculture. Duncan and Broyles (2004) agreed that knowledge of agriculture is influenced by the factors Elliot (1999) described. They found that a systematic approach to educating students about agriculture was successful in expanding students' knowledge of agriculture.

Conceptually, Kolb's Experiential Learning Theory (ELT) (1984) served as the framework for this study. Experiential learning provides a basis for students to conceptualize and experience the abstractness of agriculture (Blair, 2009). Experiential learning depicts learning as a cycle of concrete experience (CO), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) (Kolb, 1984). Concrete experience begins with the learner experiencing a situation. Reflective observation requires the learner to examine the concrete experience in order to conceptualize a variety of perspectives to place meaning with the experience. In abstract conceptualization, the learner builds on their reflective experiences to examine and infer logical conclusions from the experience. Finally, active experimentation propels the learner to make decisions and apply concepts to new and future experiences (Dunlap et al., 2008). Figure 2 illustrates the various components of Kolb's Experiential Learning Model.

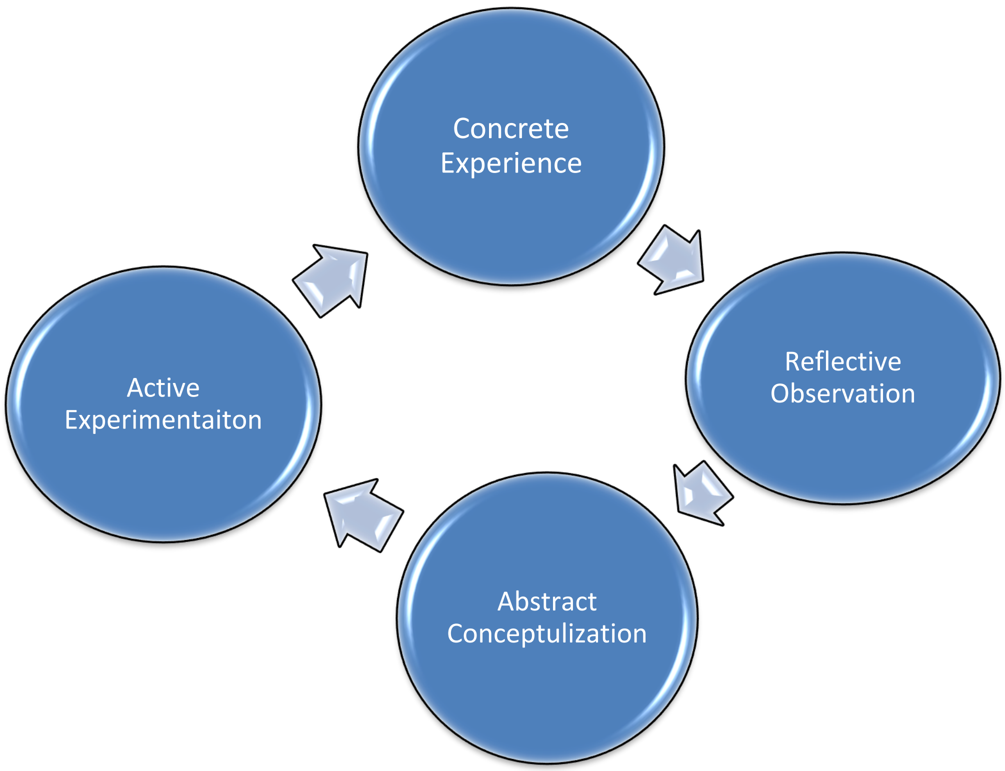

Figure 2. David Kolb's experiential learning model illustrating how experiences allow for an opportunity to reflect and learn from the experience that leads to an intimate familiarity of future applications (1984).

Assessing agricultural literacy within relevant populations can assist in gathering knowledge and perspectives of agricultural awareness, as well as identifying gaps in agricultural knowledge. Experiential learning has the potential to mitigate agricultural illiteracy by conceptualizing how agriculture relates to science through real- world experiences and applications.

Purpose and Research Questions

There are many different potential outlets to disseminate both accurate as well as inaccurate agricultural facts. Because of this, the *National Research Agenda: American Association for Agricultural Education's Research Priority Areas for 2016-2020* (Roberts, Harder, & Brashears,

2016) recognized the need for agricultural literacy in Priority Area 1. Doerfert (2011) cites the need for an increase in informing the public of agricultural awareness by "understanding of related message and curriculum development, delivery method preferences and effectiveness, and the extent of change in audience knowledge, attitudes, perceptions and behaviors after experiencing an educational program or consuming related information and messages" (p. 8). As educators and researchers, it is vital to stress the importance of agricultural literacy to those outside the discipline.

The purpose of this quantitative study was to investigate the level of agricultural knowledge among three groups of private school students; and additionally, examine the differences in agricultural knowledge gain following various teaching interventions.
Three research questions guided this study:

1. What is the current level of agricultural knowledge among 10^{th} grade biology students?
2. Are there significant differences in agricultural knowledge test scores between direct instruction and experiential learning techniques?
3. Are there significant differences in agricultural knowledge test score increases between groups based on intervention?

Methods and Procedures

We employed a quantitative, quasi-experimental research design using descriptive statistics to investigate the research questions. A nonrandomized control group, pretest-posttest design, accompanied various teaching interventions. Quasi-experimental research designs are designs where non-randomization of treatment groups are allowed (Ary, Jacobs, & Sorensen, 2010). These designs are widely used in educational research settings where pre-existing groups (i.e. classrooms) are not left up to the researcher for random assignment (Ary et al., 2010).

Ary et al. (2010) stated that using the nonrandomized control group pretest-posttest design decreases selection bias that could threaten the internal validity of the research design. Ary et al. (2010) stated "the pretest enables you to check on the equivalence of the groups on the dependent variable before the experiment begins" (p. 317). Given that each group in this study received the same pretest, threats such as maturation and instrumentation are not serious threats to internal validity (Ary et al., 2010). Also, in this design, the non-randomization contributes to the generalizability of the findings because the subjects were unaware the experiment was being conducted with other groups (Ary et al., 2010).

The study occurred during the spring 2015 semester at three private high schools in Mississippi. Private schools were identified as schools that received no state funding and/or are members of the Mississippi Association of Independent Schools. The target population for this study was 10^{th} grade biology students. The accessible population consisted of students who were enrolled in the biology course, were present at school, and whose parents consented for their child to participate. Students who were not present at the time of the pre-test assessments were allowed to participate in the activities/lessons but did not take the post-test assessment. We surveyed students in biology courses due to the integrated nature of topics, such as plant growth and development, and other scientific topics that are intertwined with agricultural production.

We assigned treatment groups beyond the control group (Group 1; received no teaching), Group 2 (direct instruction only), and Group 3(experiential learning). Traditional biology students were unable to be surveyed in the control group; therefore, the 10^{th} grade advanced biology students were assessed. Selected demographics of participants are displayed in Table 1.

Table 1

Demographics of Participants by Treatment Group

	Control		Direct Instruction		Experiential Learning		Total	
Demographic	*N*	%	*n*	%	*n*	%	*n*	%
Male	9	64	9	43	12	55	30	53
Female	5	36	12	57	10	45	27	47

Note. N = 57

The Biological Sciences Curriculum Study publication, *Nourishing the Planet in the 21st Century* (2007), served as the main teaching guide and assessment for the study. The lecture topics were created as a collaborative effort by consultants, industry leaders, and professionals in agronomy, crop sciences, and other related agricultural disciplines. The purpose of the assessment and curriculum was to help students identify aspects of food production, refine and practice critical thinking skills, encourage students to participate and examine the purpose of scientific research, and conceptualize connections of current agricultural practices and sustainability. We visited each treatment group a total of eight times, once to administer pre-tests, once per lesson taught (six lessons total), and once to administer post-tests.

The instructor taught Group 2, six, 45-minute lectures contextualized in agriculture focusing on a variety of agricultural topics that included soil properties, plant growth and development, commercial and organic fertilizers and production methods, and the history of agriculture. The instructor taught Group 2 on six consecutive days (February 9, 10, 11, 12, 18, & 19) via direct instruction in a traditional classroom setting. The students received handouts, modified notes, and additional paper materials to accompany the agricultural lessons.

Group 3 received modified instruction by incorporating hands-on activities which included fertilizer spreading, experience with soil textures and profiling, and a fully functional high-tunnel for plant growth and fertilizer experiments. Group 3 met once a week (with the exception of Spring Break) for the duration of the study. There were only two interactions with Group 1, once to administer the pre-test and once to administer the post-test. An overview of instructional conditions is provided in Table 2.

Table 2

Overview of Instructional Plan for Two Conditions of Instruction

Experiential Learning Instructional Approach	Direct Instruction Instructional Approach
Students received six lessons that were conducted outside, utilizing hands- on principles that coincided with school garden activities and outlined within the curriculum.	Students received six (6) agricultural lessons targeting specific learning goals as outlined within the curriculum.

Table 2

Overview of Instructional Plan for Two Conditions of Instruction Continued…

After each experience, students were asked to reflect on the experience. ('What do you think happened?' and 'Why did it happen the way it happened?' were used as guiding questions). The instructor facilitated the discussion and provided feedback based on subject expertise.	Instruction was based on scripted lesson plans that were developed with the curriculum according to specific learning objectives.
Students were coached and instructed to utilize their reflections within the abstract conceptualization stage to investigate comprehension of experience	Instructor provided critical information followed by opportunities for students to apply knowledge in groups (large, small, and then alone).
Students could actively experiment with other materials and ask questions to the instructor.	Instructor provided positive reinforcement based on student performance.

The three groups received the same pre and post-tests at the beginning and end of the study provided by the *Nourishing the Planet in the 21st Century* curriculum. The pre and post-test consisted of 15 multiple- choice questions. These questions assessed basic knowledge of plant, soil, and water relationships. The pre and post-test directions prompted the student to indicate if they were sure of answers, guessed the answer, or did not possess enough knowledge to answer the question correctly. Prior to administering the pre and post-tests, the instructor informed students that both unanswered and/or guessed answers would be marked as incorrect but were made to feel at ease that incorrect answers held no penalty.

At the end of the scheduled teachings, post-tests were given to each group with different questions from the pre-test, but likewise measured knowledge gained over the course of the teachings in relation to plant, soil, water, and agricultural production and relationships. As with the pre-test, post-test answers that were unanswered or where the student indicated they guessed was counted as incorrect. After collecting pre and post-tests, scored exams were recorded as a percentage out of 100 points. One limitation to this study is the three private schools could use different biology curriculums; however, this information was not made known.

Results of the assessments were analyzed using appropriate statistics within IBM SPSS® Statistics 23. Data were summarized using measures of central tendency. Distribution and frequency of scores along with means and standard deviations of pre and post-test scores were computed. Missing data were screened to determine if data were missing completely at random (MCAR) and independent samples tests were conducted for equality of means and variances. Paired samples t-tests were conducted along with multivariate analysis and categorical variables were dummy coded to achieve regression analysis.

Results

Research question one sought to determine the current level of agricultural knowledge among 10th grade biology students. Respondents' scores were based on a number of questions answered correctly divided by the total questions. The following scale classified level of knowledge out of 100 total points as reported by Terry et al. (1992):

90 – 100	Superior Knowledge
80 – 89	Acceptable Knowledge
70 – 79	Moderate Knowledge
60 – 69	Minimal Knowledge
< 60	Unacceptably low knowledge

Group 1 students' mean score was 36.4. Scores on the pre-test ranged from 20% (3/15 questions correctly answered) to 67% (10/15 questions correctly answered). A large percentage (86%) of the students scored in the 'Unacceptably low knowledge' category while the remaining 14% scored in the 'Minimal Knowledge' category.

Group 2 students achieved a mean score of 43.4. Students scored a wider range in their current knowledge of agriculture. Their pre-test ranged from 13% (2/15) to 80% (12/15). Similar to Group 1, 76% of the students scored in the 'Unacceptably low knowledge' category while the remaining 24% scored in the 'Minimal Knowledge' category.

The mean score for Group 3 was 45.4. Scores on the pre-test ranged similar to Group 2 students. Scores ranged from 13% (2/15) to 80% (12/15). Before any intervention was conducted, 77% of the students scored in the 'Unacceptably low knowledge' range while 14% of students had minimal knowledge, and the remaining 9% fell in the 'Moderate' and 'Acceptable Knowledge' category (Figure 3).

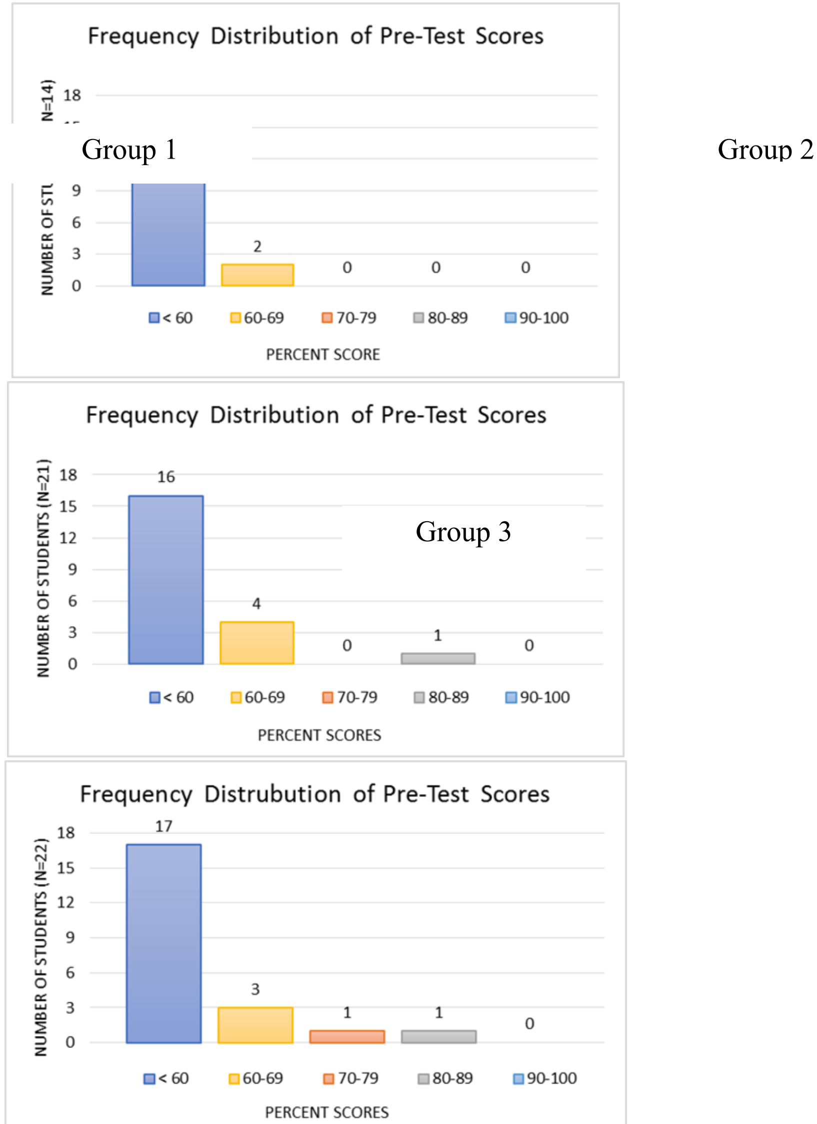

Figure 3. Distribution and frequency of pre-test scores for groups 1, 2, and 3

ANOVA was used to test the equality of means between the three groups of students. Differences in mean pre-test scores between the three groups were not statistically significant (p = .231).

Research question two sought to determine if there was an increase in agricultural knowledge among test scores regarding direct instruction and experiential learning techniques. At the time of the post-test assessment, Group 1 (control) students' scores increased, but still resulted in a low-knowledge of agriculture (M = 47.6). Post-test scores ranged from 20% (3/15) to 80% (12/15) where 64% of scores still resulted in students having an unacceptably low knowledge of agriculture.

After the teaching intervention, Group 2 students' post-test scores increased (M = 77.6). Post-test scores ranged from 60% (9/15) to 93% (14/15), with 80% of the students' scores in the 'Moderate' or 'Acceptable Knowledge' category. A small percentage of students (5%, n = 2) scored in the 'Superior Knowledge' category. The remaining 15% of the students scored in the 'Minimal' range and zero students scored in the 'Unacceptably low knowledge' category.

Group 3 displayed an increase in post-test scores as well (*M* = 87.1). Group 3 had zero post-test scores below 70%, with scores ranging from 73% (11/15) to 100% (15/15). Almost half (45%, n = 10) scored in the 'Superior Knowledge' category, 41% scored in the 'Acceptable Knowledge' category, while the remaining 14% scored in the 'Moderate Knowledge' category (Figure 4).

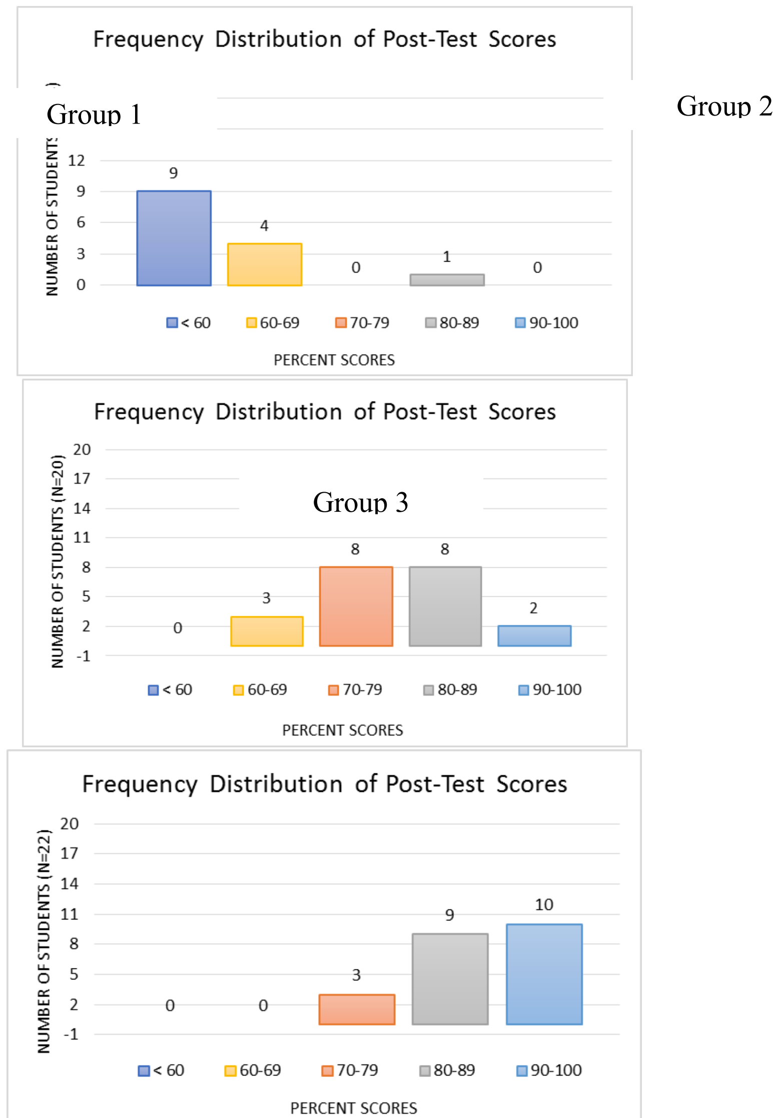

Figure 4. Distribution and frequency of post-test scores for Groups 1, 2, and 3

A paired samples t-test indicated no significant difference in pre and post-tests scores for Group 1 (p = .06). For Groups 2 and 3, paired samples t-test analysis of pre and post-test score means revealed there was a significant difference in scores at the 0.05 alpha level ($p < .001$) (Table 3). *Note. N* = 57

Table 3

Means and Standard Deviations of Pre-& Post-Test Scores

		Pre-Test		Post-Test	
	n	*M*	*SD*	*M*	*SD*
Group 1	14	36.4	14.5	47.6	16.9
Group 2 (Direct Instruction)	21	43.4	16.3	77.6	9.3
Group 3 (Experiential Learning)	22	45.4	17.9	87.1	7.9

The final research question sought to examine if there was a significant increase in agricultural knowledge test scores between groups based on intervention. There was a significant difference in post-test scores between the three groups at the 0.05 alpha-level ($p < .001$; Table 4). The interaction of pre-test and treatment received accounted for a small portion of the variance (.054), however, for post-test scores, the treatment received accounted for a much larger portion of the variance (.673). The effect size between pre and post-test scores and treatment groups are also reported to measure the degree of association between an effect (intervention) and agricultural knowledge (Table 5). Categorical variables were dummy coded to achieve a regression output that sought to determine the correlation among post-test scores and teaching intervention. The model summary of regression procedure indicated a high correlation between post-test scores and treatment group ($R = .820$).

Table 4

ANOVA Table for Pre- & Post-Test Scores

		Sum of Squares	*df*	*F*	*Sig.*
Pre-Test Scores Treatment Group	Between Groups (Combined)	823.12	2	1.51	.231*
	Within Groups	14496.14	53		
	Total	15319.36	55		
Post-Test Scores Treatment Group	Between Groups (Combined)	13832.73	2		
	Within Groups	6718.82	53	54.55	.000*
	Total	20551.55	55		

*$p < .05$

Table 5

Measures of Association Between Pre- & Post-Test Scores

	Eta Squared
Pre-Test Scores Treatment Group	.05*
Post-Test Scores Treatment Group	.67*

*$p < .05$

A multivariate test compared test scores among the groups of students (Table 6). There was no significant difference in pre-test scores between the three groups. There were significant differences in post-test scores between the three groups at the 0.05 alpha-level. Group 2 and

Group 3 means were significantly higher than Group 1 ($p < .001$, $p < .001$). Additionally, post-test mean scores for Group 3 students were significantly higher than students in Group 2 ($p = .016$).

Table 6

Multiple Comparisons of Test Score Means Based on Treatment Groups

Dependent Variable	Group	Treatment Group	Mean Difference	Sig.
Pre-Test Scores	Control	Lecture Only	-7.89	.174
		Experiential Learning	-10.74	.067
	Lecture Only	Control	7.89	.174
		Experiential Learning	-2.85	.586
	Experiential Learning	Control	10.74	.067
		Lecture Only	2.85	.586
Post-Test Scores	Control	Lecture Only	-30.03*	.000*
		Experiential Learning	-38.98*	.000*
	Lecture Only	Control	30.03*	.000*
		Experiential Learning	-8.95*	.016*
	Experiential Learning	Control	38.98*	.000*
		Lecture Only	8.95*	.016*

* $p < .05$

Conclusions and Discussion

The groups assessed in this study were private school biology students. As compared to other courses offered in traditional high school settings, biology is closely associated with agriculture and plant and animal production/stewardship (Blair, 2009). Class sizes were small to medium and private schools in Mississippi offer the flexibility to accommodate additions to current curriculums.

Conclusion 1: An unacceptable knowledge level of agriculture is prevalent among student groups.

Research question one sought to determine the current level of agricultural knowledge among 10th grade biology students. Knowledge was determined using the pre-test assessment furnished by the *Nourishing the Planet in the 21st Century* curriculum. On average, all three groups displayed an unacceptably low knowledge of agriculture, with Group 1 being the lowest ($M = 36.4$). This is particularly interesting because the 'Advanced Biology' was thought to have the higher score of the three groups. From this, we can conclude at the time of assessment, students in biology had a very low knowledge of agriculture which is similar to many previous studies that indicated agricultural literacy is low in certain populations among today's students (Birkenholz et al., 1994; Riedel, 2006).

Even though all three groups had different scores, a non-significant p value (.231) revealed they were similar in their lack of agricultural knowledge. Frick et al. (1995) and Pense and Leising (2004) indicated similar results. This could be a result of students not being offered a curriculum that contained agriculturally centered material.

Conclusion 2: Direct instruction and experiential learning significantly increased agricultural knowledge.

Duncan and Broyles (2004) explained the importance of introducing an agricultural curriculum to increase knowledge of agriculture among student groups. This study supports the findings of Duncan and Broyles (2004) and Elliot (1999). When investigating direct instruction and experiential learning techniques, students in treatment groups had a significant increase in agriculture compared to the control group. While the mean scores for the control group increased by 11 percentage points, it was not statistically significant and is believed to be due to the maturation of the student group such as desiring to perform better on the post-test than the pre-test rather than a true increase in agricultural knowledge. This may account for the small differences measured between pre- and post-tests.

The students who received direct instruction saw a significant increase in their scores ($p < .001$) by approximately 34 percentage points and a higher number of students scored in the top tier of acceptable agricultural knowledge than before the treatment. Three of 21 students were classified as having minimal or low knowledge of agriculture after the teaching intervention as compared to 20 of 21 students scoring in the same categories before the intervention.

Students who received the experiential learning intervention increased their score of approximately 42 percentage points ($p < .001$). Before the intervention, 20 of 22 students scored in the lower tier of agricultural knowledge, whereas after the intervention zero (0) students scored in the same lower categories. By incorporating agriculturally contextualized lessons, whether it be direct instruction or via experiential learning, student scores increased on average by approximately 38 percentage points.

Conclusion 3: Experiential learning is a more effective method of increasing agriculture knowledge than direct instruction.

Students who were part of the experiential learning group had higher scores than those who received direct instruction. Differences in increases of agricultural knowledge based on treatment groups were significant. This can be attributed to the active nature of the Kolb's ELT (1984) and the reflective nature that experience provides (Dewey, 1938). The ANOVA output revealed significant differences among groups regarding agricultural knowledge ($p < .001$). Groups 2 and 3 showed a significant increase in agricultural knowledge compared to Group 1. Additionally, Group 3 student scores were also significantly higher than those of Group 2. From this, we conclude students who were part of the experiential learning group gained greater knowledge than students who received only contextualized lecture and those who received no treatment. The rendered R value of .820 obtained from the regression output indicated a strong correlation of post-test scores based on the dependent variable.

The measure of association shows that approximately 67% of the variance in scores is attributed to the teaching method each group received which we believe is substantial. Kolb's ELT is attributed to the increase in scores, particularly because of the added value experiential learning contributes by providing students deeper understanding and richer experiences (Kolb, 1984). Experiential learning is credited with connecting linkages in the subject matter by allowing students to observe the vast associations that are present in the food and fiber industry (Wozencroft, Pate, & Griffiths, 2014).

Recommendations

First, the assessment tool that was utilized for this study could pose as a limitation for this study. While pre- and post-tests are an effective measure of knowledge gained, a deeper knowledge of agriculture can be further assessed with a more intense instrument. While the instrument is effective in assessing true knowledge of agriculture, agriculture production encompasses a vast array of competencies that cannot be fully ascertained with 15 questions.

More efforts should be conducted to increase knowledge of agriculture in secondary students who aren't traditionally targeted through formal settings. Most formal agricultural education in secondary schools are conducted within Career and Technical Education (CTE) programs with the public school system. In these settings, agricultural education is readily provided through teachers, greenhouses, curriculum, etc. By targeting those who are in various secondary educational settings, researchers and practitioners can further provide agricultural education to those who traditionally are forgotten. Private schools offer the flexibility for modifications within the curriculum to allow for agricultural lessons to be introduced.

Based on this study, it would be beneficial for researchers to explore other agriculture curriculums that could be utilized in secondary classrooms and increase agricultural knowledge. Many curriculums offer a variety of agricultural topics and materials that can be taught within a traditional classroom setting. Future research should be conducted to assess agricultural knowledge gain within available curriculums and how they impact and correlate with agricultural literacy and perception changes.

Future research should continue to assess agricultural knowledge by way of experiential learning. More studies should be conducted to assess agricultural knowledge and perceptions (agricultural literacy) and practical ways to implement feasible programs in existing populations. Future studies should focus on engaging the general public in meaningful and factual communication regarding agriculture and its impact on society. Furthermore, practitioners are encouraged to attempt to reach populations who are traditionally unlikely to administer such curriculums, such as private schools.

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