A NON-EXPERIMENTAL ANALYSIS OF AGRICULTURAL AND SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS (STEM) LITERACIES IN GEORGIA ELEMENTARY AGRICULTURAL EDUCATION

by

BENJAMIN D. BYRD

(Under the Direction of Jason Peake)

ABSTRACT

In the fall of 2019, Georgia passed Senate Bill 330. This bill allowed for a three-year pilot program to teach agricultural education in elementary schools. A non-experimental pretest-posttest design was implemented to test whether elementary agricultural education impacted 3rd and 4th graders' agricultural and science, technology, engineering, and mathematical (STEM) literacies. The researcher developed a 27-question instrument based on state education standards and composed of two constructs, agriculture and STEM. 622 students from five pilot programs participated in this research study. The results of this study determined that elementary agricultural education increased mean scores on the STEM construct by 7.62%. Due to low reliability scores, the agriculture construct was an ineffective measurement of student agriculture literacy. Despite this, three agriculture literacy questions showed a reliable, statistically significant increase in means. The researcher recommended studying the impact that local community, teacher aptitude, and school resources have on elementary agricultural education.

INDEX WORDS: Elementary, 3rd grade, 4th grade, agricultural education, STEM, literacy

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BENJAMIN D. BYRD

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BENJAMIN D. BYRD

Major Professor: Jason Peake
Committee: Don Edgar
Eric Rubenstein

Electronic Version Approved:

Ron Walcott
Interim Dean of the Graduate School
The University of Georgia
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DEDICATION

This thesis is dedicated to the researcher’s family, friends, and faculty that were there for the entire journey.

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CHAPTER 1

INTRODUCTION

In the spring of 2018, the Georgia House and Senate unanimously passed a bill that establishes a pilot program for elementary agricultural education in its state. Senate Bill 330 introduced elementary agricultural education into the current scholastic landscape. Beginning in the fall of 2019, 26 pilot programs began teaching elementary agriculture throughout Georgia (C. Steinkamp, personal communication, August 6, 2019). A small, but substantial body of research exists examining agricultural education outside of grades 6-12, however no research exists examining elementary agricultural education as a formal classroom program. Therefore, this research intends to analyze the interaction between agricultural and science, technology, engineering, and mathematics (STEM) literacies. Both agricultural and STEM literacies will be fully expounded upon in chapter two of this thesis, which outlines the existing knowledge base on both literacies. The basis of this study arose from the need to analyze the practice of agricultural education in elementary schools. Evidence existed to support that agricultural education in elementary schools is beneficial in producing a more scientifically and agriculturally literate base (Meischen & Trexler, 2003; Mabie & Baker, 1996). Georgia was the first state in the United States to have a state-level standardized curriculum for elementary agricultural education, and it is worth evaluating this curriculum to see the interactions between agricultural and STEM literacies.

So far, this thesis has centered on *how* Georgia is establishing elementary agricultural education, but the even more salient question is *why*. Creating a new subset of elementary education is a large undertaking; what is the logic behind doing so? Recent polls have shown that the US is 24th out of 71 countries in science proficiency and 38th in mathematics (Desilver, 2017). These results have shown that the United States could be doing better in its teaching of STEM. Elementary agricultural education was one possible contributor to create a STEM educated society. The severity of student science illiteracy was discussed more completely in chapter two.

The non-experimental design for this study was needed primarily because a true experimental design was not feasible with elementary students as true randomization cannot be achieved. This research may provide evidence for improving Georgia's emerging elementary agricultural education program. Another reason this study was needed was because of the liberty that these pilot programs had in their presentation of curriculum. Analyzing student performance in this study could highlight effective teaching strategies that could be shared with the greater education community. A final reason for conducting this study was because of the demographics represented in the pilot programs. These elementary schools represent urban areas and rural communities. While both settings can have equally low agricultural and scientific literacy levels, it is important to highlight what students require to understand both agriculture and science at a higher proficiency (Meischen & Trexler, 2003).

Problem Statement

Will the establishment of elementary agricultural education increase student increase agricultural literacy and/or improve STEM knowledge scores for 3rd and 4th grade students? This research study aimed at providing evidence that would answer these questions. By doing so, the science, education, and agricultural communities will have an opportunity to identify strengths and weaknesses in the pilot program.

Research Questions

The objective of this study was to conduct quantitative research to determine the effectiveness, or lack thereof, of teaching elementary students in an agriculture classroom. “Effectiveness” being defined by the researcher as the positive impact (testing performance, perception, etc.) that occurs as a result of teaching agriculture at this level. Research existed on standardized curriculum for middle and high school grades, but elementary agricultural education was new territory to navigate. The key question remains: “is this program worth the effort?” By collecting data via a pretest-posttest non-experimental design, the researcher was able to provide tangible data to teachers, legislators, and the public on the impact of elementary agricultural education. The data that was collected were pretest-posttest scores on standardized assessments that address science and agricultural standards for grades 3 and 4 in Georgia.

Specifically, the research questions for this study were as follows:

1. Does elementary agricultural education impact student agricultural literacy in 3rd and 4th grade students?
2. Does elementary agricultural education impact student science knowledge in 3rd and 4th grade students?

Hypotheses

Two hypotheses have been developed to test the completion of each question.

H^0 objective 1: elementary agricultural education will have no impact student agricultural literacy in 3rd and 4th grade students

H^1 objective 1: elementary agricultural education will impact student agricultural literacy in 3rd and 4th grade students

H^0 objective 2: elementary agricultural education will have no impact student science knowledge in 3rd and 4th grade students

H^1 objective 2: elementary agricultural education will impact student science knowledge in 3rd and 4th grade students

The alternative hypothesis that was developed for this study stated a difference in elementary agricultural education. Alternative: if we compare pre-test and post-test scores for 3rd and 4th grade students in elementary agricultural education, we will see a significant positive difference on post-test scores.

The connection of these hypotheses to the literature was seen in two ways: (1) student understanding of agriculture increased when exposed to curriculum, (2) standardized testing of secondary grades' agriculture and traditional curriculum demonstrated no difference (Mabie & Baker, 1996; Connors & Elliot, 1995). The hypotheses listed aim to test the validity of these two claims. Is agricultural education beneficial in elementary grades? Will science testing scores show a significant difference in favor of agricultural education? It is worth noting that in Connors & Elliot the population studied was high school students. It is possible that elementary students retain information differently and will have improved testing scores as a result.

Definition of Terms

Agricultural Education: the process of teaching students about agriculture, food, and natural resources. Comprised of three interconnected facets: classroom/laboratory instruction, experiential learning, and leadership education (NAAE, 2019).

Agricultural literacy: "possessing knowledge and understanding of our food and fiber system. An individual possessing such knowledge would be able to synthesize, analyze, and communicate basic information about agriculture. Basic agricultural information includes: the production of plant and animal products, the economic impact of agriculture, its societal significance, agriculture's important relationship with natural resources and the environment, the processing and marketing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products" (Frick, Kahler, & Miller, 1991).

Curriculum: "a course of study that will enable the learner to acquire specific knowledge and skills" (University of Delaware, 2005).

Elementary Agricultural Education: sect of agricultural education established in Georgia as a result of SB330, following developed elementary agricultural education standards developed by the Georgia Department of Education.

Elementary Agricultural Education Teacher: teacher that follows the elementary agricultural education standards developed by the Georgia Department of education.

Experiential learning: "process where knowledge is created through the transformation of experience." Cycle of four components: concrete experience, reflective observation, abstract conceptualization, and active experimentation. (Kolb, 1984).

STEM literacy: "knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity for all students" (NRC, 1996).

Limitations

There are certain limitations to this study that were taken into consideration. The aim of this data was to serve as a representation of student agricultural literacy and science literacy. While the researcher would like to see how this data set correlates to standardized testing scores, 3rd and 4th grade students do not have to take standardized tests in science or agriculture.

Standardization for science begins in 5th grade for Georgia students and continues throughout the rest of the school careers. While this research would best be conducted over the course of a complete calendar year, this study focused on a pilot program with a limited amount of time for executing the study.

Further limitations of this study were bound by teacher/student buy-in and approval. To conduct this study, the permission of each student's guardian was needed. This is to protect the privacy that each student is entitled. Teacher and school commitment are further limitations that will need to be addressed. While 26 pilot programs conducted elementary agriculture, none of these were required to participate in this study. This resulted in volunteerism, in hopes of improving elementary agricultural education. Five schools decided to participate in this research study.

Since the schools taught agricultural education as a once-per-week rotation, another limitation was the lack of randomization. This meant that it was uncontrollable who received curriculum and who did not. Since there was no formal randomization, this study was non-experimental in its approach.

An additional limitation of this study was based in subjectivity. While conducting this research, the researcher was earning a master's degree in agricultural and environmental education. The reason for such a degree was to teach agricultural education at a school in the future. Another bias that might be a factor was the researcher's involvement within agricultural education as a student. Throughout middle school and high school, the researcher was actively involved in a position of leadership in their local chapter of the National FFA Organization. While these biases exist, they were mitigated through objective, stringent research methodologies. Whether the data proved elementary agricultural education was viable or not, it was necessary to have statistical information to arrive at such conclusions.

Assumptions

When conducting this research, there were basic assumptions that must be discussed. The first was that there will be some maturation and historical differences across the course of this study. Students change with time and their perspectives may alter based on their past, thus affecting response data. To avoid this, the instrument was designed to avoid response and instrumentation bias which will be discussed more thoroughly in chapter three. The researcher also assumed that the agriculture and science standards will be presented thoroughly by educators participating in the pilot program.

Significance

As Georgia's Department of Education (DOE) was the first state DOE to pilot elementary agricultural education, education professionals nationwide can follow Georgia as an archetype for the implementation of elementary agriculture programs throughout the rest of the country. Even more so, the legislation has been passed and the programs are coming. The researcher must take advantage of any opportunity for data that they can, so that students can be served to the best of our ability. If the education community desires to have a better educated student body, they need to know to what level students understand and interact with curriculum. Furthermore, the problem was significant due to the diversity of expert opinion. Elementary agricultural education was beneficial with teachers' main complaints being that of implementation (Mabie & Baker, 1996; Graves, Hughes, & Blagopal, 2016; Hubert, Frank, & Igo, 2000; Powell & Agnew, 2011). In contrast, research conducted in high schools show no significant difference between standardized science scores of agricultural and traditional students

(Connors & Elliot, 1995). Divisions not only exist in research literature but also in the personal opinions of Georgia agriculture teachers. While 70.6% of agriculture teachers support the implementation of elementary agriculture, there was also a sector that believe that creating this program exacerbates existing problems in the current landscape, specifically funding and employment (Georgia Department of Education, 2018). In summary, this problem was significant because it: (1) may serve as an archetype for the US, (2) is going to occur, and (3) has divisive opinions.

CHAPTER 2

LITERATURE REVIEW

The following literature review was framed around four subheadings: agricultural literacy, STEM literacy, impacts of agricultural education, and teacher perceptions of agricultural education.

Agricultural Literacy

Defining Agricultural Literacy

Agricultural literacy was defined as "possessing knowledge and understanding of our food and fiber system. An individual possessing such knowledge would be able to synthesize, analyze, and communicate basic information about agriculture. Basic agricultural information includes: the production of plant and animal products, the economic impact of agriculture, its societal significance, agriculture's important relationship with natural resources and the environment, the processing and marketing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products" (Frick, Kahler, & Miller, 1991, p. 54). This definition was developed by research conducted by Frick, Kahler, & Miller (1991) as a result of an agricultural literacy push from the National Research Council. While the researcher acknowledged the age of this definition, it should be noted that this was the most common definition provided in the research of others. In Frick, Kahler, and Miller's (1991) article "A definition and the concepts of agricultural literacy," the authors conducted a Delphi study with 147 members of the agricultural industry and elementary, secondary, and higher education professionals. This study garnered the opinions of these influencers in American education to see what pertinent topics should be addressed in the classroom and public arena. By creating an all-encompassing definition of agricultural literacy, Frick, Kahler, & Martin (1991) identified proficiencies that a layperson should have regarding agricultural topics.

Agricultural literacy initiatives existed before Frick, Kahler, & Martin (1991) created their definition. The National Research Council (NRC) spearheaded efforts to illustrate the importance of agriculture to society as a whole. It has been noted that 90% of the US population is two to three generations removed from food and fiber production (Pense, Leising, Portillo, & Igo, 2005). The NRC began to focus on the subject of agricultural literacy as a result of the "diminishing profitability of American agriculture and the decrease of agricultural education enrollments in secondary schools" (Kovar & Ball, 2013, p. 168). As a result of this NRC initiative, agricultural education began to diffuse into urban and suburban communities, while eliminating labels like "vocational" to prevent the reinforcement of stereotypes (Kovar & Ball, 2013, p. 168). With the NRC's publication, agricultural literacy became a zeitgeist topic.

Thankfully, agricultural literacy research has proliferated throughout the social science, education, and agriculture communities as illustrated by Kovar & Ball (2013). Kovar & Ball (2013) conducted a synthesis of the literature which has served as a boon to those trying to deduce where we stand in agricultural literacy research. Their study raised the question: if we are using traditional methods to evaluate literacy, is the understanding of agriculture truly being evaluated? (Kovar & Ball, 2013). A synthesis helps researchers to see where research has been and where it should continue. Their research analyzed 49 studies across the spectrum of agricultural literacy. At the time of publication, there were 23 studies that assessed agricultural literacy, 19 that tested a program for agricultural literacy, and 7 developed a framework or guide for teaching (Kovar & Ball, 2013). According to their collection of research data, 10 studies found that elementary students had “some knowledge of agriculture,” while 6 studies showed that elementary teachers/students and college students were “agriculturally illiterate.” An interesting finding of their research was the one research study that showed that suburban students had significantly higher literacy scores than those rural and urban schools. The conclusion of Kovar & Ball’s synthesis posited that agricultural literacy should begin focusing on a broader audience, rather than just in schools.

Within Frick, Kahler, and Miller’s definition, agricultural literacy included the ability to “synthesize, analyze, and communicate basic information about agriculture” (Frick, Kahler, & Miller, 1991). To what level? Knobloch (2000) asked: “Should students be able to carry on a conversation with an agriculture professional? Is that realistic?” (p.6). Rather than having students, specifically elementary students, try to attain something that is mentally impossible, he proposed a practical way to evaluate conversational agricultural literacy. There were three ways to do this: 1.) was this student using age-appropriate vocabulary to explain a topic? 2.) was the information correct? 3.) did argumentation flow logically? If a student was able to do these three things, no matter the age or experience level, they were considered conversationally agriculturally literate.

Furthermore, Meischen and Trexler (2003) studied elementary students’ agricultural literacy levels. While their study was particularly focused on how well students understood meat and livestock production, they provided a helpful “updated” definition of agricultural literacy. Their definition was built off of the work done by Frick, Kahler, and Martin (1991) adding in a deeper conversational component like that of Knobloch. Meischen and Trexler (2003) defined agricultural literacy as:

> Agricultural literacy entails knowledge and understanding of agriculturally related scientific and technologically based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. At a minimum, if a person were literate about agriculture, food, fiber, and natural resource systems, he or she would be able to a) engage in social conversation, b) evaluate the validity of media c) identify local, national, and international issues, and d) pose and evaluate arguments based on scientific evidence. Because agriculture is a unique culture, an understanding of beliefs inherent in agriculture should also be included in a definition of agricultural literacy so people can become engaged in the system. (p. 44)

It was worth noting the thoroughness of their definition. Not only did it include proficiency in an agricultural topic, but it also considered discursive skills and cultural differences.

Current Level of Agricultural Literacy

Now that a set of definitions were presented, the researcher deemed it appropriate that the current level of agricultural literacy be evaluated. This section highlighted a broad group of individuals including elementary students, college students, and educators. By assessing each group, the researcher was able to see the overall agricultural literacy ecosystem in American education. Elementary school agricultural literacy has been evaluated by a plethora of agriculture researchers. Between the years of 1988-2011, 15 agricultural literacy research studies were completed (Kovar & Ball, 2013). The primary goal of these studies was to gauge American students' ability to converse about agriculture in way that was correct and age appropriate. The purpose of this subheading was to highlight the proficiency levels of these various groups and identify any gaps present.

Elementary school was the first experience most students have in a classroom. At this younger age, students were more prone to form opinions on a subject that will last a lifetime (Terry, Herring, & Larke, 1992). According to psychologists Freud, Piaget, and Erikson, people formulated ideas and notions that last throughout their lives "between years 6-11" (Terry, Herring, & Larke, 1992, p. 51). This narrow window urged agricultural literacy researchers to understand the level that students were performing at and how to improve their literacy. While elementary teachers will be discussed later in this subheading, we will begin with elementary students to set the stage.

Not only have researchers Meischen and Trexler provided the public with an updated definition of agricultural literacy, but they have also served as prominent elementary literacy analysts. They posited that literacy is constantly evolving as society evolves (Trexler, 2000). As a result, they crafted a study that aimed to evaluate how well students understand livestock and meat production. The population that they collected their sample from were elementary students at a rural Midwestern school. The authors noted that "rural non-farm students also lag behind their on-farm peers" and that "rural can no longer be directly associated with 'farm'" (Meischen & Trexler, 2003, p. 44). Their objectives were to see the backgrounds that students had with livestock/meat production, compare student understanding of production to science/agricultural standards, and determine if correlation existed between students' backgrounds with meat production and their literacy level. By employing qualitative methodology, the researchers were able to have authentic interviews that posed questions based on literacy benchmarks developed by Trexler in 1999. Results showed that students' "language used was not compatible with expert conceptions" and that "students lacked understanding of agricultural concepts even though they were raised in rural areas" (Meischen & Trexler, 2003, p. 51). Students with on-farm experience fared better than their peers, but still lacked an accurate understanding of processing and vocabulary. The researchers' recommendations included adding a vocabulary component to the Trexler benchmarks and to test the benchmarks even further to ensure their accuracy. One recommendation stood out as the researchers posed a significant question: with the recent push towards urban literacy, "should the agricultural literacy movement be primarily focused on urban/suburban students?" (Meischen & Trexler, 2003, p. 44).

Akin to the study conducted by Meischen and Trexler in 2003, Hess and Trexler sought to further understand urban students' knowledge levels in 2011. Building off of Knobloch's call to "conversational literacy," the researchers were interested in the formation of *schemata* in elementary students. The authors stated that learning is "the integration of new perceptions and ideas into existing conceptual frameworks called schemata" (Hess & Trexler, 2011, p. 152). Schemata are mental patterns that a person uses to connect new information to previous information. These concepts were first put forth by psychologists Piaget and Ausubel. Hess & Trexler's research objectives were to: determine subjects' backgrounds/agriculture experiences, compare subject understanding to expert knowledge, and to determine if connections existed between backgrounds, experience, and knowledge of agriculture (Hess & Trexler, 2011). 18 4th-6th grade students from an urban center in California served as the sample. Qualitative interviews had students "dissect a cheeseburger" and identify how its component parts related back to agriculture. They found that subjects had a very basic understanding of plant and animal production but lacked a greater understanding of processed foods. Stark examples include one student that assumed that pickles came from "tigers" and that bread was an animal by-product (Hess & Trexler, 2011). Little agricultural knowledge paired with inaccurate vocabulary led the researchers to conclude that this group was agriculturally illiterate. The students researched "lacked schemata necessary for agricultural discourse" and their experiences with agriculture in daily life proved insufficient for conversational agricultural literacy. The researchers called for further analysis of the "gaps between accurate schema and underdeveloped schema."

Trexler, Hess, and Hayes returned to this topic of schemata development again in 2013. This study used the same data set but sought to evaluate the impact that age, race, gender, and agricultural experiences had on understanding food crop origins, environmental conditions, and food safety. Following the aforementioned cheeseburger dissection, students were guided into conversations about where these products come from, how they affect the environment, and how the products are kept safe. The researchers noted that "no informant conveyed an understanding of where food originated" and that "environmental conditions were not expressed by any" (Trexler, Hess, & Hayes, 2013, p. 52). Only 4 of the students mentioned spoilage prevention, while only 2 mentioned sanitation as a whole. They found that no pattern existed with regard to "age, race, gender, and agriculturally-related experiences" (Trexler, Hess, & Hayes, 2013, p. 55). The researchers prescribed that teachers be trained in "schema development and reconstruction," while also retooling benchmarks because current benchmarks were "based on guesses rather than systemic research."

In an effort to better analyze and improve elementary student agricultural literacy, the National Agricultural Literary Outcomes were developed by the National Center for Agricultural Literacy. The NALOs were a "set of standards to measure student understanding of agricultural concepts and help engage with others (conversational literacy)" (Brandt, Forbes, & Keshwani, 2017, p. 135). While Brandt et al.'s research was covered more in depth in the 3rd heading of this literature review, their findings related to student performance in STEM and agricultural education were best suited for discussion here. Their mixed-methods study, which used interviews to formulate a quantitative assessment, gathered data on 400 students across 3rd, 4th, and 5th grade. Students completed two assessments, one that covered STEM and one on agriculture. One of their research questions focused on the current level of agricultural literacy in elementary schools by highlighting the differences between student performance in STEM and agriculture. They wanted to know if "students are more knowledgeable about agricultural/environmental topics than STEM" (Brandt, Forbes, & Keshwani, 2017, p. 134). Through the completion of two short achievement tests, the researchers found that students performed "significantly higher" on the STEM assessments than the agricultural ones. While students understand the technologies often used in agriculture (those being GPS, computers, etc.), they failed to make links between agriculture and science. Specific areas where students lacked, according to correct response rate, included genetics (53.6%), agricultural vocabulary, and most severely, in conservation (49.9%) (Brandt, Forbes, & Keshwani, 2017). 5th grade students were the most agriculturally literate, but this could have been primarily attributed to a better grasp on vocabulary and learner maturation. Their recommendations included having "grade appropriate lesson plans" that connected the "how and why" of agricultural science. Students needed to see the "synergistic relationship between STEM concepts and agricultural literacy" (Brandt, Forbes, & Keshwani, 2017, p. 146).

A lack in elementary agricultural literacy may raise questions on curricula and how the subject is being taught. In an effort to explore this issue, Vallera & Bodzin (2016) sought to see how agricultural literacy was being presented in upper-elementary science curricula. The researchers took a sample of 12 elementary school science textbooks to see the ways in which agriculture was being taught and represented. This study focused on "knowledge, skills, attitudes, and beliefs about the field of agriculture" (Vallera & Bodzin, 2016, p. 101). "KSABs" echo the established definitions of agricultural literacy, reinforcing one's ability to understand agriculture and form educated opinions. Furthermore, the authors noted the distinction between agricultural education and agricultural literacy. They posited that agricultural education's purpose was to "prepare for work within agriculture," while agricultural literacy strengthened the common knowledge-base of both the layperson and the professional. Vallera & Bodzin (2016) took the concepts of agricultural literacy even deeper, where they argued that scientific literacy does not equal environmental literacy which does not equal agricultural literacy. Each one of these topics were important in elementary science education, but they struggled to find a textbook that connected all of these literacies. The National Research Council's call for the integration of agriculture into existing educational structures was directly affected by how agriculture is presented in "basal textbooks and curricula." The diffusion of agriculture can be obstructed if students have negative perceptions reinforced by inadequate textbooks (Vallera & Bodzin, 2016). After performing a content analysis on 12 textbooks commonly used within 4^{th} and 5^{th} grades, they found that agricultural concepts were lacking from the curricula. For example, concepts like "plants" and "water" were connected to one another but not to production of plants through agriculture. This could have helped create "relevant, authentic, and familiar examples and connections for students" (Vallera & Bodzin, 2016, p.103). The authors note that agriculture was not being used to its full potential in science, especially since science was one of most readily available subjects where literacy can be reintegrated. Recommendations from this study included teacher professional development to better diffuse agricultural literacy into to preexisting educational structures.

After considering the level of agricultural literacy in elementary grades, attention was shifted towards postsecondary students. The logic behind segueing from younger students to those nearing the completion of their educational career was to see if assertions made by Piaget and Ausubel are still accurate. Did notions formed early in one's life hold true until adulthood? Birkenholz, Harris, and Pry (1994) studied a group of college students enrolled in a "World Food and Society" course at Southeast Missouri State University in the fall of 1992. Their objectives were to assess the knowledge and perceptions of a rising consumer class, i.e. those students who are about to enter the workforce full-time. Around the time of this study, there was a rising call to assess the knowledge and perceptions of consumers who purchase agricultural products (Traxler, 1992). The students in this study were not agriculture majors and had opted to take the class to meet elective credit. Birkenholz et al. wanted to see how the interactions of knowledge, perception, and demographics impacted student performance on an assessment. The demographic breakdowns of the students were 55% urban, 23% rural, and 10% farm (Birkenholz, Harris, & Pry, 1994). In relation to student knowledge, those students that performed the highest were white, had relatives on farms, and raised crops/gardens. The students that were from larger population centers were less knowledgeable about agriculture. The authors noted how problematic this was because of how vocal people from large population centers were in relation to agricultural issues (Birkenholz, Harris, & Pry, 1994). Urban student perceptions were not "negative," but were less positive. Those students with the most favorable perceptions towards agriculture were those who completed agricultural courses in high school. The authors proposed that agricultural educators can improve college student knowledge and perceptions by encouraging on-farm visits, instituting agricultural education for elementary, secondary, and college, and by having programs that address and overcome historical/sociological barriers amongst minorities in agriculture (Birkenholz, Harris, & Pry, 1994).

Educators served as another pertinent interest group when it came to agricultural literacy research. Agriculture has long been isolated into vocational pathways and electives, leading to educators that either know a plethora of information about agriculture or a dearth. While the NRC's inclusive call for "agricultural incorporation" was optimistic, researchers first must create a baseline to see what areas that teachers need help with (NRC, 1988). Research conducted by Harris & Birkenholz (1996) sought to create a tangible data set on Missouri secondary educator's knowledge base in regard to agriculture. To start their study, they found that the education professionals most interested in agricultural inclusion were agricultural educators and secondary building administrators (Harris & Birkenholz, 1996). These stakeholders were often more familiar with agricultural curriculum and felt more confident in their ability to teach it. This study analyzed agricultural knowledge and perceptions of educators, while also shedding light on perception differences between administrators and educators. The instrument that was developed for this study was based on Frick, Kahler, and Miller's (1991) definition of agricultural literacy. The sample of 146 schools had 616 teachers complete the instrument. Unsurprisingly, the highest knowledge scores and most favorable attitudes towards agriculture were held by agricultural educators. The lowest scores for perception and knowledge were from mathematics and language arts teachers (Harris & Birkenholz, 1996). An interesting finding from this research study was that all of the teachers were found to be agriculturally literate, due to them scoring 80% or higher on the knowledge portion of the instrument. The researchers argued that this could be a "ceiling effect" where teachers achieved higher literacy scores as a result of them being at an agricultural/rural school (Harris & Birkenholz, 1996). This meant that these teachers may have reached a "ceiling" that prevented them from learning any more about a subject, unless they were presented with the information in a new, unique way. This ceiling effect was demonstrated through research conducted by Wright, Stewart, and Birkenholz in 1994. The results of this research appeared optimistic, but the researchers concluded that educators must experience a "felt need" before they will make accommodations for agriculture in their traditional classrooms.

Furthermore, educator literacy was investigated by Terry, Herring, and Larke in 1992. Homing in on 4th grade teachers in Texas, these researchers were able to provide salient data on teachers' knowledge levels in agriculture. At the time of their study, only "4.5% of US high school students were enrolled in agriculture classes" (Terry, Herring, & Larke, 1992, p. 51). Today, however, there are 800,000 students that are in said classrooms (NAAE, 2019). Of the over 50 million K-12 students in the US, this number represents approximately 1.6% of all students (National Center for Education Statistics, 2019). Educators were trying to mitigate the lack of agricultural literacy, as mentioned previously, but the success of any educational program depends on the ability of the teacher (Drake, 1990). Therefore, Terry et al.'s research objectives were to identify professional/personal characteristics amongst 4th grade teachers in Texas, determine their perception/knowledge level, see how often they used agriculture in their classrooms, and detect what assistance they would prefer (Terry, Herring, & Larke, 1992). The research team tested 800 Texas 4th grade teachers, spanning rural school districts to urban ones of 100,000 students. There was also an equal distribution of teachers that were raised on farms and those that were not. The instrument that was used was a multiple-choice, open-ended, and Likert-type questionnaire. Results indicated that 75% of teachers scored below a 60/100 on the knowledge portion, with the mean score being a 48.4% (Terry, Herring, & Larke, 1992). Their findings also showed that most teachers only saw agriculture as "the raising of plants and animals." This sample of teachers taught agriculture approximately 16 hours a year, primarily relying on textbooks. It should be noted that textbooks, according to the research conducted by

Vallera et al. (2016), often inaccurately depicted agriculture. While 97% of teachers used agriculture in some form or fashion, they still desired “unstructured assistance programs” (Terry, Herring, & Larke, 1992, p. 58). Similar to Birkenholz, Harris, and Pry (1994), the teachers that preferred using agriculture and did so correctly were teachers that had a history of participation with organizations like the National FFA Organization. In summary, the results of this study demonstrated that teachers had “incorrect perceptions of agriculture,” yet still were using agriculture in their classrooms. The recommendations that Terry, Herring, and Larke had included having teachers participate in agricultural preparatory courses in their undergraduate coursework (1992).

Efforts to Improve Agricultural Literacy

With a baseline of agricultural literacy established, attention was then shifted to the programs that were attempting to mitigate the lack of agricultural literacy. This subheading covered a few approaches in smaller detail, as the third heading of this literature review dove into the methodologies behind these approaches. Thankfully, some interest groups have noticed the waning levels of agricultural literacy and have tried to assuage the damage that agricultural illiteracy causes. The following programs’ intended audiences include students and educators of all ages.

While agricultural education was commonplace in schools centuries ago, society became more industrialized and programs began to shift (Hubert, Frank, & Igo, 2000). In the latter part of the 1800s, agriculture classes became the “nature study” movement that “aimed at bringing reality to science lessons in elementary classrooms” (Hubert, Frank, & Igo, 2000). As students moved away from the farm, nature study topics, rather than agriculture, became more familiar with students. Over time students became even more agriculturally illiterate, possibly as a result of greater urban sprawl and the loss of productive acreage (Hubert, Frank, & Igo, 2000). This negative feedback loop exacerbated over time. A guide to *Food and Fiber Systems Literacy (FFSL)* was developed by Oklahoma State University in the mid-1990s. This guide was an effort to infuse agricultural topics into preexisting curriculum. The FFSL guide provided a framework to educators that allowed for them to incorporate their own distinct teaching methodologies, while still addressing agricultural topics. In short, teachers could decide how they wanted to utilize the standards in their respective classrooms. The framework was broken up into five distinct themes: 1.) Understanding agriculture, 2.) History, culture, and geography, 3.) Science and environment, 4.) Business and economics, and 5.) Food, nutrition, and health (Hubert, Frank, & Igo, 2000). Hubert, Frank, and Igo studied the effects of this new curricular approach in 2000. Their research found that, when "implemented consciously" through connections to the existing curriculum, the FFSL guide led to improvements across the five themes. This attempt to improve agricultural literacy was deemed efficacious.

The FFSL framework was "widely accepted as the standards of agricultural literacy" upon their development (Powell & Agnew, 2011). Building off of the standards that were developed in the 1990s, another program was created as a vehicle to present FFSL. Food, Land, and People (FLP) was a 55-unit curriculum that was used in 27 states across the US. These units taught agricultural literacy by way of science, math, social studies, and language arts in grades K-12 (Powell & Agnew, 2011). Powell and Agnew studied how FLP "addressed agricultural literacy standards for K-5" (2011). Both FLP and FFSL were created and field tested around the same time and have been used in conjunction since 1996 in classrooms. Similar to the research done by Hubert and Igo, FFSL was open to integration by the educators incorporating the subject. FLP provided units that teachers could use to streamline adherence to FFSL standards.

This followed the curriculum infusion approach which overlapped subjects around the academic core (Powell & Agnew, 2011). FLP intertwined food, land, and people both individually and as the collective, to show the impact of agriculture on society. Some of the reasons teachers did not use FFSL prior to FLP were time constraints and lack of preparation. Researchers, upon analyzing the "depth" and "breadth" of FLP instruction, found that all FFSL benchmarks were addressed through the FLP curriculum (Powell & Agnew, 2011). This meant that for the time restricted educator, FLP was a viable tool in presenting agricultural literacy standards. While there was a strong correlation between FLP and science courses, the researchers recommended having collaboration between the curriculum developers and educators to better cater to students' needs.

Further efforts to promote agricultural literacy were found in the "Ag in the Classroom" curriculum (AITC). AITC was developed by state departments of agriculture and Farm Bureau and acted as one of the first waves of agricultural education in K-5. This program sought to incorporate agricultural knowledge into educators' subject areas, furthering the concepts of curricular infusion (Pense, Leising, Portillo, & Igo, 2005). A research study was conducted by Pense et al. (2005) to "identify gaps in student knowledge of agriculture" in relation to AITC and the Food and Fiber Systems Literacy (FFSL) framework (Pense, Leising, Portillo, & Igo, 2005). The theoretical framework that their research was housed in was that of agricultural literacy. Best demonstrated as a multiple Venn diagram, agricultural literacy interacted and was intertwined with subjects which ranged from science and social studies to math and economics. An instrument was developed to analyze the relationship between student performance, FFSL standards, and AITC. The researchers, upon studying the results of their study, found that AITC programs "made positive differences in student acquisition of knowledge about agriculture"

(Pense, Leising, Portillo, & Igo, 2005). Students gained knowledge across all five FFSL themes and lower grade elementary teachers were able to make more connections to students, thus increasing their instrument scores. The researchers recommended that this curriculum model be fully implemented within each grade level to promote "systematic progress in agricultural literacy" (Pense, Leising, Portillo, & Igo, 2005, p. 117). By modeling their program after the FFSL framework, Ag in the Classroom implementers served as another example of an agricultural literacy effort that saw success.

After some approaches were discussed in regard to students, attention was then shifted towards educators. It was worthwhile to know what methods were being used to improve educator agricultural literacy, as this initiative was not solely aimed at improving the students' ability. The ability to synthesize, analyze, and communicate basic agricultural information was pertinent to the population as a whole, teachers included (Frick, Kahler, & Miller 1991). One such study that looked at teachers was conducted by Swortzel in 1997. His research took "AgVenture," a popular educational magazine that was used in Ohio and analyzed how teachers viewed the topics and utilized them in their classrooms. AgVenture was developed via the Ohio Agricultural Council, Ohio State University extension (OSU), the OSU College of Food, Agriculture, and Environmental sciences, and the greater Ohio agricultural community (Swortzel, 1997). Each specific issue of the magazine addressed a topic in Ohio agriculture, in hopes of creating a more knowledgeable constituency in the state. Swortzel (1997) wanted to see how the magazines were being used in 4th grade classrooms in Ohio and how teachers perceived AgVenture. Demographic data showed that a majority of the sample teachers were female and did not participate in Ag in the Classroom or Food for America (Swortzel, 1997). While the study was analyzed in further detail in the "impacts" subheading of this literature review, AgVenture was positively perceived by the sample group. Content was accurate but teachers often said they lacked time to utilize the resource in their classrooms. One of the more shocking results was the disconnect between elementary teachers and programs like FFA in the community, as teachers were virtually unaware of their local chapters. This study was conducted to gauge teachers' perceptions on a teaching resource, but also proved to be valuable in understanding teacher demographics and their knowledge about the agriculture community in their area. While the magazines were intended to focus on student populations, educators were also able to reap some of the benefits of having a diversified curriculum like this one.

Further efforts to improve educator literacy were found in a 1998 study conducted by Balschweid, Thompson, and Cole. Their study was centered on the implementation of a summer institute to educate teachers about agriculture. The Summer Agricultural Institute (SIA) was developed by Oregon State University and Oregon Farm Bureau to help teachers integrate agriculture into their curriculum (Balschweid, Thompson, & Cole, 1998). This research was conducted over an 8-year period and studied 52 teachers. A week-long training provided an overview of agriculture and its societal impact was observed to see the effects that demographics, perceptions, and barriers had on teacher agricultural literacy. The SAI had teachers create a lesson plan at the end of their week of training to demonstrate the knowledge that they had gained. This lesson plan incorporated agriculture into an existing lesson within a teacher's area of expertise. The overwhelming majority of participants were veteran teachers with between 3-35 years of teaching experience. Also, worth noting, over half of the participants at the Summer Agricultural Institute were elementary teachers (Balschweid, Thompson, & Cole, 1998). The results concluded that teachers had high perceptions of agriculture, a 4.33 on a 5-point Likert-type survey. Their most common barrier was a lack of time, followed by a lack of resources. Teachers found the "content, structure, and usability of agriculture information presented at SAI was effective and the materials were useful" (Balschweid, Thompson, & Cole, 1998). The researchers recommended that future studies look at why younger teachers were not interested in participating and how to mitigate the damage that a lack of resources have on agricultural education.

Science, Technology, Engineering, and Math (STEM) Literacy

The literature review then shifted towards STEM literacy. In the following subheadings: "STEM literacy" was defined, a baseline of STEM literacy was established, programs to mitigate and reverse STEM illiteracy were discussed, and any connections that exist between STEM literacy and agricultural literacy were drawn. By selecting a wide swath of literature across science education, the researcher hoped to create an all-encompassing picture of modern science education in the US.

Defining STEM Literacy

Similar to agricultural literacy, it was important to use proper terminology when discussing STEM literacy. The National Research Council set forth a definition that was used for this study. The NRC defined STEM literacy as the "knowledge and understanding of scientific and mathematical concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity for all students" (NRC, 1996). As one might notice, there was an emphasis on both content knowledge and one's ability to participate in society at large. STEM literacy required that a person better understand scientific processes and communicate in a way that is factually accurate and developmentally appropriate.

A study by the National Research Council in 2011 set forth the goals for STEM education in the US. Their study homed in on the science and mathematics components of STEM because they are foundational for technology and engineering as well. They posited that STEM is the primary driver for the next wave of careers, as "4% of the US workforce are scientists and engineers, creating jobs for the other 96%" (NRC, 2011). Furthering the importance of STEM was the correlation between K-12 STEM education and scientific leadership and economic growth. Their goals aimed at training for STEM jobs, growing the STEM workforce, and increasing scientific literacy among the general public (NRC, 2011).

While defining STEM literacy was beneficial for the purposes of this study, it was also worthwhile to investigate what distinguishes STEM education. Holmlund, Lesseig, and Slavit described the uncertainty that exists around STEM education. They found that three themes were often present within STEM education: 1.) Interdisciplinary connection, 2.) New instructional practices, and 3.) Real-world problem solving for students (Holmlund, Lesseig, & Slavit, 2018). While the authors posited that these three facets were vital, they also held that "a single worldwide definition for STEM is not critical." Their 2018 article sought to gather together how STEM was being taught in the US and how it could help "students attain their goals" (Holmlund, Lesseig, & Slavit, 2018). The authors argued that the institution of science, technology, engineering, and mathematics curriculum could create a better "global citizenry." The theoretical framework that Holmlund and company operated within was that of "sensemaking theory." This theory stated that "when a person encounters a gap between what exists and a proposed change or innovation" both "individual processing and socially interactive work occurs" (Holmlund, Lesseig, & Slavit, 2018, p. 3). Another way of explaining this concept is how the collective ascribes meaning to social experiences, creating knowledge as a group. The authors chose this framework because they sought to use a group to identify what makes STEM education, *STEM education*. Their study had 34 participants, including 13 teachers and administrators, 12 traditional middle school teachers, and 9 STEM educators. Through this diverse group, the authors aimed at deducing what STEM education was and if commonalities existed between participants (Holmlund, Lesseig, & Slavit, 2018). Their study revealed that the prevailing theme that existed was the "interdisciplinary nature of STEM education." While the authors concluded their article with the sentiment that a worldwide definition of STEM is not critical, it was helpful, via sensemaking, to understand what applications STEM education could be most useful (Holmlund, Lesseig, & Slavit, 2018).

How STEM literate are American students?

Now that a definition of STEM literacy was put forth, the next logical step was to analyze how STEM literate US students are. A report was developed by Epstein & Miller in 2011 that highlighted the "crisis in STEM education." The authors' thesis was centered on having underprepared teachers in the classroom, which in turn caused underprepared students (Epstein & Miller, 2011). The authors amalgamated multiple studies that demonstrated the dire straits that exist in STEM education. The following studies were cited in their report.

In 2011, the Program for International Student Assessment (PISA) revealed that the US was "average" for both mathematics and science, finishing in the middle of the 71 countries tested (PISA, 2011). In 2015, the US PISA ranking dropped even lower, with the US ranked 38th in math and 24th in science out of 71 countries (PISA, 2015). A similar metric, the Trends in International Mathematics and Science Study (TIMSS), showed that math scores for 4th and 8th graders in the US were average but behind the scores of Taiwan, Singapore, Japan, and Hong Kong. For science, American students were above average but lagged behind England, Russia, and the Czech Republic (Gonzalez, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2007). The National Assessment of Educational Progress (NAEP) conducted a study in 2009 that found only

39% of 4th graders were proficient in math, with that number dropping down to 34% proficiency in science (NAEP, 2009). The ramifications of this information were severe. Lower STEM proficiency in elementary leads to a less scientifically literate adult (Pew, 2009). Furthermore, diminishing scores in math and science were exacerbated by a lack of resources in lower income schools (Epstein & Miller, 2011).

Another report that sought to determine the levels of student STEM literacy was conducted by the National Research Council in 2011. While restating some of the same findings as Epstein & Miller, they also highlighted the gaps between various student populations. They reported that “black and Hispanic students are close to one standard deviation behind their white counterparts” (NRC, 2011). This disproportionate representation did not stop at grade school. Only “10% of STEM PhDs were non-white, non-Asian” despite minorities representing “25% of the population. As of 2007, international students represented more than 1/3 of the students in US science and engineering schools (NRC, 2011). One of the most pertinent goals of STEM literacy, reiterated in both the Epstein and NRC report, was to increase diversity in STEM.

A lack of STEM literacy interfered with employability of US students. As previously stated, only “4% of the US workforce are scientists and engineers” (NRC, 2011). While the job pool continued to expand, there was a dearth of students with the abilities to fill these positions. Employers “lament that job applicants lack the needed mathematics, computer, and problem-solving skills needed to succeed” (NRC, 2011, p. 3). The statistics reported above were not only alarming in their implications about student proficiency, but how they directly correlated to a waning working class in the United States. While these statistics make the problem seem insurmountable, there were efforts to mitigate the damage that has occurred.

Programs to Improve STEM literacy

Science, Technology, Engineering, and Mathematics are diverse subjects that can be presented pedagogically in a multitude of ways. Similar to Holmlund et al.'s argument that there need not be a concrete definition of STEM education, this portion was not intended to prescribe an ideal teaching method for STEM. Instead, this was an amalgamation of the ways in which STEM was being taught throughout the US. Multiple channels exist and it was advantageous to see the ways that schools implemented effective STEM curricula. The National Research Council did notice a commonality held by the various programs that exist. These programs "capitalize on students' early interest and experiences, build on what they know, and provide them with experiences to engage in science and sustain their interest" (NRC, 2011, p. 25). If students' interest was piqued, programs were more likely to retain and impact pupils.

According to the research literature, there were certain "key elements" that were present within effective STEM education. First and foremost, there should a clear link between standards and curriculum (NRC, 2011). It is important that students see what is expected of them from outset. In relation to curriculum, it was also shown that students have "greater achievement when there are fewer topics with greater depth" (NRC, 2011, p. 19). The second key element was having highly trained, high-capacity educators. Highly trained educators were often in short supply when it came to STEM education. 23% of teachers often had zero coursework in science education while gaining their undergraduate degrees (Epstein & Miller, 2011). In elementary schools this was often attributed to standardized testing, as most K-5 students were not tested in science on their end of course exams. In the state of Georgia, 3rd and 4th grades were not tested in science and often times teachers ended up placing greater weight on math, reading, and social studies (Epstein & Miller, 2011). According to multiple research studies, there was a stark contrast between teacher preparation and pedagogical content knowledge. Pedagogical Content Knowledge (PCK) was a teacher's ability to present content in a way that is grade appropriate and factually correct (Rice & Kitchel, 2017). PCK was reduced whenever a teacher did not have a firm grasp on the content they were presenting. US teachers ranked in the "40^{th} percentile in mathematics" and out of 77 schools only "13% provided quality mathematics preparation" (Epstein & Miller, 2011). Barber & Mourshed (2007) found that "top-performing systems were highly selective in admitting student to teacher preparation programs." One should note that only the top 5%, 10%, and 30% of students were accepted into teacher programs in South Korea, Finland, and Singapore, respectively (Barber & Mourshed, 2007). As stated previously, each of these countries were more effective at STEM education than the US (PISA, 2015). It was no surprise that teachers without an accurate understanding of math and science struggled to teach students about these concepts.

Furthermore, solutions were proposed by several interest groups to raise the standards of STEM educators. Recommendations put forth by Epstein & Miller included having a "3:1 framework" for future STEM teachers. This simply meant that a teacher would have three content courses (i.e. math, science, etc.) to each "teaching course" (Epstein & Miller, 2011). For example, if a future teacher wanted to teach science in the classroom, for each pedagogical class they would receive detailed instruction in biology, chemistry, earth science, and physics. This was an effort to ensure that not only could our educators teach a subject, but that they had a profound grasp on the topic themselves.

Another flawed component in regard to teacher preparation was the standards set forth by licensing agencies (Epstein & Miller, 2011). In the state of Georgia, a perfect score on the Georgia Assessments for the Certification of Educators (GACE) was a 300. However, the passing score for the "induction-level" was a 220 (GACE, 2019). This means that a teacher can teach at the base level with an average score of 73.3% on their content tests. In layman's terms, a teacher could teach a subject with a grade that was marginally passing. While a "professional-level" score was a 250, the same logic applied. An 83% on a content exam was expected of a teacher at a post-graduate level (GACE, 2019). In all but two states, "teachers can pass licensing exams without successfully passing the math portion of the test" (Epstein & Miller, 2011). This would be an adequate place to remind of our substandard performance compared to other countries, like Taiwan and Singapore where we scored a full standard deviation behind them (Epstein & Miller, 2011).

A final option to mitigate poor teacher performance was to cluster students in a calculated manner. By this, the authors meant that adept STEM teachers should have larger class sizes while the struggling teachers pursue certification at a higher standard (Epstein & Miller, 2011). This was known as the "Rocketship Education" charter school model. For example, a math/science specialist teacher would have 100 students a day, four blocks of 25. This teacher's affinity towards and proficiency in STEM would be rewarded with an increase in compensation. While this "cluster teacher" taught science, other teachers less adept in STEM would receive higher levels of certification and take part in the Rocketship (Kowal & Brinson, 2011). Greater compensation rates for more highly trained teachers would encourage a capitalistic approach to education and allow for meritocracy versus complacency. This addressed one of the major implications of research literature regarding student motivation, teacher ability, and overall performance in STEM. If we "reorient high-quality math and science education in early years" we will see greater STEM literacy into adulthood (Epstein & Miller, 2011; NRC, 2011; Pew, 2009).

After looking at standards and curriculum and high capacity teachers, the researcher returned back to the key elements of successful STEM programs discussed in the National Research Council's 2011 analysis. An important component that ensured quality STEM education was having a "supportive system of assessment and accountability" (NRC, 2011). Currently, most teachers are required to "teach to the test" which limits their ability to employ known pedagogical techniques that promote science and mathematical understanding. With the advent of No Child Left Behind (NCLB) policies, there was a shift from instilling a Deweyesque methodology of "learning to learn" to Prosser's pragmatism (Hyslop-Margison, 1999). Tests have shifted from abstract thinking questions to multiple-choice, which many states argue have limited the ways in which students can be evaluated (US Government Accountability Office, 2009).

Previously, the NRC had proposed a "system of science assessments … comprised of a variety of assessment strategies" (NRC, 2011, p. 21). This report called for "horizontal, vertical, and developmental coherence" for standards-based assessments. Horizontal coherence meant that the "curriculum, instruction, and assessments were aligned with the same standards, targeted the same goals, and supported students' science literacy" (NRC, 2006). Vertical coherence's goal was to have "all levels of education" (i.e. class, school, district, and state) "share a vision on the goals for science education, the purposes/uses of assessments, and what constituted competent performance" (NRC, 2006). Finally, coherence for standards-based assessment related to student development. "Developmental coherence" placed students' scientific learning into their perspective competency level (NRC, 2006). Simply put, was the student at the level that they should be for their developmental stage? The goal of being coherent along these three axes helped to ensure that science assessments were appropriate and effective.

The fourth key element for effective STEM instruction was having adequate instructional time (NRC, 2011). As previously mentioned, with the advent of standardization, there was a shift towards educating elementary school students on English language arts (ELA) and mathematics. If teachers were being evaluated by their students' performance on language arts and mathematics assessments, it should come as no surprise that these same teachers were letting the brunt of their instructional time revolve around ELA and math. According to a 2007 study of national elementary schools, teachers reported spending "178 minutes per week on science." Compare this to the "323 minutes on mathematics" and the "503 minutes spent on ELA" (Center on Education Policy, 2007). Furthermore, 28% of the districts reported efforts to further decrease science instruction in the elementary classroom (Center on Education Policy, 2007). Another study cited that 80% of elementary teachers in the Bay Area were spending "60 minutes or less per week on science, with 16% of teacher spending no time at all on science" (Dorph, Goldstein, Lee, Lepori, Schneider, & Venkatesan, 2007).

The final component to effective STEM instruction, according to the National Research Council, was having "equal access to high-quality STEM learning opportunities" (NRC, 2011). Years of research have shown that there was achievement disparity between students from "different socioeconomic, racial, and ethnic groups" (Hill, 2008). Not only was there a difference between students with contrasting backgrounds, schools as a whole were highly variable. While some schools had a plethora of resources to encourage and initiate student learning, other schools were bound by limited funds which led to "inadequate laboratory facilities, resources, and supplies" (NRC, 2006). A supply dearth caused underrepresented populations to flounder even further. Solutions to this problem were complex, but there were a few that could mitigate the damages that lack of funding causes. The first method was to place well-trained teachers in all classrooms to “redress the imbalance” (NRC, 2011). If all students were being instructed by the same high-performing educator, students should begin to see gains compared to if they had a lower-performing teacher. “Detracking” was another tactic to avoid students from slipping behind their peers. Detracking, akin to inclusion, meant that classrooms contained a range of student abilities (NRC, 2011). While successful cases of detracking were difficult to find, due to the inherit differences between each student, when it did occur low-achieving students were able to receive high-level instruction (NRC, 2011). Detracking kept students from being “stuck” in one track. This gave them agency and the ability to self-improve.

Now that the components of effective STEM education were addressed, the researcher outlined the current STEM education models that existed in the US. The four types of STEM schools that were discussed were: (1) selective STEM schools, (2) inclusive STEM schools, (3) STEM CTE schools, and (4) comprehensive STEM schools (NRC, 2011). Each type of STEM school had its perks and drawbacks and they were discussed in detail in the following paragraphs. The goal in outlining these STEM schools was to provide a more inclusive picture of the STEM education landscape in the US.

Selective STEM schools were a common vehicle of effective STEM instruction in the US. Selective STEM schools were often “organized around one or more of the STEM disciplines and have selective admissions criteria” (NRC, 2011). Students were highly skilled and were selected based on admissions criteria, similar to university admissions. The subgroups of selective STEM schools were state residential schools, stand-alone schools, schools-within-a-school, and regional centers with half-day courses (Subotnik & Tai, 2011). Selective STEM schools had resources that most other STEM models did not have. These included adept, expert educators, top-of-the-line equipment, advanced curricula, and the opportunity for apprenticeships with other scientists (Subotnik & Tai, 2011). While these programs were fantastic options for some students in the US, there were only around 90 selective STEM schools in 2011 (NRC, 2011). While some would assume that selective STEM schools were always superior due to their financial upper hand, the research literature showed that the main drivers behind success in the sciences were research experience in high school, work-place learning, and highly-trained teachers who connected concepts across subjects (NRC, 2011).

Inclusive STEM schools were similar to selective STEM schools but deviated in one major way, admissions criteria. Rather than serving a niche population that either a) tested into the program or b) were able to afford the program, inclusive STEM schools served a larger demographic. The framework that inclusive STEM schools operated within was that “math and science skills could be developed” and that “students from traditionally underrepresented subpopulations needed access to opportunities to develop these competencies” (Young, House, Wang, Singleton, & Klopfenstein, 2011). Texas instituted 51 inclusive STEM schools to evaluate their impact on student performance in the sciences. Of these schools, their research showed that students “scored slightly higher on state mathematics and science achievement tests, were less likely to be absent from school, and took more advanced courses than their peers in comparison schools” (Young, House, Wang, Singleton, & Klopfenstein, 2011). There were several factors that made these school more successful than their peers. These included a “blueprint” that outlines STEM integration, college-ready curricula, academic supports, smaller class sizes, and backing from administrators (Young, Wang, Singleton, & Klopfenstein, 2011). Schools found that these were pivotal to their success and it should be noted that schools without similar supports may struggle more than their peers.

STEM CTE schools were geared towards preparing students for "STEM-related careers, often with the broader goal of increasing engagement to prevent students from dropping out of school" (NRC, 2011, p. 13). The key difference between STEM-CTE programs was the workplace application. STEM content was taught with the intent of preparing students to become an efficient workforce. STEM was taught in these schools via "practical application through a wide range of CTE delivery mechanisms" (NRC, 2011). A more diversified approach to teaching allowed for students to find career trajectories that were based in their interests and abilities. An interesting finding with CTE STEM programs was that utilizing CTE "to motivate learning through real-life applications, did not have to be in conflict with academic achievement" (Stone, Alfeld, & Pearson, 2008). A CTE STEM school, similar to the inclusive STEM school, showed that students need not be affluent, scientific wunderkind to have success in science, technology, math, and engineering.

The final STEM model discussed in the research literature were comprehensive STEM schools. Simply stated, these were "traditional K-12 schools" with STEM integration. This method seemed to be far and away the most common way of implementing STEM curricula, as "much of the available research knowledge comes from comprehensive schools which educate the vast majority of the nation's students" (NRC, 2011). While this was the most common vehicle for STEM instruction, schools were highly variable. One school might have had infrastructure with less effective instruction, while another may have had the opposite. By having STEM in comprehensive schools, educators were able to reach a larger swath of students, which positively impacted the STEM workforce (NRC, 2011). Comprehensive schools that encouraged STEM proficiency often had students complete 3 or more math and science courses during the duration of their program (Council of Chief State School Officers, 2008). STEM integration was primarily incorporated through Advanced Placement and International Baccalaureate programs (Lee & Rawls, 2010). STEM programs in traditional schools were shown to be invaluable resources for sustaining the next generation of scientists. Differences were noted between the four modes of STEM instruction and how they compare/contrast. There was no singular "prescription" for STEM instruction, but each component had its place in the greater educational ecosystem.

Connections between STEM & Agricultural Literacy

The goal of this subheading was to highlight the ways in which STEM and agricultural literacy intersected. While the two subjects had some inherent differences, agriculture often acted as a framing device for the teaching of STEM. Whether learning about animal/plant science, technological advancements in agriculture, agricultural engineering, or fertilizer calculations, STEM education and agricultural education could mirror each other with relative ease. While it was not advised that all programs will operate as fluidly as the example listed above, it was valuable to home in on the differences and similarities that arose when teaching these subjects.

One method that was common in instituting hands-on STEM instruction was garden-based curricula. Schools would often build raised beds and plant them with produce that can be used to teach about plant science and diet. Graves, Hughes, and Blagopal (2016) decided to research the impacts that an "edible plant curriculum at a STEM-centric elementary school" had on student achievement. The researchers conducted a case study of two 3rd grade teachers and two STEM coordinators that followed this EPC curriculum. Teachers were able to make "curricular decisions" that were driven by their plant science acumen, "the accessibility of curricular material, perceptions of relevancy to science standards, and time constraints" (Graves, Hughes, & Blagopal, 2016, p. 192). Curricular materials were developed in conjunction with

STEM coordinators based on relevancy to academic science standards following an Understanding by Design approach to curriculum development. According to the authors, the incentives of horticultural-based STEM curriculum were "cost, accessibility, school-garden connection, nutrition literacy, and standards focus" (Graves, Hughes, & Blagopal, 2016). After the completion of the study, teacher perceptions were gathered by the researchers. Teachers believed that the EPC did not address science standards and were instead "enrichment activities" (Graves, Hughes, & Blagopal, 2016). Other major concerns that the two teachers held were that they were not properly prepared to teach the edible plant curriculum, relating back to pedagogical content knowledge which was mentioned in the previous heading (Rice & Kitchel, 2017). While researchers like Brandt found that agriculture was an effective framing device for the gamut of topics in elementary school, these researchers discovered a caveat. If teachers did not feel prepared to teach the content, lacked time, and lacked resources, they were more likely to have negative views of garden-based curricula (Brandt, Forbes, & Keshwani, 2017; Graves, Hughes, & Blagopal, 2016). The authors summated that the one of the biggest hindrances to the creation of a school-based horticultural STEM program was negative perceptions. While the teachers found that the STEM curricula did not coordinate with their existing methodologies, administration thought otherwise and hired a "school garden coordinator" to keep the project going.

A similar STEM-agriculture crossover study was conducted by Gupta, Hill, Valenzuela, and Johnson in 2017. The problem that these authors addressed was recruiting young students into STEM. As stated previously, philosophers including Piaget and Freud argued that we develop perceptions that stay with us throughout our lives at a young age (Terry, Herring, & Larke, 1992). With this in mind, the researchers tested an interactive and engaging STEM and agricultural lesson plan. The subject of the lesson was food spherification and chemical processes. Spherification is the chemical process that transforms a liquid product into a more "stable jelly-like" substance (Gupta, Hill, Valenzuela, & Johnson, 2017). The reason for this specific topic was because of the food production industry that was surrounding students in this community. The long-term goals of this study were to create "safe, reproducible, economical, and scientific hands-on activities that increase participation" in STEM (Gupta, Hill, Valenzuela, & Johnson, 2017, p. 6). Results stated that students were "successful in demonstrating their understanding of chemical reactions" and were able to "follow lab procedure to evaluate the effectiveness of factors that influence a chemical reaction" (Gupta, Hill, Valenzuela, & Johnson, 2017, p. 9). The results of this study showed that inexpensive STEM and agriculture lessons positively impacted a students' perceptions on science and provided them with greater literacy in both topics.

Impact of Agricultural Education

Pense, Leising, Portillo, and Igo (2005) sought to understand how Agriculture in the Class (AITC) impacted students understanding of the Food and Fiber Systems Literacy Framework (FFSL). The desire of their study was to "identify gaps in student knowledge of agriculture" and better hone programs to address agricultural illiteracy (Pense, Leising, Portillo, & Igo, 2005). AITC was a program that infused agricultural lessons into K-5 curriculum in an effort to help students better understand agricultural processes and how agriculture was pivotal to their daily lives. By utilizing a pretest/posttest assessment of 52 elementary classrooms receiving the FFSL curriculum via AITC, the researchers were able to compare the results to those of their 48 control classrooms (Pense, Leising, Portillo, & Igo, 2005). 100 elementary classrooms provided the researchers with 1,734 students. Results for this study favored agricultural education as there was “a positive difference in student acquisition of knowledge about agriculture” (Pense, Leising, Portillo, & Igo, 2005). Students experienced knowledge gains in every subject of the FFSL curriculum, with lows of +3-point differential to a +26.85 differential between pre and posttest. Researchers posited that “students acquired knowledge in all five FFSL themes” (Pense, Leising, Portillo, & Igo, 2005). Due to the positive responses to agricultural education in elementary schools, the researchers recommended a “curriculum model be fully implemented at each grade level.” This would allow for “systematic progress in agricultural literacy” (Pense, Leising, Portillo, & Igo, 2005, p. 116).

A study conducted by Monk, Norwood, and Guthrie in 2000 highlighted the impacts that experiential learning in agriculture had on elementary students’ levels of agricultural literacy in Texas. These researchers investigated how a mobile dairy unit informed students about milk production and the dairy industry. They selected 651 students in Texas and had them complete a questionnaire a week prior to having the mobile dairy unit at their school. The dairy unit taught about the “importance of milk and other dairy products to the diet, life on a dairy farm, and the treatment and handling of dairy cattle” (Monk, Norwood, & Guthrie, 2000). A week after the dairy unit was on campus, researchers had students complete a posttest to test the effectiveness of this methodology. On the pretest questionnaire, “only 3.7% of males made a passing score of 70% or better” while females passed at a rate of “3.4%” (Monk, Norwood, & Guthrie, 2000, p. 12). After the dairy unit lesson, “50.9% of males and 42.4% of females made a 70% or better.” These results showed that students were capable of learning about the agricultural industry via experiential, hands-on lessons. Not only did students have a memorable experience, their knowledge base and understanding of dairy science was “greatly improved” (Monk, Norwood, &

Guthrie, 2000). This unit was temporary, but teachers were also left with materials to teach about dairy production at a later date.

In the realm of agricultural education, it was often assumed that students from urban areas have less of an understanding about agricultural concepts. The more cosmopolitan our population becomes, the more likely we are to feel isolated from agriculture. In a 1996 study, researchers Mabie & Baker studied the impacts that the experiential learning model can have on elementary students in an urban environment. By introducing agricultural education, students in these schools were able to answer and reflect on concepts that included: 1) what is agriculture? 2) Understanding the state food/fiber industry, 3) list three crops grown on farms in their state, 4) familiarity with agricultural terminology, 5) newfound interests in agriculture (Mabie & Baker, 1996). The researchers had students participate in one of three groups: “a ten-week garden project, a ten-week series of three short in-class projects, and a control group” (Mabie & Baker, 1996, p. 2). The ten-week garden project had students participate in a 15-20-minute lecture, followed by discussion, a demonstration, and then a set of group gardening activities. Lessons were “one hour each week for a ten-week period” (Mabie & Baker, 1996). The second treatment was a series of in-class projects that included topics which included bread baking, chick rearing, and germination. The control group did not receive any treatment. Mabie & Baker designed a written response pre-test and post-test instrument that gauged how much students “knew where their food came from, their level of awareness of careers in agriculture, and their understanding of the social, economic, and environmental significance of agriculture” (Mabie & Baker, 1996, p. 3). Results for this study showed concrete gains in agricultural literacy following the treatments. Students in both the pre-test and post-test phase were asked the question “what is agriculture?” On the pre-test, students in the control group answered correctly at a rate of 32%, 21% in the garden group, and 3% for the short project group (Mabie & Baker, 1996). On the post-test, 43% of the control group were able to correctly define agriculture, while 91% of students in the garden group and 83% of the projects group answered correctly. (Mabie & Baker, 1996). These results show that students made tangible gains following a garden-based curriculum in an urban setting. Not only did the garden group improve, the agricultural projects group made strides. This transition from a lack of agricultural knowledge to proficiency in the topic showed that educators could shift the paradigms of agriculture in an urban setting.

Knobloch, Ball, & Allen (2007) expounded on the salience of elementary agricultural education. In 2007, they were able to describe the direct benefits of using agricultural curriculum in an elementary/middle school setting. They concluded that by providing agricultural education as a framework for other traditional classroom topics, teachers were able to provide "situatedness, connectedness, and authenticity to their students" (Knobloch, Ball, & Allen, 2007). Their research did provide a caveat that certain topics in school coalesced with agriculture more smoothly, i.e. teaching science with a garden was easier to accomplish than teaching language arts with one. Situatedness allowed for students to view their education in relation to the context around them. For example, teaching a science lesson about plant life cycles while outside in a garden, allowed for students to see the greater context of these lessons. Connectedness is similar to situatedness, but it deviated in that where situatedness related students back to their immediate area, connectedness placed things in a global context. Finally, authenticity was achieved by demonstrating concepts that could be "observed in action." This roughly translated to students being able to see that lessons had inherent value and were applicable to their daily lives. The benefits of agricultural education were wide-ranging and stark.

Similarly, Thorp and Townsend did an ethnographic study of a school garden in an elementary school to see the ramifications that it held. They were able to show five different ways that agricultural education, by way of a school garden, aided an elementary school: 1) shifted school culture, 2) mediated loss of time in modern education schema, 3) connected students via experiential learning, 4) allowed for creativity through garden, 5) perception of agricultural shifted from commodity to a community (Thorp & Townsend, 2001). Each of these five topics, according to their research, had an ample effect on the school that was being studied They helped shift the paradigms that students and educators had on agricultural education. This study, and many others that the researcher has reviewed, called for the installation of a "dedicated school garden volunteer." This was rooted in both a lack of time and pedagogical content knowledge of the educator.

With all of this focus on the introduction of elementary agriculture curriculum, it was equally valuable to investigate the impact that agricultural and environmental education had on standardized testing scores. Connors & Elliot sought to find out if there was a direct, observable correlation between students that took experiential, non-traditional science classes like agricultural education. By analyzing the performances of two test groups, the researchers noted that there was no significant difference in standardized science tests scores between students that had taken "hands-on" sciences and those that went the formal route (Connors & Elliot, 1995). One of the points of contention, however, was that previous science credits and existing GPA were factors in the discrepancy. This could mean that if students were presented with agricultural curriculum sooner, they might have seen a noticeable increase in favor of agricultural education. The researcher aimed to answer similar questions about agricultural education, but the research was conducted through the lens of the elementary school classroom.

Research conducted by Brandt, Forbes, and Keshwani (2017) aimed at understanding students' level of scientific understanding in regard to agriculture. By having 3rd-5th grade students complete a qualitative interview process, the researchers were able to develop a specific quantitative instrument to measure students' agricultural literacy. The framework that there were specifically trying to analyze was a set of literacy standards, the National Agricultural Literacy Objectives (NALO). Their mixed-methods study had 110 third, 108 fourth, and 182 fifth grade students (Brandt, Forbes, & Keshwani, 2017). The results they found on their pretest and posttest assessment showed that students scored "significantly higher" on STEM assessments than agricultural ones (Brandt, Forbes, & Keshwani, 2017). While students had a grasp on how technologies can aid farmers (i.e. GPS, computers), they struggled to understand conservation practices and genetics. Agricultural awareness and literacy were highest amongst 5th grade students and titrated down to lower grades. This can be attributed to maturation differences or the depth of curricula at higher grades. Researchers also found that students had a limited vocabulary which led to gaps in understanding agriculture topics (Brandt, Forbes, & Keshwani, 2017). Students also found difficulty in abstract conceptualization, meaning they could tell you "what" but not "why" or "how." In conclusion, the researchers found that there was a "synergistic relationship between STEM concepts and students' agricultural literacy" (Brandt, Forbes, & Keshwani, 2017, p. 146). Being one of the few mixed-methods agricultural literacy studies, the authors work was formative to this research project.

Teacher Perception

This section was designed to explain the perceptions of elementary teachers in regard to instituting agricultural education in their schools. Topics covered include curriculum, pedagogical content knowledge, lack of time, and benefits of elementary agricultural education.

By analyzing the literature, the researcher became acclimated to the perceptions that some educational professionals had towards the subject matter.

What do elementary teachers believe about agricultural education?

Work conducted by Balschweid, Thompson, and Cole (1998) sought to understand teachers' perception of a Summer Agriculture Institute (SAI). This institute was designed to educate teachers on agriculture concepts so that they could utilize lessons in their own classrooms. (Balschweid, Thompson, & Cole, 1998). A week-long training was provided to teachers via Oregon State University and the Oregon Farm Bureau. After completion of the training, teachers completed a Likert evaluation to better understand what they thought about the SAI. There was a total of 52 teachers that participated, a 64% response rate. Teacher demographics included 55% in elementary, 21% in middle, and 17% in high school (Balschweid, Thompson, & Cole, 1998). On a 5-point Likert scale, institute teachers averaged a 4.33, which showed a large amount of support towards agricultural education in their classrooms. The most commonly cited barrier to implementation of agricultural education was time, as teachers scored a 3.71 (Balschweid, Thompson, & Cole, 1998). Teachers stated that the "content, structure, and usability of agriculture information presented at SAI was effective and that the material was useful" (Balschweid, Thompson, & Cole, 1998). Teachers also agreed that having a local resource person would "help alleviate the time factor" felt. (Balschweid, Thompson, & Cole, 1998). This study showed that well-prepared teachers had favorable opinions of agriculture in the classroom.

Terry, Herring, and Larke (1992) conducted a study that gauged the levels of agricultural literacy for teachers. They found that teachers enjoyed using agriculture in their classroom as, 97% of 800 used agriculture in some form or fashion in their teaching. (Terry, Herring, & Larke, 1992). While teachers may have liked to use this subject matter in their classes, they often had large gaps in their understanding of the topic. The mean score on an agricultural literacy assessment for these educators was 48.4% (Terry, Herring, & Larke, 1992). It was worthwhile to have educators that are passionate about agricultural education, it was equally important that they have a proper grasp on the content themselves.

Knobloch and Ball (2003) analyzed elementary teachers' beliefs related to the integration of agriculture in their schools. The authors began to notice a trend in regard to the implementation of agricultural education and experiential learning. They found that if "teachers believe that agriculture is a powerful context for experiential learning, they will be more likely to incorporate agriculture concepts into their daily teaching plans" (Knobloch & Ball, 2003, p. 2). These beliefs that teachers held about experiential learning from an agricultural standpoint seemed to play a pivotal role in the "value that they place upon new knowledge and experiences" (Knobloch and Ball, 2003). The researchers looked at a group of 334 elementary teachers. Their objectives included: describing the demographics of participating teachers, identifying teachers' beliefs about integrating agriculture, compare the affect that teachers' beliefs on agriculture had on the amount of instructional time dedicated to the topic, and explore how beliefs may limit the amount of time on agricultural topics (Knobloch and Ball, 2003). The authors results showed that elementary teachers needed to "feel comfortable to integrate agriculture more frequently in their instruction" and that "teachers who felt more confident . . . were more likely to integrate agricultural topics into their instruction" (Knobloch and Ball, 2003, p. 15). This study showed one of the areas that causes disconnect between elementary teachers and agricultural curricula.

Bellah and Dyer (2006) also saw the value in understanding teacher perceptions towards elementary agricultural education. These researchers conducted a study that aimed at understanding “teachers’ attitudes and perceptions toward agriculture and its use as a context for teaching across grade level content area standards” (Bellah & Dyer, 2006). The framework that these authors operated under involved looking at standardization and the effects of cross-curricular subjects. In an effort to connect subjects, a context like agriculture can be helpful, especially in a rural community. Concerns felt by teachers included: teaching to the standards, keeping lessons student-centered, and properly instituting agriculture curricula into existing standards (Bellah & Dyer, 2006). The perceptions that teachers held following this study echoed the sentiments of previous studies. Teachers did not feel like they had adequate time or pedagogical content knowledge to effectively educate their students in agriculture (Bellah & Dyer, 2006). Changes that can be made include pre/in-service training for teachers in agriculture or the creation of a new agricultural education teacher in elementary schools. Teachers in this study saw the value of agricultural education but were stymied by the same problems that other teachers around the country also face.

Conclusion

The research that was selected aims to describe how to properly implement an elementary agricultural education program. The gaps that existed in the literature were primarily those that failed to look at the long-term impacts of experiential learning in an elementary setting. Most of the articles came close to analyzing such a program, but most of them were restrained by the fact that elementary agricultural education was being performed by a teacher who was already committed to other areas of expertise. If schools were to introduce a dedicated agriculture teaching professional into an elementary setting, the research may begin to shift more favorably into the pro-elementary agricultural education camp. This sentiment was reiterated in this study’s alternative hypothesis: if traditional science curriculum is compared with elementary agricultural curriculum, a significant positive difference will be seen on pretest/posttest scores for 3rd and 4th grade students who have been enrolled in agricultural education.

Theoretical Framework

The theoretical framework that was selected for this study was Kolb's model of experiential learning. Since 1919, learning by doing has been the method of choice for agricultural educators (Moore, 1988). Kolb's model of experiential learning was based on constructivism. Constructivism argued that learners built meaning from their experiences (Doolittle & Camp, 1999). This teaching theory placed a strong emphasis on the learner and shifted attention away from the educator. By opting for a student-centered teaching approach, educators were able to treat each student as an individual and consider each student's own personal learning style. A large portion of this framework was described and compiled brilliantly in Roberts' 2006 article in the Journal of Agricultural Education. As a result, his article will be utilized as a guide for this framework.

There are five key elements that occur in the experiential learning model: direct involvement, learner initiation, pervasiveness, and learner evaluation (Rogers, 1969). Direct involvement means that each learner is engaged in an individualized way, a central tenet of constructivist ideologies. Learner initiation, pervasiveness, and learner evaluation are required from the student, as well as consistency in presentation and allowing for self-evaluation after a concept has been presented. It is important to note how the student is a pivotal member of his or her learning experience.

Experiential learning can be looked at through two lenses: process and context (Roberts, 2006). The process of experiential learning began with the father of experiential learning, John Dewey. Dewey was one of the first educational theorists that proposed teaching via experience.

He posited that one of the key facets of experiential learning is reflective thought (Dewey, 1910). Reflective thought occurred when a learner was presented a topic and then was allowed to contemplate the ramifications of what they have learned or did not learn. He claimed that students needed to experience five different sensations in order to think reflectively. First, they must feel a difficulty. This means that they must come to a new situation and see that their previous problem-solving techniques are lacking, initializing a necessity to learn. When experiencing this newfound difficulty, the location and duration of the difficulty is important to inform the possible solution that can be employed. The learner must then try a possible solution and see whether or not it solves the issue. After this step, reasoning must be developed and analyzed through cognitive compartmentalization. When a period of observation and reflection has been completed, the student must come to a conclusion (Dewey, 1910). This entire process exists to move students from a state of inductive reasoning to deductive reasoning. As deductive reasoning is achieved, students are able to accomplish intelligent activity, or the ability to delay action until they have reflected (Dewey, 1910).

The next reason that experiential learning acted as a proper framework for this study was because of its cyclical nature. The process of arriving at a problem and developing strategies to solve said problem is rooted in a trial-and-error mentality. This means that the student can implement a potential solution to a perceived problem and test its effectiveness. By doing so, students are able to enact efficacy and grow into lifelong learners. Joplin reiterates this concept with his “five-stage experiential learning model” (Joplin, 1981). The cyclical nature of experiential learning models demonstrated that learning is a life-long process that should not cease with the presentation of a diploma.

While experiential learning was discussed, studied, and practiced for years, Kolb produced a model that was deemed most beneficial to the nature of this study. Kolb's model, while cyclical like Dewey's and Joplin's, was more compact and easier to interpret by the layperson. Since this research study was conducted with educators who are either new to agricultural education or were applying it in an unfamiliar context, it was helpful for these teachers to have a succinct research visualization of their methodologies. Kolb divided his model into four distinct quadrants: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984).

While learners could join into this cycle at any stage, the purposes of this study began by focusing on concrete experience. Concrete experience is the stage in which a learner gathers information via their various senses (touch, smell, taste, etc.). This is where a student comes into contact with a previously unknown situation and experiences it at the base level. After experiencing with the senses, reflective observation occurs. Reflective observation is the process where learners begin to mentally compartmentalize and store information. The learner sees the information and then must use preconceived understanding to know how to organize it in his or her mind. After this phase, abstract conceptualization takes place. This is the stage where the learner forms "new rules, generalizations, and hypotheses about an observation" (Kolb, 1984). Abstract conceptualization means that the learner is forming a new method of understanding the topic and dealing with it. The final phase before the cycle repeats is that of active experimentation. The learner places the new problem into his newly established schemas and then tests to see if his problem is solved in accordance with his rules. If it is solved, the cycle then shifts to a new problem. If it is not solved, the learner then repeats the cycle, creating new ideas as to how to solve this conundrum. (Kolb, 1984).

Now that the process of experiential learning was discussed, the focus shifted to the context in which this theory was useful. Socio-cultural theory distinguished a distinct relationship between learner and environment (Vygotsky, 1978). This meant that both the learner and the environment must be conducive to learning. Experiential learning benefits in this regard because it can incorporate multiple classroom environments. Teaching environments occur on a continuum ranging from non-formal, informal, and formal (Etling, 1993). This means that the lab setting can be just as effective to teach a concept as working in a vocational setting. Context of experiential learning is based on four different factors that interact: level, duration, outcome, and setting. (Roberts, 2006). This level of learning takes into consideration the learner's current acumen and then caters a lesson that meets those needs. Duration is the time taken to conduct an experiential learning activity. Understanding the audience's attention span is also an important factor to consider when preparing a lesson. Outcome is what you expect to see from the learning activity taking place. What levels of knowledge and practical ability would be the most desirable as a result of this lesson? Finally, setting is similar to what Vygotsky and Etling spoke of before. The learner is in a relationship with his or her environment and these environments can vary between levels of formality.

While experiential learning may sound lucrative, it was worth knowing whether or not this method of learning was authentic. Authentic learning is learning via tasks, activities, and assessments that relate to real-life problems and situations (Newmann & Wehlage, 1993; Woolfolk, 2001). Authentic learning benefits students by teaching the applicability of their knowledge, allowing them to be creative, and giving them a proper context (Collins, 1991). Authentic learning is vital in schools because it creates effective, high achieving students across "race, class, gender, or social background" (Knobloch, 2003).

Now that the researcher established the process, context, and the authenticity of experiential learning, it was worthwhile to see the central tenets of experiential learning. There were four vital components that experiential learning needed to have to be successful: learning in real-life contexts, learning by doing, learning through projects, and learning by solving problems (Knobloch, 2003). Each of these tenets were studied and practiced for years within the profession of agricultural education and were deemed effective after successive implementations. Thankfully, the pre-established curriculum for elementary agricultural education included a component that addressed each of these tenets (Georgia Department of Education, 2018). Students learned about a science/agricultural topic in a setting that mimicked the real world (i.e. student garden). The students then put knowledge into practice and experimented within the cyclical model of experiential learning. By doing so the students solved unique problems, created by themselves and their instructor. The only facet that is currently being experimented with is learning by way of projects. The current agricultural education landscape employed a "three-circle" model with one of those components being a Supervised Agricultural Experience (SAE). This project allowed for a student to develop a unique agricultural venture and see it through to completion. While there were certain restrictions inherent to implementing this in elementary schools (transportation, money), learning projects were feasible and could be accomplished by these young learners.

By describing experiential learning, the researcher showed the logic behind this method of problem-solving. Experiential learning was efficacious and created life-long learners who are proficient in creating their own knowledge. The research that was conducted aimed to study this concept in regard to elementary agriculture. This theoretical framework acted as a basis to situate how elementary agricultural education impacted students. The experiential learning theory aligned with this study because that was the type of education that occurred in these elementary classrooms. Teachers used hands-on, experience-based instruction to teach agricultural and scientific concepts. The research procedures for this study were supported by this framework because the researcher analyzed the proficiency scores from a pre-test/posttest that were influenced by the presence of experiential learning. If experiential learning was taking place, did those observed groups show differences? If experiential learning was not present in these elementary agriculture classrooms, existing researchers would not consider it to be authentic agricultural education (Roberts, 2006; Knobloch, 2003; Kolb, 1984). The theory of experiential learning guided this study by ensuring that: (1) the research results were impacted/not impacted by the presence of EL, (2) elementary agricultural education was in-line with the existing methodology of agricultural education.

CHAPTER 3

METHODOLOGY

For this study, the researcher analyzed the effects that elementary agricultural curriculum had on STEM achievement scores in 3rd and 4th grade. The researcher analyzed pre-test and post-test scores on two achievement tests at the beginning and end of the fall semester to determine whether or not a significant difference existed between student understanding of agriculture curriculum. This study was housed within quantitative research paradigm and followed such methods. By conducting this research, the objective was to provide tangible data that showed the level of effectiveness of elementary agricultural curriculum in relation to science and agricultural proficiency scores.

Non-Experimental Design

No randomization and a lack of a control group led the researcher to conduct a non-experimental study. A non-experimental research design was defined as "purely observational and the results are intended to be purely descriptive" (Thompson & Panacek, 2007, p. 2). Even more specifically, this research study was descriptive. Descriptive research helps portray accurately the incidence, distribution, and characteristics of a group or situation (Tuckman, 1999). The reasons the researcher chose this specific design is due to the nature of the pilot programs. These programs operated on a "connections rotation." In Georgia, a connections rotation was that rotation of art, music, physical education, and, now, agricultural education. Each week the students attended an agricultural education class along with other members of their grade level. Since all students at each of the pilot schools had to participate in agricultural education, it was impossible to have a control group housed within each school. Due to the structure of the "connections rotations and the variations between demographics within enlisting schools, a non-experimental approach was selected as the most appropriate and feasible approach.

In descriptive research, there are a set of steps that must be followed to ensure that the study still remains valid and reliable. These steps included stating the problem, identifying necessary information to solve the problem, developing instruments, identify population and sampling procedure, gathering data, summarizing/analyzing/interpreting data, and preparing the report (Tuckman, 1999). The researcher, throughout the course of his study, highlighted each of these steps in an effort to collect accurate and beneficial data to aid the greater knowledge base on elementary agricultural education.

Population and Sample Size

The population studied was comprised of elementary school students across 26 different schools throughout Georgia. This is the total population of schools participating in the pilot program. The researcher, upon contacting all of the schools, recruited 8 schools to participate. The schools were not required to participate in research and had no direct incentive other than improving our understanding of the impact that elementary agricultural education has on students. Beginning in the fall of 2019, a stratified random sample was collected from 3rd and 4th grade students at each of the 8 participating pilot schools implementing elementary agricultural education. The total sample of students that completed the instrument was 362 for the pretest and 260 for the posttest. Both tests had sample sizes large enough to achieve normal distribution. Attrition occurred between the tests and the researcher hypothesized that this was due the gap between tests and the time of year that they were administered. The posttest was given prior to

Christmas break for most of the elementary schools in this study and the researcher assumed that teachers were preoccupied with other testing that had to occur before the break.

Normality

Before running tests to analyze the data, the researcher had to determine if the data set was homogenous. Homogenous distribution would allow for parametric tests on the data set. Parametric tests showed that the "dependent variable is a parameter or quantity characteristic of a population" (Tuckman, 1999, p. 93). The researcher analyzed scores by grade to determine if there was homogeneity for both age groups. For 3rd graders, see figure 1, the data had a skewness of .235 and a kurtosis of -.538 (Figure 3.1*)*. This gave a normality of -0.44, which fell within the acceptable range of homogeneity (-1.96 to 1.96) (Tuckman, 1999). For students in 4th grade, see figure 2, the skewness was -.297 and the kurtosis was -.504 (Figure 3.2). This gave a normality of 0.59 which was also within the range of homogeneity. As a result of these findings, the researcher decided that parametric data tests were applicable.

Figure 3.1

Distribution of Mean Scores – 3rd Grade

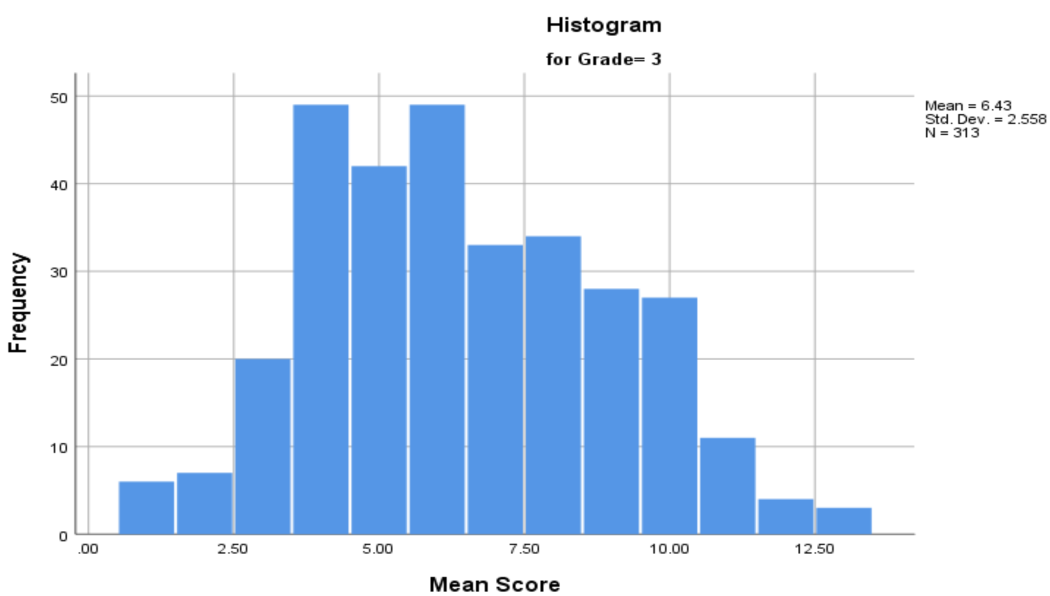
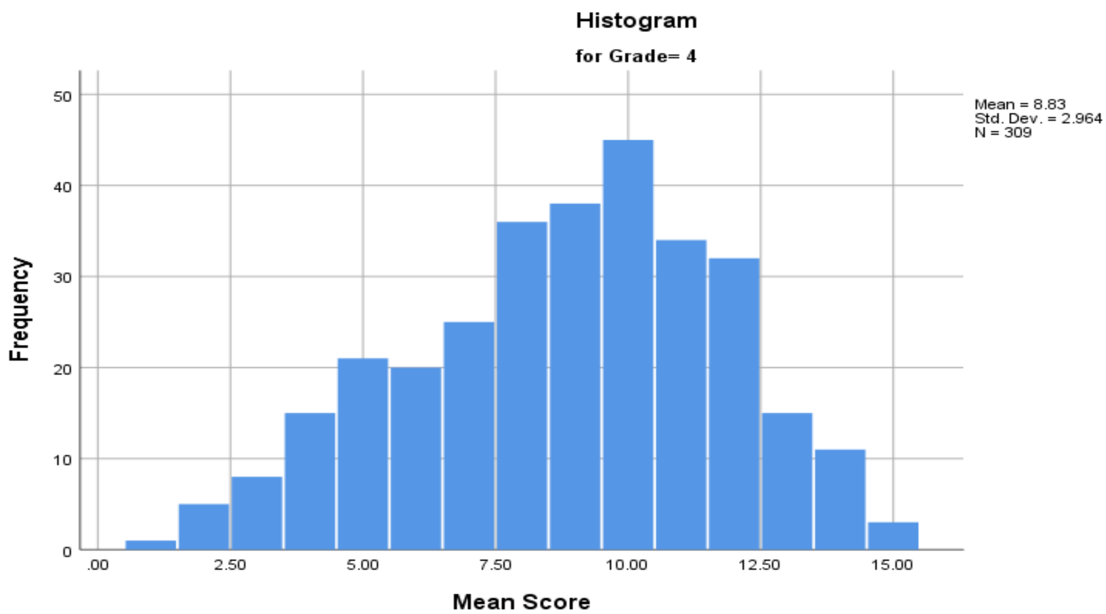


Figure 3.2

Distribution of Mean Scores – 4th Grade



Instrumentation and Design

Data was collected utilizing two instruments, both achievement tests. The instrument selected was that of a test format because it was a systematic procedure that allowed participants to react to stimuli and respond (Tuckman, 1999). A test format was familiar with elementary students and was not foreign to them. The type of test that was most efficacious was an achievement test. Achievement tests measure proficiency and/or mastery of topic showing the researcher how well a student performs according to a specific standard (Tuckman, 1999). In this case, those standards would be the agricultural ones instituted by the Georgia Department of Education. Achievement tests were conducted in the form of a standardized, test which focused on student knowledge of science content in agriculture and STEM (See Appendix C). Standardized tests like the one that was conducted were proven to be reliable, valid, and cater to a larger number of schools (Tuckman, 1999). This allowed the researcher to create a master achievement test which was given to each school. This reduced variability and researcher error. Standardization was ensured as the researcher provided the same copy of the instrument to both the pretest and posttest groups. Furthermore, the test was constructed in a way that reduced instrumentation and response bias. Instrument bias was mitigated by having a pilot testing period which helped to eliminate questions that prompted incorrect responses. For example, following the pilot testing phase, the researcher noticed an error in one of their questions regarding watersheds. The question was written in a way that two answers were correct. This skewed the data, so removing it made the instrument more trustworthy. Questions like this were analyzed through SPSS using Cronbach's reliability coefficient alpha to find any noticeable discrepancies or outliers. As particularly unreliable questions were removed, Cronbach's alpha increased. If unreliable questions were left in, Cronbach's alpha decreased.

Response bias was addressed by having questions based on both science and agriculture standards. While some of the agriculture content was unfamiliar to students, leading to issues with response bias, the test format was not changed between pretest and posttest. Doing so, reduced the risk of response bias because the instrument was more familiar. This does bring up a concern for test/retest bias, due to the instrument staying the exact same between pretest and posttest. However, there was a two-month gap between each testing phase which allowed for ample time for students to forget the test questions. The questions developed for this instrument were based on Bloom's Taxonomy, primarily knowledge, comprehension, and application (Bloom, 1956). Questions were written at these levels because standards were developed at these levels and the material was taught accordingly.

The instrument was pilot tested in a Georgia school with similar demographics to those of the schools participating in the formal research study. The pilot testing phase was completed on September 26, 2019 and had 45 students finish each instrument. It should be noted that in the pilot testing the researcher was able to resolve issues that might arise in the testing phases. Originally, the STEM and agricultural literacy tests were two separate Qualtrics surveys. When attending the pilot test, the researcher noticed that students had difficulty navigating between tabs. It also was not as fluid of a testing experience for both researcher and students. The pilot testing also revealed information in regard to the nature of the Qualtrics forms. For example, students found that when the answer choices “turned red” when selecting an option, they thought they missed the question. This led students to feel concerned about the score that they would receive. Another concern, in the pretest phase, was that students believed they needed to know the content prior to testing. The researcher had to explain to students that they “should not know the material” at this stage and it is normal to not know the correct answers at this stage.

This study followed a non-randomized pre-test/post-test design. The experimental group, students participating in agricultural education and completing the instrument, were measured twice (once at the beginning of fall and once at the end). The experimental group was observed starting with the pretest, then the independent variable was applied, and it was observed a second time to determine the effects of the treatment. Students received the same pretest and posttest at both phases. The material did not change, nor did the order of questions. This was intended to measure whether or not students performed at a higher level according to science and agriculture standards.

After data was gathered and reliability was analyzed, the researcher and committee decided to eliminate the short-answer questions on the agriculture construct due to their formatting and negative impact on Cronbach's Alpha. These included questions 19, 28, 29, and 30. The researcher sought to employ four questions that were more qualitative in nature, but since they were detrimental to the study as a whole, they were removed from analysis.

Threats to Validity

The validity tests that were run with the data included face validity and criterion-related validity. Face validity was achieved by the completion of a pilot test phase alongside having an expert panel that evaluated the instrument that was developed. A face validity test showed that this test appeared to test what it aimed to test. Criterion-related validity was utilized at the end of this study. Criterion-related validity was a way of drawing correlations between two separate concepts in an effort to predict one's impact on the other (Ary, Jacobs, & Razavieh, 1990). For example, if a student scored highly on the SAT that can be indicative of their performance in college, hence why colleges use this as a metric to determine admissions. For this research, agricultural and STEM scores on the instrument may be able to gauge how well students are doing in school overall. If students had success in the testing phase, they might also have had success in other subjects as a result.

Reliability tests that were run on the data included average inter-item reliability and split-half reliability. Average inter-item reliability compared the means of questions and helped determine if there was a correlation between certain questions. This meant that if one student answered "question 1" correctly, did that also lead them to answer "question 15" correctly. This was utilized to determine if there are any questions that were outliers, which were removed as they lowered reliability. By analyzing the Cronbach's Alpha for the correct response rates to questions, the researcher determined trustworthiness of the instrument. The other reliability test that was utilized for this study was split-half reliability. In split-half reliability, a test for a single knowledge area is split into two parts and then both parts are given to one group of students at the same time. The scores from both parts of the test are correlated. A reliable test will have high correlation, indicating that a student would perform equally well (or as poorly) on both halves of the test. Doing so lets the researcher know whether or not the participant would have scored the same score if they just completed one half of the test by itself. Employing both of these tactics made the instrument more reliable and the data more indicative of the population.

The external threats to reliability that arose from this design were history, maturation, and testing. Threats to validity as a result of history included events or conditions, other than the treatment, that may occur to the subjects between the first and second measurement that produce changes in the dependent variable (Campbell & Stanley, 1963). This meant that there were intangible factors that were often at play when students were completing the achievement test. The ways that the researcher mitigated this threat was by providing teachers with step-by-step processes to administer the test. While history was challenging to control, maturation was a natural effect that occurred amongst elementary students. Maturation was defined as the “process that happens within subjects as a function of time” (Campbell & Stanley, 1963). Maturation was addressed because of the short time period between treatments (tests) and limited education towards STEM and agriculture. As a result, effects were limited and did not affect scoring to any degree. Another threat to validity with this research study was test/retest. The treatment phase was two months, which could leave some students more likely to remember the material from the first pretesting phase.

Variables

As mentioned briefly, this study had independent, dependent, and control variables. The independent variable was 3rd and 4th grade elementary agricultural education curriculum. The dependent variable was a proficiency score difference between pretest and posttest. The dependent variable reflected whether or not the independent variable made a statistically significant difference. By having independent and dependent variables, the researcher was able to form a pattern of relationship between each and find whether the null and alternative hypotheses were supported or rejected. Variables were interval-based because even if a student scored a zero on the test that did not mean that they had zero knowledge in agriculture.

Data Testing

Descriptive statistic data tests were run on both the pretest and posttest. These tests included the mean, median, mode, and standard deviation. Each of these metrics were tested on individual test questions, the total scores, and scores between individual schools. These data tests told the researcher how many respondents there were at each school, what questions they struggled with the most, and what the average scores were for individual questions and the instrument as a whole.

Inferential data analysis was completed by running an independent samples *t*-test. This test analyzed the difference between independent means to determine if there was statistical significance between figures. This *t*-test had to be independent because the instrument was anonymous, which prevented the researcher from matching responses to specific individual (Tuckman, 1999). Following the independent samples *t*-test, the researcher tested for practical significance using Cohen's d. This test showed the strength of association between variables and results (Cohen, 1988).

Reliability of Constructs

For this research study, there were two constructs that were analyzed to determine reliability. These included a science construct and an agricultural construct. Constructs were selected due to subject knowledge being abstract to measure (i.e. how much do you know about science?). Reliability was tested using Cronbach's Coefficient alpha. Cronbach's alpha was used to "assess the reliability, or internal consistency, of a set of scale or test items" (Goforth, 2015). The preferred Cronbach's coefficient alpha for this study was a minimum of 0.70. This figure showed that the instrument and/or independent items was an accurate measurement of a 3rd and 4th grade student's science and agricultural knowledge.

As previously stated, this research study had a pilot testing phase that was utilized to determine reliability of the instrument, as well as work out any potential problems that might occur in the pretest/posttest phases. During the pilot phase, the instrument was broken up into its component parts, i.e. a STEM instrument (15 questions) and an agriculture instrument (15 questions). Having a split test was confusing to students and was deemed unnecessary for the pretest/posttest phases, so this format only applied to the pilot phase. Cronbach's coefficient alpha for the pilot phase STEM test was .132. This was not terribly surprising as it would be nearly impossible to measure a student's understanding of STEM concepts using a 15-question multiple-choice instrument. While this number was lower than what was expected, it follows that a smaller instrument would produce a smaller reliability coefficient. Similarly, the Cronbach's alpha for the agriculture test was equally low. Rather than being the preferred > 0.7, the researcher found that the instrument was rated at .182. Again, this was due to the instrument having only a few items that could measure student knowledge on a broad subject and the sample size being 45 students.

Once the pilot testing ended, the researcher collected data. For the pretest, Cronbach's coefficient alpha for the STEM instrument was .653 and the agriculture instrument was .336. This was based off a sample size of 362 students. According to DeVellis, a Cronbach's alpha between .65 and .70 had an implied reliability of “minimally acceptable” An alpha lower than .60 had implied reliability of “unacceptable.” (DeVellis, 1991). As a result, the researcher decided, upon consultation of committee members, that the STEM instrument was reliable while the agriculture instrument had to have an individual-item analysis to determine which questions were reliable and which were not.

CHAPTER 4

RESULTS

Descriptive Statistics

Five elementary schools participated in the pretest phase of this research study, identified as Schools A, B, C, D, E, and F. Schools A, B, C, D, E, and F had a response rate of 67, 34, 4, 175, 37, and 45 on the pretest respectively for a total n = 362. Four elementary schools participated in the posttest phase, as School E failed to report data. Schools A, B, C, D, & F had a response rate of 58, 19, 4, 137, and 41 respectively for a total response rate of n = 260. The pretest was completed by 185 3rd graders and 177 4th graders. The posttest was completed by 128 3rd graders and 132 4th graders.

Measures of central tendency were conducted for this data set and included mean, median, mode, and standard deviation. The researcher analyzed descriptive statistics under the following metrics: cumulative pretest/posttest score, pretest/posttest by school, pretest/posttest by grade level, and pretest/posttest scores per individual question.

The cumulative mean for the pretest was 48.76 with a standard deviation of 14.84 (Table 4.1) The median and mode scores were both 50.00. The mean for the posttest was 54.46 with a standard deviation of 15.64 (Table 4.2). The median was 56.67 and the mode was 43.44. Overall, cumulative mean scores increased by 5.7 points.

Table 4.1

Pretest Total Score

Total Responses (n)	362.00
Mean	48.76
Median	50.00
Mode	50.00
Std. Deviation	14.84

Table 4.2

Posttest Total Score

Total Responses	260
Mean	54.46
Median	56.67
Mode	43.44
Std. Deviation	15.64

Pretest scores varied by school. School A (*n* = 67) had a mean score of 47.91, a median of 50.00, a mode of 36.67, and a standard deviation of 13.96. School B (*n* = 34) had a mean score of 50.88, a median of 53.33, a mode of 56.67, and a standard deviation of 13.86. School C (*n* = 4) had a mean score of 51.67, a median of 50.00, a mode of 50.00, and a standard deviation of 3.33. School D (*n* = 175) had a mean score of 43.89, a median of 43.33, a mode of 40.00, and a standard deviation of 13.94. School E (*n* = 37) had a mean score of 59.01, a median of 60.00, a mode of 60.00, and a standard deviation of 9.99. Finally, School F (*n* = 45) had a mean score of 58.67, a median of 60.00, a mode of 66.67, and a standard deviation of 15.22 (Table 4.3).

Table 4.3

Pretest Scores by School

	School A (n = 67)	School B (n = 34)	School C (n = 4)	School D (n = 175)	School E (n = 37)	School F (n = 45)
Mean	47.91	50.88	51.67	43.89	59.01	58.67
Median	50.00	53.33	50.00	43.33	60.00	60.00
Mode	36.67	56.67	50.00	40	60.00	66.67
SD	12.99	13.86	3.33	13.94	9.99	15.22

Table 4.4

Posttest Scores by School

	School A (n = 59)	School B (n = 19)	School C (n = 4)	School D (n = 137)	School E (n = 0)	School F (n = 41)
Mean	64.46	61.75	67.50	46.59	No posttest	61.71
Median	63.33	63.33	70.00	46.67	response	63.33
Mode	60	63.33	73.33	46.67	data	63.33
SD	12.99	11.88	7.88	13.73		13.14

There was variance between pretest and posttest scores amongst 3rd and 4th grade students. A mean score of 42.31 was achieved by the 185 3rd graders who took the pretest, with a standard deviation of 11.95 and a median/mode of 40.00. 177 4th graders averaged a 55.50 on the pretest, with a standard deviation of 14.60, a median of 56.67, and a mode of 50.00. On the posttest test, 3rd graders (n = 128) had a mean score of 49.06, a standard deviation of 13.85, a median of 46.67, and a mode of 43.33. 4th grade students (n = 132) had a posttest average of 59.70, a standard deviation of 15.53, a median of 60.00, and a mode of 63.33. It should be noted that 3rd grade mean scores improved by 6.75 on posttest and 4th grade means scores increased by 4.20 points (Table 4.5 and Table 4.6).

Table 4.5

Pretest Scores by Grade

	3rd Grade	4th Grade
Mean	42.31	55.50
Median	40.00	56.67
Mode	40	50
SD	11.95	14.60

Table 4.6

Posttest Scores by Grade

	3rd Grade	4th Grade
Mean	49.06	59.70
Median	46.67	60.00
Mode	43.33	63.33
Standard Deviation	13.85	15.53

The final descriptive metric that the researcher analyzed was the difference between pretest and posttest scores on individual questions. Students performed worst on question 21, even going so far as to score -4.1% lower between the pre and posttests. Students scored the highest on question 28 with an 85.08% correct rate on the pretest and a 93.85% correct rate on posttest. By listing out the data from individual questions on the pretest and posttest, the researcher highlighted the impact that certain questions had on overall mean scores.

Inferential Statistics

As previously, stated the science construct had an implied reliability of “minimally acceptable” with a Cronbach’s coefficient alpha of .65 (DeVellis, 1991). With this information and a homogenous distribution, the researcher conducted inferential analysis to determine if the treatment improved scores on the STEM instrument. The researcher completed an independent samples t-test. A t-test was selected because it is a “statistical test that allows you to compare two means to determine the probability that the difference between them reflects a real difference between groups . . . rather than a chance variation in data" (Tuckman, 1999). The reason that this t-test had to be "independent" was because the instrument was anonymous, rendering the researcher unable of connecting specific pretest scores to specific posttest scores.

The independent sample t-test had two test variables, being group 1 (pretest) and group 2 (posttest). After running the t-test, $t(df) = -4.31$ and the p (sig.) = .00 (Tables 4.8 and 4.9). This shows that there was a statistically significant difference between STEM pretest and posttest scores. The pretest mean score was lower than the posttest mean score, showing an improvement overall. In Table 4.7, the mean number of correct responses on the 15-question instrument climbed from 7.19 to 8.23. This is an increase of 1.04 correct responses for the samples tested. A t-test for equality of means was conducted on the STEM construct data and the researcher found that the sig. (2-tailed) was equal to 0.00 (Table 4.9). This showed the researcher that there was a significant difference between means and that the null hypothesis can be rejected (Tuckman, 1999). Using Cohen's *d* to test for practical significance, the researcher found that the effect size was .351. This showed a small to moderate practical significance, meaning that the treatment had a moderate strength of association between variables and results (Cohen, 1988). Tables were included below that showed the t-test results of the both the STEM construct as a whole and the individual STEM questions that made up the construct

Table 4.7

Group Statistics – STEM Construct

	Pre (1) or Post (2)	N	Mean	Std. Deviation	Std. Error Mean
STEM Construct	1	362	7.19	2.90	0.15
	2	260	8.23	3.07	0.19

Table 4.8

Independent Samples Test (Levene's Test) – STEM Construct

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
STEM Construct	EVA	0.95	7.19	-4.31	620
	EVNA			-4.27	538.66

Note: EVA stands for "Equal Variances Assumed," EVNA stands for "Equal Variances Not Assumed."

Table 4.9

Independent Samples Test (t-test for Equality of Means) – STEM Construct

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
STEM Construct	EVA	0.00	-1.04	0.24
	EVNA	0.00	-1.04	0.24

Table 4.10

Independent Samples Test (95% Confidence Interval) – STEM Construct

		t-test for Equality of Means 95% Confidence Interval of the Difference	
		Lower	Upper
STEM Construct	EVA	-1.52	-0.56
	EVNA	-1.52	-0.56

Table 4.11

Independent Samples Test – STEM Construct Individual Item

		Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
Q1	EVA	0.18	0.67	-0.22	620.00	0.83	-0.09	0.04	-0.09	0.07
	EVNA			-0.22	557.54	0.83	-0.09	0.04	-0.09	0.07
Q2	EVA	26.79	0.00	-2.52	620.00	0.01	-0.10	0.04	-0.17	-0.02
	EVNA			-2.55	581.81	0.01	-0.10	0.04	-0.17	-0.02
Q3	EVA	11.97	0.00	-3.50	620.00	0.00	-0.14	0.04	-0.22	-0.06
	EVNA			-3.48	549.56	0.00	-0.14	0.04	-0.22	-0.06
Q4	EVA	0.23	0.64	-0.24	620.00	0.81	-0.01	0.04	-0.09	0.07
	EVNA			-0.24	559.04	0.81	-0.01	0.04	-0.09	0.07
Q5	EVA	3.48	0.06	0.97	620.00	0.33	0.04	0.04	-0.04	0.12
	EVNA			0.96	551.47	0.34	0.04	0.04	-0.04	0.12
Q6	EVA	0.08	0.77	0.15	620.00	0.89	0.01	0.04	-0.07	0.09
	EVNA			0.15	557.44	0.89	0.01	0.04	-0.07	0.09
Q7	EVA	19.21	0.00	-2.13	620.00	0.03	-0.08	0.04	-0.15	-0.01

	EVNA			-2.16	585.07	0.03	-0.08	0.04	-0.15	-0.01
Q8	EVA	17.19	0.00	-2.51	620.00	0.01	-0.10	0.04	-0.18	-0.02
	EVNA			-2.49	545.50	0.01	-0.10	0.04	-0.18	-0.02
Q9	EVA	67.61	0.00	-5.51	620.00	0.00	-0.21	0.04	-0.29	-0.14
	EVNA			-5.40	516.91	0.00	-0.21	0.04	-0.29	-0.13
Q10	EVA	66.30	0.00	-4.24	620.00	0.00	-0.15	0.04	-0.22	-0.08
	EVNA			-4.11	492.09	0.00	-0.15	0.04	-0.22	-0.08
Q11	EVA	20.45	0.00	-2.20	620.00	0.03	-0.08	0.04	-0.16	-0.01
	EVNA			-2.23	581.33	0.03	-0.08	0.04	-0.16	-0.01
Q12	EVA	74.54	0.00	-4.66	620.00	0.00	-0.17	0.04	-0.24	-0.10
	EVNA			-4.53	497.52	0.00	-0.17	0.04	-0.24	-0.10
Q13	EVA	3.62	0.06	0.94	620.00	0.35	0.04	0.04	-0.04	0.11
	EVNA			0.94	569.54	0.35	0.04	0.04	-0.04	0.11
Q14	EVA	1.26	0.26	-1.52	620.00	0.13	-0.06	0.04	-0.14	0.02
	EVNA			-1.52	558.86	0.13	-0.06	0.04	-0.14	0.02
Q15	EVA	1.16	0.28	-0.54	620.00	0.59	-0.02	0.03	-0.09	0.05
	EVNA			-0.54	567.06	0.59	-0.02	0.03	-0.09	0.05

The Cronbach's Coefficient Alpha was too low to be deemed reliable for the agriculture construct (α = .336). As a result of the entire construct being unreliable, the researcher decided that it would be more appropriate to conduct a t-test on the individual items that made up said construct. While the instrument as a whole was not able to indicate agricultural knowledge of the sample tested, individual questions were still able to indicate whether or not student scores improved significantly between the pretest and posttest phase. For the independent samples t-test of individual items, the researcher sought a t-value < -2.042 and a p < .05 (Tuckman, 1999). Three items were deemed reliable following the individual items t-test. These questions included Q17 (*t*(*df*) = -2.193, p = .029), Q18 (*t*(*df*) = -2.73, p = .007) and Q26 (*t*(*df*) = -2.658, p = .008) (Table 4.13). The entire instrument, including these specific questions can be found in Appendix C. The independent samples t-tests told the researcher that these three questions were the only ones on the agricultural instrument that could reliably measure knowledge gain between pretest and posttest. On Q17, students went from a correct response rate of 52% to a correct response rate of 61%, demonstrating a 9% improvement on this item between pretest and posttest. On Q18, student averages jumped from 59% to 69%, a 10% increase. Finally, on Q26, student mean scores went from 29% to 39%, another 10% increase (Table 4.15). To test for practical significance, the researcher used Cohen's d and found an effect size of 0.205. According to Cohen, this means there was a small to moderate strength of association between variables and results (1988).

Group statistics for the agricultural construct showed an increase in the mean amount of questions that students answered correctly, 5.01 to 5.40 (Table 4.12). The reliability of the agriculture construct was conducted *a priori* and the construct was found to not be reliable (alpha = 0.336). This table shows the Equality of Variances and t-test results for those specific questions. Table 4.14 listed out all the Equality of Variances and t-test results for the questions that did not meet the parameters of statistical significance (t < -2.042, p < 0.05). All in all, this meant that for the entire 12 question instrument, three questions showed statistically significant improvements between the pretest and the posttest

Table 4.12

Group Statistics – Agriculture Construct

	Pre (1) or Post (2)	N	Mean	Std. Deviation	Std. Error Mean
Agriculture Construct	1	362	5.01	1.92	0.10
	2	260	5.40	1.92	0.12

Table 4.13

Independent Samples Test – Agriculture Construct Individual Item (Significant)

		Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.
Q17	EVA	15.70	0.00	-2.19	620.00	0.03	-0.09	0.04
	EVNA			-0.22	565.38	0.03	-0.09	0.04
Q18	EVA	30.63	0.00	-2.73	620.00	0.01	-0.10	0.04
	EVNA			-2.76	578.25	0.01	-0.10	0.04
Q26	EVA	24.50	0.00	-2.66	620.00	0.01	-0.10	0.04
	EVNA			-2.63	532.32	0.01	-0.10	0.04

Table 4.14

Independent Samples Test – Agriculture Construct Individual Item (Non-Significant)

		Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.
Q19	EVA	0.40	0.53	0.33	620.00	0.74	0.01	0.04
	EVNA			0.33	557.25	0.74	0.01	0.04

Q20	EVA	16.12	0.00	-1.96	620.00	0.05	-0.06	0.03
	EVNA			-1.99	593.85	0.05	-0.06	0.03
Q21	EVA	9.78	0.00	1.53	620.00	0.13	0.06	0.04
	EVNA			1.54	569.93	0.12	0.06	0.04
Q22	EVA	8.54	0.00	1.44	620.00	0.15	0.04	0.03
	EVNA			1.47	593.94	0.14	0.04	0.03
Q23	EVA	4.63	0.03	-1.06	620.00	0.29	-0.04	0.04
	EVNA			-1.06	563.11	0.29	-0.04	0.04
Q24	EVA	6.59	0.01	-1.38	620.00	0.17	-0.06	0.04
	EVNA			-1.38	550.47	0.17	-0.06	0.04
Q25	EVA	5.59	0.02	-1.19	620.00	0.23	-0.04	0.03
	EVNA			-1.18	533.90	0.24	-0.04	0.03
Q27	EVA	1.59	0.21	-0.64	620.00	0.53	-0.02	0.04
	EVNA			-0.63	548.70	0.53	-0.02	0.04
Q28	EVA	0.31	0.58	0.28	620.00	0.78	0.01	0.04
	EVNA			0.28	560.09	0.78	0.01	0.04

Table 4.15

Agricultural Construct Individual Item Pretest vs. Posttest Scores

	Pre (1) or Post (2)	N	Mean	Std. Deviation	Std. Error Mean
Q17	1	362	0.52	0.50	0.03
	2	260	0.61	0.49	0.03
Q18	1	362	0.59	0.49	0.26
	2	260	0.69	0.46	0.29
Q26	1	362	0.29	0.45	0.02
	2	260	0.39	0.49	0.03

Confirmation or Rejection of Hypotheses

There were two hypotheses developed which were based off of the two research objectives. These hypotheses are listed below.

> $H^0$1: elementary agricultural education will have no impact student agricultural literacy in 3rd and 4th grade students
>
> $H^1$1: elementary agricultural education will impact student agricultural literacy in 3rd and 4th grade students
>
> $H^0$2: elementary agricultural education will have no impact student science knowledge in 3rd and 4th grade students
>
> $H^1$2: elementary agricultural education will impact student science knowledge in 3rd and 4th grade students

For objective 1, the researcher failed to reject the null hypothesis (H^0) and rejected the alternative hypothesis (H^1). While there were three questions that showed tangible improvements between the pretest and posttest phase, the agriculture construct as a whole was unreliable. Even though Q17, Q18, and Q26 showed a 9%, 10%, and 10% improvement (respectively), the researcher could not with full confidence say that elementary agricultural education had an impact on agricultural literacy in 3rd and 4th grade students. With an unreliable construct, it would be irresponsible to determine correlation. The statistically significant t-values included Q17 ($t(df) = -2.193$, $p = .029$), Q18 ($t(df) = -2.73$, $p = .007$) and Q26 ($t(df) = -2.658$, $p = .008$) (Table 4.13)

For objective 2, the researcher rejected the null hypothesis (H^0) and failed to reject the alternative hypothesis (H^1). The STEM construct was deemed reliable (0.653) and student mean scores improved by 1.04 correct responses between the pretest and posttest phase. Conducting an independent samples t-test yielded a value of t(df) = -4.31 and p (sig. 2-tailed) = .00. This told the researcher that differences between means were statistically significant, emphasizing an improvement between both phases. H^0 for objective 2 was rejected because of this statistically significant difference following the treatment of the elementary agricultural education curriculum.

CHAPTER 5

CONCLUSIONS

Summary of Key Findings

At the start of fall 2019, the Georgia Department of Education began a three-year pilot program for elementary agricultural education. This curriculum was designed to improve students' levels of agricultural literacy beginning at young age. Furthermore, being exposed to agriculture in a positive light could help students view agriculture in a more favorably. As previously stated, psychologists Freud, Piaget, and Erikson stated that people formulate ideas and notions that last throughout their lives "between years 6-11" (Terry, Herring, & Larke, 1992). For this research study, the population was the 26 elementary agricultural programs throughout Georgia. The sample size was five schools that completed the pretest and four schools (all schools minus School E) that completed the posttest.

Students were tested using an instrument that had both a science, technology, engineering, and mathematics (STEM) construct and an agricultural construct. The researcher used Cronbach's Coefficient Alpha to determine whether or not the individual constructs were reliable. The STEM construct showed an overall reliability of 0.653, which made it minimally acceptable (DeVellis, 1991). While the ideal range of reliable is $\alpha = \geq 0.70$, minimal acceptability allowed to still be analyzed (DeVellis, 1991; Tuckman, 1999). Once the construct was deemed trustworthy, the researcher conducted an independent samples t-test which revealed an increase in correct answers on the STEM instrument of 1.04. As a result of the means increasing between the pretest and posttest phases and the STEM construct being reliable, the researcher concluded that this change was statistically significant and demonstrated an increase in STEM literacy following the elementary agricultural education curriculum.

As for the agriculture construct, the Cronbach's Coefficient Alpha yield a reliability of 0.336. This is well below the acceptable range of reliability, $\alpha = \geq 0.70$ (Tuckman, 1999). With a reliability this low, the researcher tested the reliability of individual questions that made up the construct. This led the researcher to find that Q17, Q18, and Q26 all were reliable measurements of student understanding. Following this step, the researcher conducted an independent samples t-test on the entire instrument, including these three questions. These questions showed a 9%, 10%, and 10% improvement between the pretest and posttest phase. While these questions demonstrated a greater understanding between the pretest/posttest, this result was seen exclusively on these three questions.

Results in relation to Research Questions

There were two research questions for this study. They were:

1. Does elementary agricultural education impact student agricultural literacy in 3rd and 4th grade students?
2. Does elementary agricultural education impact student science knowledge in 3rd and 4th grade students?

For research question one, statistical tests were aimed at determining reliability and statistical significance of the agriculture construct. These tests included Cronbach's Coefficient Alpha to determine the reliability of the construct as a whole and an independent samples t-test to analyze whether or not results were statistically significant. Results indicated that the construct as a whole was not an accurate indicator of agricultural literacy. Three questions arose as both reliable and statistically significant, these included Q17, Q18, Q26. While research question one was partially answered, the researcher determined that with the construct developed and the results reported, that elementary agricultural education did not significantly improve agricultural literacy.

Research question two had different outcomes. The STEM construct was deemed reliable after conducting Cronbach's Coefficient Alpha, yielding an $\alpha = 0.653$. This reliability was "minimally acceptable" and the researcher accepted the construct as a whole (DeVellis, 1991). Following this step, the researcher conducted an independent samples t-test to determine if there was a statistically significant difference between pretest and posttest means. The t-test revealed a $t(df) = -4.31$ and p (2-tailed sig.) = 0.00. This meant that not only was this construct reliable but the positive change between means was significant and trustworthy. Students answered 1.04 more questions correctly on the posttest than they did on the pretest. This was a 7.26% increase on overall STEM construct scores. This meant that research question two was answered because elementary agricultural education appeared to have positively impacted student understanding of science concepts.

The null hypothesis (H^0) for question one was confirmed as there was not enough conclusive data to conclude that elementary agricultural education had an impact on agricultural literacy in 3rd and 4th grade students. The alternative hypothesis (H^1) was rejected for question one as there was no reliable data to support elementary agricultural education improving 3rd and 4th grade student agricultural literacy. The null hypothesis (H^0) for question two was rejected because there was a statistically significant difference between student mean scores on the STEM construct. The alternative hypothesis (H^1) was not rejected because student means scores went up by 7.26% between the pretest and posttest phases.

Connection to Existing Literature

The researcher's findings were connected to literature in multiple ways. Similar to the research of Pense, there was no difference found between general education and agricultural education students' agricultural literacy (2004). Students in the researcher's study had difficulty making distinctions between livestock and processed foods. Previous research found that students lacked this component of agricultural literacy as well (Meischen & Trexler, 2003). Furthermore, it was determined that, due to a lack of agricultural literacy amongst students, student schemas regarding agricultural had not changed (Hess & Trexler, 2011). Student scores on the STEM construct were also higher than on the agriculture construct, a result found in Brandt, Forbes, & Keshwani (2017). While there were a myriad of other researchers who found positive gains in agricultural literacy between treatments, the researcher's unreliable agriculture instrument does not allow any conjecture (Brand, Forbes, & Keshwani, 2017; Monk, Norwood, & Guthrie, 2000; Powell & Agnew, 2011; Pense, Leising, Portillo, & Igo, 2005).

Alternative Explanations of Results

The researcher acknowledged that there could be alternative explanations to the results that were found in this quantitative study. The following was an analysis of the alternative explanations for the STEM and agriculture construct results.

Extraneous Variables in STEM

There were multiple extraneous variables that could explain the scores that students received on the STEM construct. The first alternative explanation behind these results could be the frequency that students were receiving science instruction outside of their agriculture class. In simpler terms, how much time were these students spending in science classes per week? While each of the students tested were in an elementary agricultural education course, the researcher did not investigate the time 3rd and 4th grade students at the sample schools spent in their science courses. This could influence the results because particular students could have had more time spent in their traditional science courses outside of agricultural education. This would give these students a potentially unfair advantage over students that were receiving less hours in the sciences per week. Collecting data on time spent in science classes was outside of the scope of this research study but could be a potential research topic for others in the future.

Furthermore, there was a risk of test/re-test bias with students that participated in this research study. While the researcher provided a two-month treatment window, there might have been some students who remembered particular questions from the pretest that they may have missed. This could be taken even further if elementary teachers, despite being advised against it, helped students prepare for the posttest by answering questions that they found confusing on the instrument. The researcher did not assume that this was the case by any means, but the option should be left open. On the other hand, test/re-test bias could have been non-existent. It was also possible that students did not remember a single question from that two-month window and took the posttest just as unfamiliar with the structure as when they took the pretest.

Another possible explanation of these results could be rooted in the aptitude of both the agricultural and science educators. If students at a particular school did better than students at another, this could be the result of the instruction of said teachers. This extraneous variable was outside of the scope of this research study as the research sought to examine the impact of elementary agricultural education and its curriculum. In relation to the aptitude of the educators, the quality of educational resources in the school and community could impact student scores. If a student is provided with more options to engage in hands-on, experiential learning (see theoretical framework), they may have a higher retention rate on the content (Kolb, 1984). While the researcher did ask if students had access to electronic devices to complete the instrument, he was unable to determine what other resources might be available to each individual student at their particular school. Again, this was outside of the scope of this research study.

The final two extraneous variables that could have influenced the results of this study were a student's previous familiarity with science topics and the correlation between when science content was taught in traditional science classes. First, each student was unique and as a result may have had more familiarity with the content that was analyzed via the instrument. If a student had already learned a topic in their science class, they might have been predisposed to correctly answering questions more frequently. Second, the researcher did not have control over the curriculum pacing guide of any educators in the school. This could have meant that a student entered into their agriculture classroom to take their posttest after just being taught about planets, simple machines, pollinators, etc. in their other science classes. This would have given an unfair advantage to particular students and could have raised their scores over students that were tested at the remaining four schools.

Extraneous Variables in Agriculture

Similar to the STEM construct, there were also extraneous variables that could explain the results of the agriculture construct data. First, student scores may have fluctuated based on the aptitude of the elementary agricultural educator. Students at a higher performing school could have had a teacher that was more adept at matching the curriculum to the needs of their students. Teacher aptitude covers a multitude of factors including, but not limited to content knowledge, classroom management, and accommodation to student needs. A teacher with these three teaching traits may have had more success with their students as they were providing a classroom that was more conducive to authentic learning (Knobloch, 2003).

Second, the researcher did not know the influence that school resources have on student performance. According to research, “school resources and student performance are not directly associated to one another – neither in the US nor abroad” (Nascimento, 2008; Hanushek, 2006). However, some have noted that “school factors seemed to outweigh family characteristics on the determination of student outcomes” (Heyneman & Loxley, 1983). Either way, a study on the effect of school resources on agricultural literacy is beyond the scope of the researcher’s work. Third, a student may have previous familiarity with agriculture that could have led to skewed testing results. If a student had a greater amount of day-to-day interactions with agricultural content, this may have given that students a greater chance to perform at a higher level than their peers.

Finally, as previously stated, this instrument did not have an appropriately reliable agriculture construct. This meant that this instrument was not thorough enough to measure the desired variables. It was challenging to determine the effects that the treatment had on the sample if the construct cannot be completely relied upon. A 12-question agriculture construct was not long or detailed enough to grasp a student’s understanding of agricultural concepts. Therefore, student data, in relation to the agriculture construct, can only be trusted for Q17, Q18, and Q26. Put simply, 25% of the agriculture construct was seen as an accurate measurement of mean student growth between the pretest and posttest phase.

Implications of Findings

There were two major implications of these findings. The first was that elementary agricultural education appeared to have increased student performance on the STEM instrument after a two-month treatment. This could imply that elementary agricultural education could be a useful framework through which students can apply scientific material learned in their other science classes. This meant that elementary students seemed to fair well when taught in an agricultural classroom, so much so that it made them more proficient in STEM content.

The second implication of these findings was that elementary agricultural education did not appear to have improved 3rd and 4th grade students' levels of agricultural literacy. As previously stated, this could be the result of the extraneous variables mentioned above or it could be that elementary agricultural education had a negligible effect on student's understanding of agriculture. Elementary agricultural education needs to be investigated more thoroughly to determine if the results of this study were influenced by the researcher's methodology, the students tested, or the testing situations that these students were located within (i.e. teacher, classroom, school district, etc.).

Limitations

Limitations of this study included 6 factors. The first limitation was the two-month treatment period that students were subjected to. The researcher was bound by a specific timetable, which led to a shorter treatment period than desired. Ideally, this research would have been conducted over a complete school year with the formative assessment (pretest) conducted at the very beginning of fall 2019 and the summative assessment (posttest) conducted at the end of spring 2020. While the researcher saw a 7.26% increase in mean scores on the STEM construct, a longer treatment period would not have raised the agriculture scores due to the unreliable construct that was developed.

The second limitation was in regard to school, teacher, parent, and student participation. As one may have noted, there were multiple checkpoints that the researcher had to go through to generate the sample size studied. First and foremost, schools (i.e. administrators) had to agree to participate in this study. If they consented, the next group that had to consent were teachers. If teachers did not want to add the stress of a research study to their newly founded programs, they likely did not choose to participate. If teachers chose to join in this study, parents and guardians had to give consent to have their student complete the instrument. Finally, the student had to provide assent which showed that they were interested in being studied. This was a wide group of stakeholders that had to be catered towards and this led to a smaller sample tested.

While the researcher was not able to test all 26 pilot programs in Georgia, they were capable of testing a total number of 622 students from across the state. While the entire population was not represented, a homogenous distribution was still achieved. The researcher was able to deduce the effects that the elementary agricultural curriculum had on a large group of students but there were still thousands of other students that were not studied, spanning from kindergarten to 5th grade. Furthermore, even though School E provided a sample of 37 students in the pretest phase, they were unable to participate in the posttest phase due to delayed response times. The researcher was unable to determine whether or not these students' scores improved on the either construct. The results of their posttest scores could have improved the reliability or could have lowered the average mean score overall. It was impossible to conclude what impact was had and it should be taken into consideration that all the data was not available from the total sample.

The third limitation was a lack of randomization within the sample. This lack of randomization was attributed to the "connections rotation" of the students that were receiving the agricultural education curriculum. A connections rotation meant that all students were receiving the same weekly grade-level content in their agriculture classes, meaning that it would not be possible to have a control group at each school. However, the lack of randomization was mitigated by conducting a non-experimental research study. Non-experimental research did not allow for control over the independent variables or randomization (Thompson & Panacek, 2007). Non-experimental research fit this study well because the researcher already had no control over the writing of the curriculum (the independent variable) or the rotation that students received said curriculum (randomization).

The fourth limitation was in regard to anonymity between pretest and posttest results. Since the instrument was anonymously conducted, in accordance with the IRB protocol, the researcher could not connect specific scores to specific students. To assuage this, the researcher applied an independent samples t-test. An independent samples t-test analyzed the difference between independent means to determine if there was a statistically significant difference between data points (Tuckman, 1999). Since the researcher was more concerned with overall improvement for the entire sample, an exact score for each student was unnecessary.

The fifth limitation was rooted in subjectivity. As this research was being conducted, the researcher was earning a master's degree in agricultural and environmental education in hopes of becoming an agricultural educator. While the researcher ascribed to the methods of Dewey, Vygotsky, Stimson, and Kolb, this study was intentionally designed to be quantitative in an effort to mitigate bias. The data has been assessed with the aid of fellow researchers and statisticians to keep results as pure as possible. Both statistically significant and non-statistically significant results have been listed in chapter four of this thesis.

The final limitation that the researcher wishes to address was the difficulty of questions. While the instrument was pilot tested with 45 elementary school students in 3^{rd} and 4^{th} grade and edited by agricultural education professors, the questions may still have been beyond the ability levels or cognitive capacity of participating students. If certain students began from a position of privilege (i.e. broader vocabulary, larger index of prior information), it could potentially impact overall results. Furthermore, this test was proctored by elementary agricultural education teachers. If students had a specific Individualized Education Plans (IEP), 504 plans, or Behavior Intervention Plan (BIP) and their accommodations were not met, the students' performance may have suffered.

Recommendations for Future Research

There are multiple questions that the researcher would ask for future studies to investigate. The elementary agricultural pilot program is continuing until 2022. The researcher strongly advises that other researchers investigate the following questions and problems.

Geographic Region & Literacy

The first major question was: "do geographic regions influence student performance in agriculture and science?" More specifically, if an elementary student is exposed to agriculture on a daily basis, does this impact their understanding of science and agriculture topics? The hypothesis here is that familiarity can breed understanding. A research study investigating geographic regions in Georgia and the impact that elementary agricultural education has on STEM and agriculture would be worthwhile. Should urban elementary agricultural education look entirely different that rural elementary agricultural education? This research would help curriculum developers understand what necessary changes need to be made over the course of this pilot program.

School Resource and Student Literacy

As mentioned previously, certain researchers have deduced that a lack of school resources does not impact student performance as severely as one may think (Hanushek, 2006). It would be helpful to know what impact school resources in elementary agricultural education have on students. Do more affluent schools with access to newer technologies have higher-performing students in science and agriculture? Do students that live in rural communities, with access to farmland, greenhouses, etc., have greater agricultural literacy? Answering this question would be helpful in determining what resources elementary agriculture teachers should be employing in their classrooms, whether rural or urban, for the greatest gains in literacy.

Characteristics and Skills Needed from Elementary Agriculture Teachers

Furthermore, what characteristics and skills do elementary agriculture teachers need to have to be effective? If there are set traits that are inherent to students learning agriculture and STEM, it would be beneficial to list those out for teachers. By using a standardized test measurement, similar to the one developed for this study, another researcher might be able to determine what content students improved the most on and then investigate the teaching methods that those successful teachers used.

Length of Literacy Instrument

Another area that would be worth researching would be the length of science and agricultural literacy tests. How long should a science and agricultural literacy instrument be to accurately measure student understanding of these topics? The researcher chose a shorter format to prevent burnout from students and increase the likelihood of teacher, parent, and student participation. How could the instrument that was developed for this research study be refined to become a more accurate barometer of student literacy in agriculture and the sciences?

Current Curriculum and Student Ability Levels

The final question that the researcher would advise answering is in relation to student abilities and the current Georgia elementary agricultural education curriculum. Is the current curriculum accurately titrated to student ability levels? Put another way, are curriculum writers scaffolding elementary agricultural instruction in a way that is appropriate for students developmentally? While the curriculum development team spent weeks determining what students should learn via a Delphi method, it would be worthwhile to investigate how students and teachers can best accomplish these standards in the day-to-day classroom. What supports are necessary for students with IEPs, 504 plans, and BIPs to succeed in elementary agricultural education?

Recommendations for Practitioners

Elementary Agricultural Education Teachers

There a few recommendations for elementary agricultural education teachers that the researcher would like to include. First, the researcher believes that it would be incredibly beneficial for elementary agricultural education teachers to combine their efforts with science and mathematics teachers in their schools. This would allow for elementary agricultural education teachers to see what is being taught in their students' traditional science and math courses, providing "vertical coherence" to students (NRC, 2006). By doing so, agriculture teachers would be able to better align their curriculum pacing guides to match content that is being taught in these other classes. Working alongside their fellow teachers would also allow agriculture teachers to better access educational supports that they have. Literature shows that teachers enjoy using agriculture as a framework but needed greater skill teaching about these topics (Knobloch & Ball, 2003; Bellah & Dyer, 2006).

Another recommendation that the researcher has pertaining to elementary agricultural education teachers is participation in professional development workshops. While elementary agricultural education is in its infancy, teachers may not have the same opportunities to participate in professional development like high school or middle school teachers do. Teachers should look into what options Region Coordinators and Extension Services could offer them to better learn content. Balschweid, Thompson, & Cole (1998) highlighted the positive impact that the Summer Agricultural Institute had on K-12 teachers. A similar venture would be beneficial for elementary practitioners.

The final recommendation that the researcher has for elementary agricultural education teachers is that they should create an open discussion between themselves and curriculum writers. The elementary agricultural education curriculum was created via a Delphi approach which had education and industry professionals decide what was most salient for young students to know. Frick (1993) discussed how the middle school curriculum also followed a Delphi approach. This approach is most appropriate for curriculum development, in the researcher's eyes, but it is equally important that teachers communicate with administrators and curriculum writers about what content is best suited for these students. Elementary teachers are most keenly aware of the areas in which these students are lacking and by communicating with curriculum writers during the pilot phase, most issues could be assuaged before the curriculum expands to the rest of the state.

Schools

Recommendations for schools include investigating the resources that teachers need and the Connections Rotation frequency. While some argue that resources are not indicative of student success, the researcher thinks that agricultural education is in a different category than traditional classroom instruction (Hanushek, 2006). Agricultural education is reliant on the three-component model which balances equal parts instruction, leadership, and experience. The researcher found that most of the schools that performed at a lower rate where located in lower socio-economic status regions. These schools often lack the necessary resources that teachers require to be thorough in their instruction. Schools need to survey the needs of their elementary agricultural education teachers to find out what items they need to have to be successful in their classrooms.

Second, schools need to analyze their current Connections Rotation and agricultural education's place within it. For science instruction to be thorough, their needs to be enough time to cover all necessary topics (NRC, 2011). The National Research Council noted that highly successful science programs dedicated more time to instruction (2011) With the current Connections Rotation, most elementary agriculture students are receiving approximately one hour of agricultural instruction per week. Research literature shows us that that is not enough time for students to learn content (NRC, 2011; Thorp & Townsend, 2001). Schools should decide how they could potentially involve agricultural lessons into students' science classes on a daily basis. While the researcher acknowledges that this is a large task, they believe that it would be a worthwhile investment into these students' futures.

Teacher Preparation

The final stakeholder group that the researcher wishes to address are those involved in teacher preparation programs. There are three major recommendations that the researcher would like to offer which would improve elementary agricultural education. The first is utilizing the 3:1 framework for elementary agriculture teachers. The 3:1 framework is a method of preparing science educators that has candidates complete three content courses to every one teacher preparation course (Epstein & Miller, 2011). Research shows that teachers with greater pedagogical content knowledge are more successful in the classroom (Epstein & Miller, 2011; Rice & Kitchel, 2017). Teacher preparation should begin shifting from focusing solely methodology to focusing on methodology in light of content. When teachers better understand the content they are teaching, they are more apt communicators on the topic (Rice & Kitchel, 2017).

The final two recommendations that the researcher would like to offer for teacher preparation programs are dual-certification pathways and elementary agricultural education student teaching internships. A dual-certification pathway would allow for teachers to become certified both in agricultural education and elementary grades education. This would allow for teachers to become more well-versed on both agricultural content and the necessary pedagogical techniques needed for elementary grades. Universities should begin the protocol that would allow for teachers to accomplish both of these tasks in a timely manner. In relation to this, student teaching internships should also be encouraged at the end of this three-year pilot program. Student teaching is an invaluable experience in the life of a future educator and provides them with the pertinent skills they need to begin teaching. Universities and teacher preparation programs should anticipate the advent of elementary agricultural education and begin preparing cohorts for the end of this pilot phase.

Conclusion

For this research study, a non-experimental pretest-posttest design was chosen to test whether elementary agricultural education positively improved mean scores of 3rd and 4th graders' agricultural and science, technology, engineering, and mathematical (STEM) literacies on an instrument. The researcher developed a 27-question instrument based on state education standards and composed of two constructs, agriculture and STEM. 622 students from five pilot programs participated in this research study. The researched concluded that elementary agricultural education increased mean scores on the STEM construct by 7.62%. Due to reliability scores that were lower than desired, the agriculture construct was an ineffective measurement of student agriculture literacy, despite three questions show a reliable, statistically significant increase in means. The researcher recommends studying the impact that geography, teacher aptitude, school resources, length of instrumentation, and student accommodations have on elementary agricultural education.

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APPENDICES

APPENDIX A: IRB APPROVAL FOR RESEARCH STUDY

UNIVERSITY OF GEORGIA

1785

Tucker Hall, Room 212

310 E. Campus Rd.

Athens, Georgia 30602

TEL 706-542-3199 | FAX 706-542-5638

IRB@uga.edu

http://research.uga.edu/hso/irb/

Human Research Protection Program

EXEMPT DETERMINATION

August 3, 2019

Dear Jason Peake:

On 8/3/2019, the Human Subjects Office reviewed and approved the following submission:

Title of Study:	A Non-Experimental Analysis of Agricultural and Science, Technology, Engineering, Mathematics (STEM) Literacies in Georgia Elementary Agricultural Education
Investigator:	Jason Peake
Co-Investigator:	Benjamin Byrd
IRB ID:	PROJECT00000808
Funding:	None
Review Category:	Flex-Exempt 3(A)

Should you modify this study in the future, please be aware that not all modifications will *require review by the IRB since it was determined to be "Exempt." For more information on modifications that will require review and approval by the IRB prior to implementation, please see Appendix C of the Exempt Research Policy (https://research.uga.edu/docs/policies/compliance/hso/IRB-Exempt-Review.pdf). As noted in Section C.2, you can simply notify us of modifications that will not require review via the "Add Public Comment" button.*

Note: This study will involve the participation of several schools. Prior to the initiation of any human research activity in a particular school, please submit the school's authorization via "Add Public Comment."

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Please close this study when it is complete or submit a Progress Report by 8/2/2024, whichever comes first.

Sincerely,

Benilda P. Pooser, Ph.D., CIM

Director, Clinical Research Compliance

APPENDIX B: LETTER TO PARENT AND CONSENT FORM FOR STUDENT TESTING

UNIVERSITY OF GEORGIA
CONSENT FORM
An Analysis of Agricultural Literacy in Elementary Agricultural Education

Researcher's Statement
I am/We are asking you to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: Jason Peake
Agricultural Leadership, Education, and Communication
jpeake@uga.edu

Co-Investigator Benjamin Byrd
Agricultural Leadership, Education, and Communication
bbyrd94@uga.edu

Purpose of the Study
This study is an attempt to see how elementary agricultural education affects understanding of agricultural and STEM concepts. You are being asked to participate in this study because your school is offering an elementary agricultural education pilot program. These programs are designed to understand how to best implement elementary agricultural education. This data will help to improve agricultural education and is valuable to the future of said programs.

Study Procedures
If you agree to participate, you will be asked to …

- Complete a pretest and posttest covering both agriculture and STEM. These tests are based on Georgia standards for 3rd and 4th grade.
- Time to complete pretest/posttest: approximately 30 minutes for each test, totaling 2 hours.
- Tests will be kept anonymous and will only include grade level in findings.
- No photographs, videos, or audio recordings will be conducted. Only the record of the anonymous online survey will be kept.

Risks and discomforts
- There are no foreseeable risks or discomforts associated with participation in this study.

Benefits
- This study will allow for elementary agricultural education to refine its methods to make sure that future students have the best possible educational experience. Participation could aid educators in improving their teaching methods.

Alternatives
There are no alternative methods for data collection. If student has disability preventing completion of online test, accommodations can be provided.
Incentives for participation
Incentives are the benefits listed above.
Audio/Video Recording
- No photographs, videos, or audio recordings will be conducted. Only the record of the anonymous online survey will be kept.

Privacy/Confidentiality
Participants' information will be kept private and confidential. Those who decide to participate will be kept completely anonymous, excluding grade level.

Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written consent unless required by law.

Taking part is voluntary
Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled.

If you have questions
The main researcher conducting this study is Benjamin Byrd, a graduate student at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact [Benjamin Byrd at bbyrd94@uga.edu] or at (706) 391-3602. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Research Subject's Consent to Participate in Research:
To voluntarily agree to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire consent form and have had all of your questions answered.

Benjamin Byrd	Benjamin Byrd	
Name of Researcher	Signature	Date
Name of Guardian	Signature	Date

Please sign both copies, keep one and return one to the researcher.

APPENDIX C: STUDENT ASSENT LETTER FOR TESTING

Assent Script/Form for Participation in Research

An Analysis of Agricultural Literacy and STEM Integration in Elementary Agricultural Education

We are doing a research study to find out how much children like you understand science and agriculture. We are asking you to be in the study because you are in a class that is learning agriculture. If you agree to be in the study, you will take two quick tests that go over science and agriculture. After taking those tests, you will go about semester like normal. When the semester ends, you will take the same two tests. The total time you will be taking these tests will be around 1-2 hours. Participating in this study will help us improve agriculture classes like the one you are in. We can see what we are doing right and what could be made better.

You do not have to say "yes" if you don't want to. No one, including your parents, will be mad at you if you say "no" now or if you change your mind later. We have also asked your parent's permission to do this. Even if your parent says "yes," you can still say "no." Remember, you can ask us to stop at any time. Your grades in school will not be affected whether you say "yes" or "no."

We will not use your name on any papers that we write about this project. We will only use your grade level to tell others about this study.

You can ask any questions that you have about this study. If you have a question later that you didn't think of now, you can ask us by calling (706) 391-3602 or having your guardian email bbyrd94@uga.edu.

Name of Child: ________________ **Parental Permission on File:** ☐ Yes ☐ No**
***(If "No," do not proceed with assent or research procedures.)*

(For Written Assent) **Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don't want to be in the study, don't sign.**

Signature of Child: ___________________ **Date:** ________________

(For Verbal Assent) **Indicate Child's Voluntary Response to Participation:** ☐ Yes ☐ No

Signature of Researcher: __Benjamin Byrd__________ **Date:** __________________

APPENDIX D: STEM AND AGRICULTURAL LITERACY PRETEST/POSTTEST

What grade are you in?

- o 3rd
- o 4th

What is the name of your school?

____

STEM Literacy

Q1 What is a mineral? (3rd Grade)

A. A type of soil found in Georgia

B. Consumer

C. A solid object found in nature that has never been alive

D. A type of fossil

Q2 Which of these are a type of rock? (3rd Grade)

A. Jurassic

B. Elementary

C. Metamorphic

D. Sandific

Q3 Which is a type of soil? (3rd Grade)

A. Sand

B. Silt

C. Clay

D. All of the above

Q4 Water is the only way erosion occurs. (3rd Grade)

A. True

B. False

Q5 ______ are structures in space that orbit around a star. (4th Grade)

A. Planets

B. Galaxies

C. Suns

D. Stars

Q6 Which of the following planets is the largest? (4th Grade)

A. Earth

B. Mercury

C. Venus

D. Jupiter

Q7 What states of matter are shown (in order left to right)? (4th Grade)

A. Solid, gas, liquid

B. Liquid, solid, gas

C. Solid, liquid, gas

D. Liquid, gas, solid

Q8 Which of the following is a source of heat? (3rd Grade)

A. Sunlight

B. Friction

C. Burning

D. All of the above

Q9 A _______ measures air pressure. (4th Grade)

A. Barometer

B. Rain gauge

C. Thermometer

D. Wind meter

Q10 A(n) ______ is an object that heat can move through easily. (3rd Grade)

A. Insulator

B. Gauge

C. Conductor

D. Plastic

Q11 ______ is the force that makes things fall down to earth. (4th Grade)

A. Force

B. Gravity

C. Work

D. Pressure

Q12 The ______ region is an area with rolling land between the coast and mountains. (3rd Grade)

A. Blue Ridge

B. Estuary

C. Piedmont

D. Barrier Island

Q13 What kind of simple machine is shown below? (4th Grade)

A. Wheel and axle

B. Pulley

C. Lever

D. Inclined Plane

Q14 A plant uses sunlight to create energy. A plant is a type of ________. (4th Grade)

A. Consumer

B. Decomposer

C. Producer

D. Predator

Q15 Predators consume prey. (4th Grade)

A. True

B. False

Agricultural Literacy

Q16 What characteristic do bees, birds, and butterflies have in common? (3rd Grade)

A. Pollinator

B. Herbivore

C. Producer

D. Decomposer

Q17 ________ is the science of farming plants and animals for food and other products. (3rd & 4th Grade)

A. Tilling

B. Aquaponics

C. Agriculture

D. Biology

Q18 Which of the following is NOT a renewable resource? (3rd Grade)

A. Oil

B. Trees

C. Water

D. All are renewable resources

Q19 Name an agricultural product grown in Georgia's Coastal Plain. (3rd Grade)

____

Q20 One of Georgia's main crops is wheat. (3rd Grade)

A. True

B. False

Q21 What are the three parts of agricultural education? (4th Grade)

A. Leadership, plants, classroom

B. Classroom, hands-on learning, leadership

C. Hands-on learning, livestock, leadership

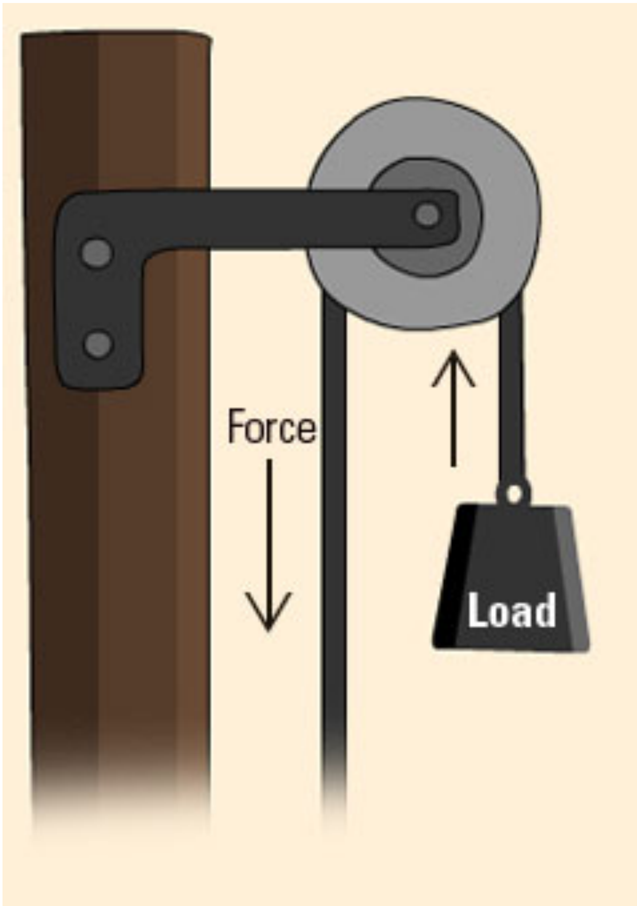
D. Livestock, plants, crops

Q22 Humans have a negative impact on the environment by polluting. (3rd Grade)

A. True

B. False

Q23 What type of simple machine is shown below? (4th Grade)



A. Lever

B. Wheel and axle

C. Pulley

D. Inclined plane

Q24 Where are chickens primarily raised in Georgia? (3rd Grade)

A. Coastal Plain

B. Piedmont

C. Barrier Islands

D. Chickens are not raised in Georgia

Q25 Which of the following is used to measure air pressure? (4^{th} Grade)

A. Thermometer

B. Barometer

C. Compass

D. Wind Gauge

Q26 Which of the following is a "non-verbal" communication skill? (3^{rd} & 4^{th} Grade)

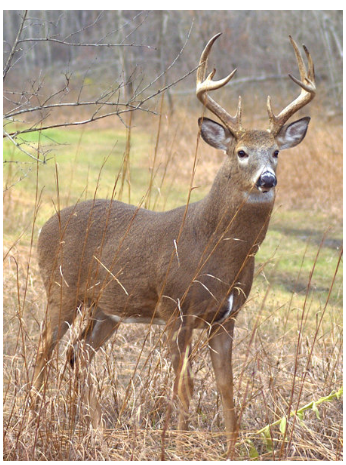
A. Smiling

B. Public Speaking

C. Lecturing

D. A & C

Q27 What type of consumer is the animal below? (4^{th} Grade)



A. Producer

B. Carnivore

C. Scavenger

D. Herbivore

List three agricultural products that are in the picture below. (3rd & 4th Grade)

Q28. ____

Q29. ____

Q30. ____