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Exploring Elementary Students' Agricultural and Scientific Knowledge Using Evidence Centered Design

Molly R. Brandt

University of Nebraska-Lincoln, molly.brandt@huskers.unl.edu

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EXPLORING ELEMENTARY STUDENTS' AGRICULTURAL AND SCIENTIFIC
KNOWLEDGE USING EVIDENCE-CENTERED DESIGN

By

Molly Rose Brandt

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EXPLORING ELEMENTARY STUDENTS' AGRICULTURAL AND SCIENTIFIC KNOWLEDGE USING EVIDENCE-CENTERED DESIGN

Molly R. Brandt, M.A.S.

University of Nebraska, 2016

Advisor: Cory Forbes

The public is more disconnected from agriculture than ever. Americans are two to four generations removed from the farm, and a majority of Americans, even in rural agricultural states have no direct link to agriculture. As a result, the public lacks the knowledge and appreciation of the food, fuel, and fiber it demands. The National Center for Agricultural Literacy (NCAL) uses National Agricultural Learning Objectives (NALOs) to measure student's agricultural knowledge. The purpose of this project is to develop assessments aligned with the NALOs and to use results from the assessments to further understand students' agricultural literacy. This study focuses on the NALOs in the areas of agriculture and the environment (AgE) and the STEM dimensions of agriculture (STEM) for third through fifth grade students. No research has been conducted to analyze the NALOs. This study uses a sequential exploratory mixed methods design. Thirty-five students participated in semi-structured interviews surrounding the NALOs. Interview data was coded and analyzed while using the evidence-centered design process to create empirically grounded assessment tests that were administered to four hundred students across a single Midwestern state in the United States. Results suggest that students are more knowledgeable about the STEM dimensions of agriculture than the agricultural and environmental topics. Results indicated that fifth grade students possessed the greatest level of agricultural literacy. Recommendations are provided to improve future work with the NALOs.

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CHAPTER ONE: INTRODUCTION

“Agriculture is our wisest pursuit because it will in the end contribute most to real wealth, good morals, and happiness.” Thomas Jefferson’s quote describes the importance of agriculture to our country. When the United States was founded, almost everyone was a farmer. Each of these farmers grew a variety of crops and livestock. The crops and livestock they raised fed their immediate families. However, today less than 2% of the population is involved in production agriculture. Americans are two to four generations removed from the farm, and a majority of Americans, even in rural agricultural states, “have no direct link to agriculture” (Powell and Agnew, 2011). With only 2% of the population involved in production agriculture, the public has formed misconceptions about agriculture. Agriculture is commonly referred to as farming factories, and some consumers even believe their food comes from the supermarket. Agriculture provides the food, fiber, and fuel the world demands. Americans need to learn the facts about agriculture and the science upon which it is based. This knowledge is referred to as agricultural literacy.

What is agricultural literacy? Agricultural literacy is defined as understanding and possessing knowledge of our food and fiber system (Frick, Kahler, & Miller, 1991). Individuals possessing such knowledge would be able to synthesize, analyze, and communicate basic information about agriculture (Frick et al., 1991). In 1999, the

National Council for Agricultural Education (1999) defined goals for literacy in terms of a person becoming “conversationally” literate about agriculture.

Meischen and Trexler (2003) broadened the definition of agricultural literacy to include science– and technology–related concepts “required for personal decision making, participation in civic and cultural affairs, and economic productivity” (pg. 44). Throughout the past twenty years, efforts to define agricultural literacy have moved from the mostly technical aspects of production and distribution of agricultural goods to include a sense of broader environmental and global social significance. More recently, there have been efforts to define agricultural literacy in terms of conversational knowledge, critical analysis, and value-based judgment (Powell, 2008).

Efforts have been made to develop K-12 educational programs focused on agricultural literacy. Most of these programs focus on STEM (Science, Technology, Engineering and Mathematics). In the elementary grades, it especially important to incorporate agriculture when teaching interdisciplinary topics such as STEM. However, it’s often difficult to define and measure agricultural literacy. No reliable measures exist for agricultural literacy. Agriculture isn’t a focus in most elementary or high school classrooms throughout the nation. As described by the National Research Council (1988), “Agricultural education in U.S. high schools usually does not extend beyond the offering of an agricultural education program” (p. 2). Most high schools, especially those in urban areas, have limited or no access to agricultural education programs such as the FFA. Students of the 21st century differ from those of the last century in many ways including a demographic change that well under 5% of the U.S. population live on farms (NRC, 2009). Students need to understand and appreciate the importance of the

agricultural industry. Furthermore, students need to understand the STEM concepts that are involved in agriculture. The National Research Council states that agriculture “is too important of a topic to be taught to only to the relatively small percentage of students considering careers in agriculture and pursuing agricultural education studies” (pg. 1). The NRC 1988 also states that all students beginning in kindergarten and continuing through twelfth grade should develop agricultural literacy (Pense, Leising, & Portillo, 2011). Incorporating agriculture and STEM topics into existing elementary school curriculum would accomplish this objective.

To address this need, I engage in research to develop reliable and valid measures of agricultural literacy for upper elementary students. The National Center for Agricultural Literacy (NCAL) was formed in 2014 from a collaboration between the USDA and national and state Agriculture in the Classroom programs. NCAL’s goal is to change how the world thinks about agricultural systems and their science foundations. NCAL uses National Agricultural Literacy Outcomes (NALOs) to measure students’ agricultural literacy. These NALOs exist in a variety of topic areas and have been organized by grade level benchmarks from elementary to high school (Spielmaker, 2013). The purpose of this project is to develop assessments aligned with the NALOs and to use results from the assessments to further understand students’ agricultural literacy. This study focuses on the NALOs in the areas of agriculture and the environment (AgE) and the STEM dimensions of agriculture (STEM) for third through fifth grade students. No research has been conducted to analyze the NALOs.

The study’s purpose was achieved using a sequential exploratory mixed-methods research design process grounded in evidence-centered design. The qualitative

component included interviewing thirty-five elementary students in third through fifth grade about agricultural and science topics. Four hundred students took an assessment consisting of 12 or 15 questions respectively for the quantitative portion. Analysis of these results suggest which topics students are more knowledgeable about. The results also suggest which grade of students are the most agriculturally literate.

Recommendations are provided to improve future work with the NALOs. Future work with the NALOs is essential to the future of agricultural literacy. The NALOs will be used to create lesson plans and resources in conjunction with the Agriculture in the Classroom program.

CHAPTER TWO: LITERATURE REVIEW

Studies have been conducted around the nation to measure K-5 student's agricultural literacy. They have been conducted in the context of agricultural literacy programs described in the previous section, as well as smaller-scale interventions aimed at fostering agricultural literacy in K-12 students. These studies have included student interviews, tests, activities, and assessments. Various researchers have concluded that elementary school children know very little about agriculture, its social and economical significance, and, particularly, its links to human health and environmental quality (Swartzel, 1997). Students' ideas about agriculture were often guesses, underdeveloped, or contradictory to expert conceptions (Hess & Trexler, 2011). When asked "what is agriculture?", only a small percentage of students could give a basic definition (Mabie & Baker, 1996). Students failed to convey an understanding of the types and variety of farms, the purpose of farms, or the cultural practices dominating conventional farming (Hall, 2011).

Students' Agricultural Knowledge

A significant focus has been placed on urban students' agricultural literacy. Results have indicated that urban citizens lacked the most knowledge of agriculture, however, rural non-farm citizens also lagged behind their on-farm peers (Meischen & Trexler, 2003). Children living and going to school in rural areas may have no more ties to agriculture than urban youth (Meischen & Trexler, 2003). Terry, Herring, and Larke (1992) discovered that school age children in Kansas knew little about the food and fiber system. Students' demographic and background information has been taken into consideration in a majority of the studies. Gender, ethnicity, parents' occupation, home

location, and livestock experiences are some of the factors that were taken into consideration. Areas of inadequacy existed in the size and scope of modern agriculture including careers in agriculture and bi-products of agricultural products. In addition, studies have been conducted to measure the effectiveness of current agricultural literacy programs (Pense & Leising, 2004).

Size and scope of modern agriculture. A study was specifically conducted on rural students' agricultural knowledge. Seven fifth grade students were selected from a rural Midwestern school for qualitative interviews. The students were conversationally interviewed twice as part of the study. The second interview included interview questions based on the benchmarks for Science Literacy and Food and Fiber Systems Literacy (Meischen and Trexler, 2003). Student understanding was low for this objective. Only 4 of the 7 students had an understanding of by-products from cattle and could give an example of them. When asked to describe farms and their products, all students gave an incompatible elaborate response. Their conceptions of what these farms looked like were not in line with modern agriculture. None of the students understood that most cattle are produced on large farms. The main findings from this study suggest that students do not understand the size and scope of modern agriculture, and students were unable to use "scientific" language when describing the food and fiber system.

A similar study conducted in California supports Meischen and Trexler's (2003) findings. Eighteen urban students in grades 4-6 were selected to take part in semi-structured interviews. None of these students had ever grown a plant or raised an animal. The purpose of this study was to determine elementary students' understandings of agri-food concepts. The four benchmarks investigated in this study included the origins of

food, selection for production, addressing environmental conditions, and preventing spoilage. Students were asked to dissect a cheeseburger and describe where the products came from. After conducting interviews and analyzing responses, the results suggested that students had no discernable understanding that crops came from different parts of the world. They were also unaware that plants and animals selected for production came from different parts of the world. Students did not fully understand concepts related to plant and animal growth (Trexler, Hess, & Hayes, 2013). Students failed to convey an understanding of the types and variety of farms, the purpose of farms, or the cultural practices dominating conventional farming (Hess & Trexler, 2011).

Many very similar studies have been conducted with the cheeseburger interview approach. This activity is intended to assess knowledge and get students talking about food. Findings from three studies of fifth grade students in Michigan, Iowa, and California concluded that students did not know that most livestock are raised on large farms or the geographic region where food was produced. It also suggests that students hold misconceptions of farms based on stereotypes. Studies have also concluded that students are not familiar with careers in agriculture such a forester, entomologist, landscape architect, dairy farmer, and plant breeder (Mabie and Baker, 1996). A study was conducted in Los Angeles fifth and sixth grade students with an experiment and control group. Students completed a pre-test prior to study. Most students couldn't give a basic definition of agriculture prior to the study. The students also had difficulty naming crops grown by producers in their own states. The treatment groups (garden group and projects group) took part in a 10-week instructional unit in science. This 10

week program results in students becoming very knowledgeable about agriculture.

Students were better able to define agriculture and careers that exists in the industry.

Agricultural bi-products. Meischen and Terry's (2003) study consisted of two parts. The first part was focused on student's understanding of the size and scope of modern agriculture while the other portion was focused on agricultural products. This study was composed of seven fifth grade students from a Midwestern school. Students were interviewed as part of the study. The interview included the student receiving a hamburger and told to draw a concept map regarding the journey meat takes from farm to consumer. Students were all able to identify food products from animals for objective one. "All students effectively articulated an understanding that cattle produce meat and milk for human consumption. Some students said that different types of cattle were used for different types of production (Meischen & Terry, 2003). The students did a good job at describing the journey of meat products. Six of the seven students gave compatible elaborate response because they were referring to terms such as "butcher" instead of "processor."

Students do possess some understanding of our food and fiber system. Students know that farms and ranches are the places where farmers and ranchers raise plants and animals (Trexler et al., 2013). Children who have the most direct experience growing food and preparing meals had the most complex understanding of the food system (Trexler et al., 2013). In a study of fifth and sixth grades in Los Angeles, the students did understand the origin of most common food and fiber products. Most students were aware that tortillas were a product of corn, bacon comes from pigs, tee-shirts come from cotton, and wool blankets come from sheep (Mabie & Baker, 1996). Urban 4-6grade

students were aware that water, soil, and light are requirements for plant growth (Trexler et al., 2013).

Agricultural Literacy Programs

A variety of programs currently exist for teachers to incorporate agricultural and STEM topics into their curriculum. The USDA National Agriculture in the Classroom program has been widely used throughout the nation to teach agricultural literacy. Project Food, Land and People and Food and Fiber Systems Literacy curriculum framework are two other programs geared at improving agricultural literacy in schools across the nation.

The National Agriculture in the Classroom program began when the United States Department of Agriculture invited agricultural representatives to a meeting in Washington, D.C to discuss agricultural literacy (AITC, 2014). “Increasing agricultural literacy through K-12 education” is the mission of the AITC program. The AITC program strives to enhance agricultural literacy through awareness, knowledge, and appreciation. Agriculture in the Classroom programs seek to improve student achievement by applying authentic, agricultural-based content as the context to teach core curriculum concepts in science, social studies, language arts, and nutrition. AITC’s vision is that “agriculture is valued by all.” AITC is unique within the agricultural education community as the lead organization to serve the full spectrum of K-12 formal education (AITC, 2014).

Project Food, Land and People is an agricultural literacy program that was developed in the 1990s. The FLP curriculum consists of fifty-five units and is used in twenty-seven states. The curriculum is based on seven thematic ideas. These ideas

include awareness and appreciation; historical perspectives; the agricultural base; economics; images, attitudes, and behaviors; decisions; and implications for the future. The ideas are based on the interconnectedness of land, food, and people (Powell & Agnew, 2011). FLP's mission is to develop citizens literate about the relationship between agriculture, the environment, and human populations. It aims to promote agricultural literacy in grades Pre-K through 12th grade (Powell & Agnew, 2011). Lessons and activities are specifically designed "to support state and national academic standards."

The Food and Fiber Systems Literacy program was also originally developed in the 1990s (Powell and Agnew, 2011). This program has been widely accepted as the standards for agricultural literacy. The Food and Fiber Systems Literacy curriculum framework focuses on five thematic standards. These standards include understanding: food and fiber systems; history, geography, and culture; science technology, and environment; business and economics; and food, nutrition and health. Benchmarks have been created; however, they will need to be reassessed as not all Food and Fiber Systems Literacy components were not equally addressed in units at each grade level. Additional thematic standards may be included as part of the reassessment.

Effectiveness of Current Programs

So how effective are well known national programs such as Agriculture in the Classroom and Food and Fiber Systems Literacy? A study was conducted in order to assess change in agricultural knowledge from programs such as Agriculture in the Classroom and Food and Fiber Systems Literacy programs (Pense & Leising, 2004). This study was comprised of K-6 grade classrooms in Arizona, Montana, Oklahoma, and

Utah. 48 classrooms were control classrooms while 52 classrooms were treated with the Agriculture in the Classroom material. Prior to the beginning of the study, students took a pre-test over the five thematic areas of student knowledge of agriculture in the Food and Fiber Systems Literacy framework. Pretest results showed no difference in agricultural knowledge between the control and treatment groups.

Throughout the school year, teachers incorporated agriculture in their classes. At the end of the school year, post tests were distributed to students. The scores for the treatment group were higher than the control group indicating that students in the treatment group had a higher gain in agricultural knowledge than students in the control group. Conclusions can be drawn from this study that the agricultural program makes a positive difference in student knowledge of agriculture. Students in the treatment group acquired knowledge in all five thematic areas. The article suggests that a curriculum model should be fully implemented to ensure students in each grade level are making systematic progress in agricultural literacy.

Balschweid, Thompson, and Cole's (1998) research also supports the success of agricultural literacy programs. Current programs have been successful at implementing agriculture into K-12 grade classrooms. In 1988, Oregon State University hosted a Summer Agriculture Institute to see how many teachers, if any, were incorporating agriculture into their lesson plans. The Summer Agriculture Institute was established to assist teachers in acquiring knowledge of agriculture and to aid teachers in developing lessons that integrate agriculture into their curriculum. The study involved fifty-two K-12 teachers over an eight year time span. Teaching experience for these veteran teachers ranged from three to thirty-five years (Balschweid et al., 1998).

As a result the program, 22.9% of the teachers integrated agriculture into 1-5 lessons in their existing course work. 13.3% of the teachers incorporated agriculture into more than 30 lessons a year. Only 9.6% of the teachers did not use agriculture in their classrooms after the program. Teachers perceived students to be most interested in animals, crops, food processing, and agricultural careers. Teachers responded with a mean score of 4.27 out of 5 in regards to the effectiveness of the SAI materials (Balschweid et al., 1998).

A Guide to Food and Fiber Systems Literacy was developed at Oklahoma State University over a four year span. The goal of this guide was to help with challenges teachers might encounter with the integration of agriculture in their curriculum. It includes the explanatory narrative needed for implementing this curriculum in classes. After conducting a study with K-8 grade students from California, Montana, and Oklahoma, results suggests that “the development of an easy to use, field-tested, broad-based curriculum guide should be a valuable addition to the teaching resources of K-12 teachers in their classrooms. The Guide has the potential to educate students and teachers thus bringing about the desired changes (Hubert, Frank & Igo, 2000).

From the results of this study, it can be concluded that it is only one thing to have available materials in existence for teachers. Teachers also need to know how to use these materials. In this study, hundreds of K-8 students took a pretest and posttest regarding agricultural knowledge. In between the test, the teacher implemented components from the Food and Fiber Systems literacy program. In order for these materials to be useful, teachers must know how to effectively integrate them. Teachers can't teach about what they don't know. Creating materials and resources like the

“guide” may be the deciding factor for a teacher choosing to implement agricultural topics into their classrooms. The development of an easy to use, field-tested, broad based curriculum guide should be a valuable addition to the teaching equipment of K-12 teachers in their classrooms (Hubert et al, 2000).

AgVenture Magazine is a resource available for Ohio teachers to incorporate agricultural topics into their classrooms. A study composed of 750 fourth grade teachers was conducted to identify rural use of AgVenture magazine. It was also conducted to identify other resources teachers used when teaching their students about agriculture.

Individuals, businesses, and organizations donate their time and resources to make AgVenture magazine available for every public and private fourth grade classroom in Ohio (Swortzel, 1997). The study was conducted by mailing out a survey to the teachers in which the teachers filled in demographic information and completed likert-type statements. Results concluded that 66% of teachers used AgVenture magazine in their classrooms during the school year. The teachers that didn’t use it in their classrooms stated that they did not have the time to do it, they did not know about the magazine, or they were not interested in using it. These teachers spent an average of 8.6 hours per year with topics from this magazine. Teachers most often incorporated this magazine into social studies classes.

An important finding of this study was the discovery of outside resources used by teachers to incorporate agriculture into their classrooms. 20.8% of the teachers used Agriculture in the Classroom resources in their classrooms. 16.5% of teachers got agriculture in their classroom through extension agents. Extension projects that were

commonly used included exploring plants and The Incredible egg activities (Swortzel, 1997).

This study concluded that teachers had a positive perception of AgVenture magazine. Ohio fourth grade teachers used this magazine in a variety of classes to teach their students about the importance of agriculture. The study listed recommendations for conducting a students' perception of AgVenture Magazine. This study suggest that having an available resource like AgVenture magazine is a great resource for teachers and that a majority of them will continue to use this available material.

A study was conducted in Illinois to discover the needs and beliefs of elementary and junior high school teachers in regard to integrating agriculture into their classrooms. Four hundred fifty-two public school teachers took part in this study in which they responded to three, open-ended questions regarding their beliefs of the most beneficial aspects and needs of teaching and learning about agriculture (Knobloch et al., 2007). 32% of teachers believed conservation and the environment to be the most important of teaching agriculture. Food production and the important of agriculture to students' lives were the second and third benefits believed by the teachers. The teachers also identified the most important topics they felt needed to be taught. These topics included farming, sustainable food production systems, environment and conservation, crops and soybeans, and insects. 15% of the respondents felt that farming which included the role of farmers, their occupations, farm life, the business of farming, and changes that have occurred in farming was an important topic. The final question the teachers were asked dealt with what resources they need to implement agricultural subjects in their classrooms successfully. Only 23% of the teachers listed resources they would like available.

Curricula, units, and lessons was the top response followed by projects and activities, field trips, guest speakers, AITC program, videos, and student-focused experiences (Knobloch et al., 2007). Results of this study also concluded that the teachers believed that agriculture provided situatedness, connectedness, and authenticity to teach their content areas to their students. Program developers need to take the insights of these teachers into consideration when planning and creating agricultural curriculum. “The conclusions were aligned with the existing knowledge base that the integration of agriculture into the general curriculum would help students learn based upon the arguments of experiential learning (Knobloch et al., 2007).

Another study that focused on teachers occurred in Texas in 1989. The population of this study included 11,626 elementary teachers at 4,140 different schools. When this study was conducted, only 4.5% of the high school students in the United States were enrolled in agriculture classes (Terry et al., 1992). Results suggest that assistance programs should be implemented.

Teachers and Agricultural Literacy

Students are not the only focus in agricultural literacy research. Agricultural literacy begins with the teachers. The teacher serves a very important role. Several of the studies mentioned above have been focused on the teacher component. Are our teachers agriculturally literate themselves? Why aren't teachers incorporating agriculture into their classrooms? These are just a few of the questions agricultural literacy researchers are investigating.

In Terry's (1992) research he concluded that 73.3% of teachers said agriculture was just “farming and ranching only”. Teachers associated the term “agriculture” with

raising plants and animals.” The teachers were tested on their agricultural knowledge. Scores ranged from 5% to 89% with a mean score of 48.4%. Nearly three-fourths of the respondents had a score indicating unacceptably low knowledge about agriculture. Fewer than 25% of the group knew that Americans spend around 12% of their income on food, and fewer than 15% of the teachers were aware that one farmer produces enough food for about 75 people (Terry, 1992).

Demographic information was collected from teachers that participated in studies. Information such as years of experience, degree attained, gender, population of nearest town, and 4-H/FFA background were taken into consideration. In Balschweid, Cole, and Thompson’s (1998) research with the Oregon Summer Agriculture Institute, 75% of respondents had no background with 4-H or FFA. The majority of these respondents (26.9%) came from town populations ranging from 2,501-10,000 (Balschweid et al, 1998). Terry also looked into the demographics of the 510 fourth grade teachers in Texas. He discovered that only 24% of the teachers had been active in 4-H while only 4% had been FFA members and agricultural education students. In this study though, the majority (40%) of the teachers came from populations ranging from 10,000 to 99,999 (Terry et al, 1992).

Reasons why agriculture is not a focus. What subjects related to agriculture and natural resources are most important to teachers? A study was conducted with the primary purpose of developing a document that provides agricultural educators with the subjects and topics for core curriculum. Data was collected through a method of eliciting and refining group opinions of individuals who possess an interest in middle school agricultural education. Individuals felt that agriculture’s important relationship with the

environment and agriculture's important relationship with natural resources were the most important subject areas. Careers and the future of agriculture and agricultural benefits to the world were the top two areas on the refined list of subject areas (Frick, 1993).

Three curricular approaches to promote agricultural literacy were identified at the meeting of the American Association for Agricultural Education. This approach include a deductive approach based on programmed frameworks, an inductive approach based on the application of knowledge and process skills, and a utilitarian, value-based approach promoting evaluation of the agri-food systems issues (Powell et al., 2008). These approaches contribute to a shared vision that promotes the cultivation and communication of a common knowledge base linked to agricultural issues.

Terry's research identified textbook chapters about agriculture to be the most popular source of teaching material used in the classroom with 71% of the teachers in Texas using this teaching method. 53% of the teachers used articles about agriculture featured in newspapers and magazines to teach agriculture. Only 23% of teachers used resources from the United States Department of Agriculture in their curriculum. A mere 15% of the teachers took students on field trips to agricultural expositions and agricultural businesses (Terry, 1992).

Barriers to implementation. Balschweid, Cole, and Thompson's (1998) research also focused on the barriers to implementing agriculture in their classrooms. The top barriers that exists include time, access to necessary information/supplies, lack of student interest, failure of previous lessons, and lack of teacher interest. Although this study is considered a success because a majority of teachers ended up integrating

agriculture in the classrooms; barriers still exists that prevent teachers from teaching agriculture (Balschweid et al., 1998). Beliefs and mental images that teachers have about agriculture influence what and how they integrate agriculture in their classrooms (Knobloch et al., 2007).

State assessments directors have cited demands on classroom time as a deciding factor in curriculum development (Powell and Agnew, 2011). Agricultural topics are commonly used as “fit-it-in” infusion modules. Mandates under the No Child Left Behind Program have restricted and reduced resources and time for non-tested subject areas such as agriculture and STEM. Many programs have focused on intertwining the agricultural standards and benchmarks with state and national standards. For example, the Food, Land, and People program lessons and activities were specifically designed “to support state and national academic standards.”

Another great barrier that exists is that many teachers do not know these programs exist. Some of these teachers would not even know how to integrate this material into their existing coursework. Virtually no effort is made anywhere to educate teachers about agriculture, except for the teacher education programs designed for agricultural education teachers (Terry, 1991). The current programs need to be promoted. Availability of these resources must also increase. Teachers who are oblivious to the wealth of agricultural education resources that exists are a main resource why these programs are not implemented or not properly implemented.

Next Steps in Agricultural Literacy

Although a multitude of programs and materials exist for agricultural literacy, there is no common thread in these materials (Terry, 1991). It is generally agreed by

various agricultural literacy researchers that the best way to deliver programs of agricultural literacy is by integrating agricultural topics into the curriculum of established disciplines (NRC, 1988). Current programs need to be evaluated. The benchmarks that exist under these programs also need to be reassessed. The challenge for educators in infusing food and fiber systems literacy is recognizing existing connections (Hubert et al., 2000). Intertwining agricultural and STEM topics into existing coursework is the most efficient and effective way to promote and teach agricultural literacy. In order to improve agricultural literacy by incorporating agriculture and STEM topics in curriculum, new programs are needed. Benchmarks and standards must also be reevaluated. Research needs to be conducted in order to ensure these benchmarks are appropriate. These recommendations are based on recommendations from the various agricultural literacy studies.

Needed programs and standards. Further study is needed in agriculturally based standards. This recommendation is supported by the Trexler (2013) study. This study only included data from eighteen students; however, results similar to these have occurred in other studies conducted throughout the nation. The benchmarks that have been established were developed systemically without an investigation into what learners of different ages understand. Trexler (2013) also suggested that technology benchmarks should be revisited in addition to the agriculture benchmarks. The article states that elementary teachers need training. This training needs to occur in order for teachers to effectively incorporate agriculture and STEM topics into their classrooms. Teachers need to use students' everyday food experiences to integrate agri-food systems learning (Trexler et al., 2013).

Additional resources need to be provided and readily available for teachers.

Throughout the studies, teachers have mentioned a variety of resources and programs that would assist them in incorporating agricultural and STEM components into the curriculum. Curricula, projects and activities, field trips, and guest speakers are the types of resources that they would like to use (Knobloch et al., 2007). Mabie and Baker (1996) states that Extension professionals are those well-equipped to bring agriculture into classrooms. The NRC (1988) suggests that cooperative extension in each state needs to develop better networks between classroom teachers and active researchers and extension scientists knowledgeable about local agricultural production activities and the sciences basic to agriculture. The cooperative extension should consider working with agricultural education instructors to develop applied research. The main thing to keep in mind is that teachers need to be trained to use these materials. A multitude of resources can exist, but it is only useful if teachers know how to use them.

Hands-on activities need to be created for students. Mabie and Baker (1996) suggest that many literacy programs place little emphasis on experimental activities. The treatment groups in their study participated in various hands-on activities especially in gardening. This led to greater agricultural understanding and literacy. Many existing lesson plans consists of crossword puzzles and worksheets that do not excite students about agriculture and the agri-food system (Mabie and Baker, 1996). A traditional lecture style classroom environment is not the best way to introduce agriculture to students. Student must learn agriculture by doing.

In order for teachers to teach their students about agriculture, we must teach the teachers. Teachers need to be introduced and taught how to efficiently and effectively

use the resources. “Instructional assistance should be provided through pre-service and in-service programs which would facilitate the use of agricultural examples in elementary and secondary school classes” (Balschweid et al., 1998). Frick (1993) suggests that state education agencies and teacher education programs should design inservice and preservice programs to prepare current and prospective teachers for teaching middle school agricultural education program content (Frick, 1993). The NRC (1988) suggests that in-service education or special summer programs for teachers should be offered focusing on how to use new instructional material and take advantage of students’ interest in agricultural subjects.

In order to create agriculturally literate individuals, teachers must teach agriculture through science. The NRC (2009) calls this the era of “scientific agriculture.” Disciplines such as chemistry, engineering, and ecology are becoming increasingly intertwined with food, fiber, and fuel production. It has been proposed changing the STEM (science, technology, engineering and mathematics) acronym to STEAM in order to include the agricultural component. In addition to agriculture connecting with science, it also connects with social science disciplines such as in rural development, medicine, and nutrition (NRC, 2009). The NRC (1988) states that all students need an understanding of basic science concepts. “Teaching science through agriculture would incorporate more agriculture into curricula, while more effectively teaching science (NRC, 1988). Agriculture is based on science concepts. Integrating science and agriculture will allow students to make real world connections between the two subjects. According to the National Research Council, agriculture should not be introduced as a separate subject. This would worsen the barrier of the existing time pressures.

Curriculum integration is a reasonable approach to the agricultural literacy goal. It allows teachers to kill two birds with one stone without creating more time pressures. Many connections exist between science and agriculture. Some of the strongest connections exist in biology in topics such as genetics, bacteria, food production, and multicellular organisms. Science teachers and specialists should be involved in these curriculum development projects (NRC, 1988).

Benchmarks. Current agricultural literacy benchmarks need to be reevaluated. Based on Meischen and Terry's (2003) findings, research suggests that the current agricultural benchmarks developed by both agriculture and science educators have not been thoroughly tested for suitability to the age groups for which they were designed (Meischen & Terry, 2003). Educators can more effectively develop agricultural literacy curriculum once they have a clearer picture of children's vocabulary and understanding. Each program that exists has benchmarks to measure student performance. However, study after study are finding these benchmarks to be inappropriate for students. Researchers and educators need to take student's current knowledge and understanding into consideration before creating extremely optimistic benchmarks. Benchmarks need to be realistic and age-appropriate.

Future Research

The National Center for Agricultural Literacy (NCAL) has been formed from a collaboration between the USDA-NIFA and national and state Agriculture in the Classroom programs. NCAL's goal is to change how the world thinks about agricultural systems and their science foundations. The objectives of the center are to develop secondary-level curricular resources focused on science, technology, engineering and

mathematics involved in agriculture and natural resource systems, develop an evaluation framework and associated measures that can be used to assess AITC program outcomes, and build capacity of state-level AITC programs by strengthening collaboration and partnerships between AITC and higher education institutions.

In order to develop an evaluation framework and associated measures that can be used to assess AITC program outcomes, the NCAL utilizes the National Agricultural Literacy Outcomes (NALOs). These NALOs exist in the areas of agriculture and the environment; plants and animals for food, fiber and energy; food, health and lifestyle; science, technology, engineering and math; and culture, society, economy, and geography. These NALOs have been organized by grade level benchmarks in early elementary, upper elementary, junior high, and high school categories. For example, a specific NALOs suggests that an early elementary student in grades (K-2) should be able to identify natural resources and provide examples of how weather patterns affect plant and animal growth for food.

Agriculture and STEM topics need to be integrated into elementary school curriculum. The consensus reached by these various studies indicates that elementary students do not know enough about agriculture in the 21st century. Even though students have proved to have some understanding of agriculture, steps must be taken to improve and enhance agricultural literacy. Teachers have identified various reasons why they are not implementing agricultural topics in their classrooms; however, these are not an excuse as a variety of programs and resources exist for teachers to use. Programs such as National Agriculture in the Classroom, Food and Fiber Systems Literacy, and Land Food and People exist in order to enhance students' agricultural knowledge. Studies show that

when these programs and materials are successfully implemented in classrooms, students' agricultural literacy is increased. The research has also pointed out that the current benchmarks created for many of these programs and materials needs to be reevaluated. Individuals and organizations are willing and wanting to help in this agricultural literacy deficiency.

Research must be conducted to develop assessments aligned with the NALOs used by the National Center for Agricultural Literacy and to use results from the assessments to further understand students' agricultural literacy. A mixed methods research design embedded in evidence-centered design was used to evaluate the NALOs and student understanding of agricultural topics. Thirty-five students in grades 3-5 were interviewed in order to gauge current agricultural literacy among students. These interviews were transcribed and coded into various themes and levels of understanding. Evidence-centered design was used to construct assessment items for each topic area. The final assessments were administered to over 400 students throughout the state. This research seeks to address the following research questions: are students more knowledgeable about agricultural/environmental topics than STEM (Science, Technology, Engineering and Mathematics) topics, and how does students' agricultural literacy compare among upper elementary grades?

CHAPTER THREE: METHODS AND PROCEDURES

The purpose of this study is to investigate elementary students' knowledge of food systems. The foundation of the assessment design process is a set of defined, NGSS-aligned outcomes (i.e., standards) for 3rd-5th-grade students' learning about the STEM dimensions of food systems (Spielmaker, 2013). This empirical study is embedded in a broader process of assessment design and development grounded in evidence-centered design (ECD; Mislevy & Haertel, 2006). The long-term objective of this work is the development, validation, and testing of an empirically-grounded assessment instrument designed to measure K-12 students' knowledge about STEM in food production systems. In this study, thirty-five students were interviewed to gauge understanding of agricultural topics for the qualitative strand. This data was used in the evidence-centered design process to create an assessment test that was then administered to 400 students in grades 3-5 students across a single Midwestern state. Data collected was used to characterize 3rd-5th-grade students' knowledge of a) agriculture in the environment (AgE) and b) the STEM dimensions of food systems (STEM). To empirically investigate students' understanding of agriculture in the environment and the STEM dimensions of agriculture, I ask the following research questions:

1. Are students more knowledgeable about agricultural/environmental topics than STEM topics?
2. How does students' agricultural literacy compare among upper elementary grades?

Assessment Development

Evidence-centered assessment design (ECD) is an approach to constructing, designing, producing, and delivering educational assessments in terms of evidentiary arguments (Mislevy, 2003). The evidence-centered design framework explains the interrelationships among substantive arguments, assessment design, and operational processes. Evidence-centered design views assessment as an argument using imperfect evidence. The present study focuses on the first three stages of ECD: 1) *domain analysis*; 2) *domain modeling*, and; 3) articulating the *conceptual assessment framework*. These stages lead to the development of initial assessment items that are aligned with targeted outcomes for learners.

In this study, the domain of interest is identified by the National Agricultural Literacy Outcomes (NALOs) shown in Table 1. The NALOs exist for a variety of topics, such as AgE (agriculture and the environment); plants and animals for food, fiber and energy; food, health and lifestyle; STEM (science, technology, engineering and math); and culture, society, economy, and geography. The NALOs have been organized by grade level benchmarks in early elementary, upper elementary, junior high, and high school categories. Here, the study focuses on two sets of NALOs for 3rd-5th-grade students: 1) agriculture and the environment (AgE) and 2) the STEM dimensions of agriculture. I chose to focus on the upper elementary NALOs because students in this age range should have well developed language skills and be able to communicate clearly.

Table 1: NALO Content Standards for 3rd-5th Grade Students

AgE - Ag and the Environment	STEM
<ol style="list-style-type: none"> 1. Identify the major ecosystems and agro-ecosystems in their community or region (e.g., hardwood forests, conifers, grasslands, deserts) with agro-ecosystems (e.g., grazing areas and crop growing regions) 2. Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production 3. Recognize the natural resources used in agricultural practices to produce food, feed, clothing, landscaping plants, and fuel (e.g., soil, water, air, plants, animals, and minerals) 4. Identify land and water conservation methods used in farming systems (wind barriers, conservation tillage, laser leveling, GPS planting, etc.) 5. Describe similarities and differences between managed and natural systems (e.g., wild forest/ tree plantation and natural lake/ fish farm) 	<ol style="list-style-type: none"> 6. Describe how technology helps farmers/ranchers increase their outputs (crop and livestock yields) with fewer inputs (less water, fertilizer, and land) while using the same amount of space 7. Identify examples of how the knowledge of inherited traits is applied to farmed plants and animals in order to meet specific objectives (i.e., increased yields, better nutrition, etc.) 8. Compare simple tools to complex modern machines used in agricultural systems to improve efficiency and reduce labor 9. Provide examples of science being applied in farming for food, clothing, and shelter products

Domain analysis. In domain analysis, each standard for student learning that defines the domain was unpacked to identify core concepts and relevant information. Assessment designers consider the assessment domain from a number of perspectives, including cognitive research, available curricula, expert input, standards and current testing practices, test purposes and various requirements, resources and constraints to which the proposed product might be subject (Mislevy, 2003). Designers gather information from a variety of sources and tag it in terms of key assessment design features. Here, NALOs in Table 1 are aligned with the Next Generation Science Standards (NGSS Lead States, 2013). For example, the NALO that asks students to explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production aligns with standard NGSS 5-PSE3 Energy

that asks students to use models to describe that energy in an animal's food was once energy from the sun. Since the NALOs are aligned with the NGSS, it allows teachers to see the relationships between agricultural topics and their science foundations. In this step of the process, I created a summary description of each NALO. This complete description included expanded background information related to the NALO. Research was done on each individual topic in order to include all of the relevant information surrounding the NALO. This step was used as a way to brainstorm all of the conceptual connections that existed within a particular NALO. References to all used resources were provided in each document.

Domain modeling. Information about each standard in the domain analysis stage was then used to establish relationships among proficiencies, tasks, and evidence in the domain modeling stage (Mislevy, 2003). In the domain modeling stage, each standard was used to define a primary claim about students' performance to articulate focal knowledge, types of work products that would elicit targeted performances, and features of these tasks. This work leads to the articulation of an assessment design space for each targeted outcome. An individual claim was defined as a student learning outcome for each of the NALOs in Table 1.

To elaborate core concepts related to each NALO, three to four paragraphs were written as focal knowledge for each NALO about student learning. These paragraphs included the component knowledge of the NALO. This content built off of the information collected during the domain analysis stage. The goal in this stage was to continue brainstorming and writing additional information that was relevant to the specific claim grounded in each NALO.

Work products were also identified for each NALO in this stage of the domain modeling step. Anything that students could say regarding a specific NALO was recorded. The work products that were identified included written descriptions, verbal descriptions, diagrammatic descriptions, and graphical descriptions. Predictions and ideas regarding what students might say about specific NALOs was documented.

Finally, features of the tasks were identified for each specific NALO. Each NALO was examined to discover exactly what kind of activities and questions could possibly be asked from it. Features of the task include asking the, “who,” “what,” “where,” and “when” for each NALO. Most NALOs necessitated students perform tasks that included identifying, describing, and distinguishing between ideas. Students performed these tasks in the interviews and on the assessments by focally explaining a process or choosing the correct option.

Conceptual assessment framework. The third step of ECD involves the development of the conceptual assessment framework. Information from the previous two steps is used to articulate levels of student understanding related to standards-based claims, identify appropriate assessment tasks, and make decisions about how to evaluate evidence of students’ thinking. To identify levels of 3rd-5th-grade students’ understanding of outcomes in Table 1, we planned and conducted clinical interviews (Westcott & Littleton, 2005) with a sample of 35 3rd-5th grade students ($n_{3rd}=12$; $n_{4th}=14$; $n_{5th}=9$). The University of Nebraska – Lincoln Institutional Review Board approved all procedures followed in this study.

First, I identified types of tasks that align with the conceptual demands of each NALO (Ruiz-Primo, 2009; Shavelson et al., 2003). This task model includes specifications for the environment in which the student will say, do, or produce something, and provides a framework for constructing and describing the situations in which examinees act. The task model defined the types of questions students might be asked about each NALO and informed the development of the clinical interview protocol upon which student interviews were based. All interview questions were open-ended with no “correct” answer. The purpose of the interview was to gauge student’s understanding and have a conversation about the topic.

Student interviewees were recruited from classrooms in two elementary schools from the same school district serving K-5 students in a large Midwestern city. Students were primarily from suburban backgrounds, though each school held an ‘ag day’ event and included elements of agriculture in the K-5 curriculum. Students were allowed to choose if they wanted to participate in the study. I came into each classroom and read a recruitment script to the students and gave the students a packet of information to take home to their parents about the study. The packet included a pre-stamped and pre-addressed envelope for the students and parents to return the assent and consent forms. Parents had two weeks to return the forms to the research team. Teachers facilitated communication with parents.

Interviews were semi-structured (Patton, 2001) in nature. Interview protocols were designed around each of the target outcomes in Table 1 and included additional sub questions for interviewer probing around each target outcome. Interviews ranged from 11-26 minutes, with an average of fifteen minutes. I worked with teachers to

create a schedule to interview students during non-core subject class time. All interviews were audio recorded and transcribed for analyses.

In the evidence model, I identified objective means of evaluating this evidence of student understanding in light of the cognitive demands of the NALO-based learning performance and demands of the task (dichotomous scoring, rubrics, etc.). Here, analysis of the student interview data involved qualitative methods. All student interviews were transcribed. QDA Miner Lite software was then used to code and analyze the data qualitatively. Each interview transcript was uploaded into the software. A coding framework was developed to align with the outcomes in Table 1, with each NALO serving as a distinct code. Once coding was complete, code queries were performed to isolate data and create coding summaries for each NALO in Table 1.

Both task and evidence models are fundamentally influenced by the student model, or differentiated levels of student understanding of the target outcome. These documented levels of student understanding can be derived from prior research or research associated with the assessment development process itself. Here, I take the latter approach to ground the item design and use empirical evidence from student interviews to identify levels of student understanding. Coding summaries for each NALO were then used to identify trends in students' thinking about each content standard within and across grade levels. Queried data was categorized to differentiate observed 'levels' of understanding about each content standard. A subset of codes was discussed among the authors to establish inter-coder reliability and aid in interpretation of students' reasoning. Student understanding was categorized as low, medium, or high for each NALO. Based on the analysis of student interview data, a set of three forced-response

assessment items were developed to align with each of the observed levels (low, medium and high understanding) for each NALO. A total of 27 assessment items were developed: 15 for the Agriculture in the Environment NALOs and 12 for the STEM in Agriculture NALOs.

Assessment Administration

Data Collection. The assessments were administered to 400 3rd-5th-grade students across the state. Students either received an AgE or STEM assessment. The tests were composed of fifteen or twelve questions respectively. Students took the assessments during non-core subject class time. Students recorded grade and gender on the assessment. Teachers or a member of the research team introduced the project to the students. Students were allotted 20-30 minutes to finish the assessment.

Teachers and students from nine public and private elementary schools in two cities participated in the project. Classrooms were selected from existing connections with partner schools. I visited with prospective teachers and students to further discuss the study. A parent notification letter was sent home with each child. If the parents did not want their child to participate in the study, the parents could sign and return the form to excuse them from the study. Parents had one week to choose if they wanted their student to participate. Students took the assessment during non-core subject class time. Any students that did not wish to be included in the study were given alternate activities to complete.

Table 2: Student Demographics by School

School	Third Grade	Fourth Grade	Fifth Grade	Total
School 1	23	21	23	67
School 2	24	20	21	65
School 3	13	13	19	45
School 4	-	-	53	53
School 5	18	15	41	76
School 6	-	-	24	24
School 7	17	-	23	40
School 8	15	-	-	15
School 9	-	-	18	18
TOTAL	110	108	182	400

Analysis of Assessment Data

I scored all assessments. The assessment included questions of a variety of types, including true/false, matching, and multiple choice. Data was recorded in an excel spreadsheet. Students received a “1” for a correct answer and a “0” for incorrect answers. If a question required more than one response, answering any part of the question incorrectly resulted in a wrong answer. The excel spreadsheet included a row for grade and gender and a column for each assessment question. Points were totaled for each correct response. Because the AgE assessment consisted of fifteen questions, and the STEM assessment consisted of twelve questions, students’ scores were recorded as percentages. These percentages were used to compare scores across assessments and grade levels. Subscores were also calculated for each NALO. A percentage was calculated for each question based on the amount of students that answered the particular question correct. This was calculated by taking an average of the “1s and 0s” recorded in the spreadsheet for each question. Subscores for the low, medium, and high understanding question for each NALO was used to determine which topics students were the most and least familiar with.

The assessment data was normally distributed for each NALO category and each grade level, so standard parametric statistical tests were used to analyze the data. To address research question #1, students' scores for the two NALOs were compared using an independent samples t-test. To address research question #2, a single factor or one-way ANOVA was used to compare students' overall assessment scores by grade-level.

CHAPTER FOUR: RESULTS

In this section, I present results from analysis of the student interviews and assessments to inform the ECD process and answer my two research questions. First, I present an example of the ECD process for one NALO to illustrate how assessment instruments were developed from the NALOs. Second, I present empirical results to address my two research questions. Findings for research question #1 indicate that students are more knowledge about STEM concepts than AgE topics. Findings for research question #2 indicate that fifth graders exhibit the highest levels of agricultural literacy followed by fourth graders and third graders, respectively.

Assessment Development using Evidence-Centered Design – An Example

The ECD process was used to develop assessment items for each one of the NALOs in Table 1. Here, I present an example of the completed ECD process for one NALO in Agriculture and the Environment category, which asks students to describe the similarities and differences between managed and natural systems (e.g. wild forest and tree plantation; natural lake/ocean).

Domain Analysis. To analyze the conceptual domain associated with this NALO, information was largely derived from the field of ecology and agroecology with guidance from the Next Generation Science Standards (NGSS Lead States, 2013). Here, the NGSS aligned with the NALO focus on the notion of ‘systems’, whether natural or managed, that are grounded in ecological principles that highlight interactions between living organisms and non-living components of their physical environment. Natural ecosystems and agro-ecosystems are characterized by nutrient flows and cycles, energy flows, and the interactions of living organisms with each other and the physical

environment. The notion of ‘natural’ versus ‘managed’ systems foregrounds the role of humans in these systems. Human beings may shape or engineer natural systems for a particular purpose. Agricultural production is one of those purposes. A managed system oriented toward agricultural production is called an ‘agrosystem’ or ‘agroecosystem’. An agrosystem can be classified as a subset of a conventional ecosystem. As such, a managed system is one in which humans directly and purposefully alter the system in pursuit of a particular objective. For example, a temperate forest of mixed deciduous and coniferous trees could be a natural system. A managed version of this system could be a tree farm. Human intervention may take many forms. These ideas provide a broad overview of core ideas underlying this NALO.

Domain Modeling. The domain modeling step of the ECD process involves identifying the claim, focal knowledge, work products, and features of tasks for the NALO. The claim that was identified for this NALO was that “natural and managed systems possess both similarities and differences for which students can provide a thorough, detailed account using multiple representational forms.”

The focal knowledge for this NALO included a summarized version of the domain analysis step. Processes, structure, and characteristics of natural ecosystems are also present in agroecosystems. This includes living and nonliving components, levels of organization, energy flow and mass cycling, and sun as a primary source of energy. However, there are differences that exist between natural and managed systems. Humans change natural ecosystems to get them to produce particular goods in abundance. Agrosystems or managed systems are also expected to export particular biological goods for use by humans.

Work products were also identified for each NALO. The work products are what students may know or talk about. This included written, verbal, diagrammatic, and graphical descriptions. Students could talk about the different managed and natural systems they have seen or learned about. They might mention prairies, ponds, grasslands, tree plantations, cornfields, or fish farms. They might mention the role humans play in a managed system. Students can classify examples of landscapes as either managed or natural systems.

Features of this particular standard include identifying, describing, and distinguishing. Students should be able to identify natural and managed systems that exist such as fields, forests, and lakes. Students will describe the characteristics of these specific systems. Students will then describe what distinguishes a managed system from a natural system. Students should talk about the role humans play in changing a natural system into a managed system. Assessments questions will be based on the features of the task. “who,” “what,” “where,” and “when.” Students should account for what component of a system they are referring to and how it is similar/different in natural and managed systems. The “who” in this case is the humans. The “what” would be the practices that humans or farmers apply to the land. The “where” includes any landscapes. Finally, “when” would refer to anytime humans or farmers are changing natural land for production purposes.

Conceptual Assessment Framework. Both the domain analysis and domain modeling steps lead into the final stage, the conceptual assessment framework stage. The conceptual assessment step includes the student, task, and evidence model.

The student model was obtained from the student interviews. Student understanding was categorized as low, medium, or high understanding. Table 3 shows how student understanding varied across levels. Students with a low understanding on the topic may not have been exposed to many different landscapes. Students briefly mentioned some of the landscapes they have seen in their home state, such as a field or prairie. When asked to name landscapes they had seen or learned about, students with lower levels of understanding mentioned, “dirt, crops, grass, trees, and plants.” Students were unaware of the animals that may be living in these landscapes, and they were unsure of the role humans play in managed systems. Students were also asked how a prairie would change if cattle were grazing it. Students with a low understanding thought the cattle would change the color of the grass “it’ll probably be brown, light brown, maybe a little green.”

Students with a medium understanding were able to list and describe different landscapes they have seen or learned about. The landscapes they discussed were common landscapes such as forests, deserts, fields, and prairies that transcended their own daily experience. A student described a prairie as “very, very flat with grasses and assorted birds, groundhogs, and mice.” Students were aware of what types of crops and livestock they could observe in their local environment. A student stated that “mostly corn and soybeans” and “mainly cows and horses” were grown and raised in fields in their state. Additionally, these students agreed that humans actively changed natural systems.

Students with a high understanding on the topic were able to identify and describe multiple systems in the environment. They didn’t hesitate to discuss different landscapes

and the plants and animals that may be living in them. Students with high understanding also understood how landscapes are different in many regions and parts of the world. A student stated that, “in [state] I see a lot of flat land and farms and stuff, but in the [other area] stuff is higher, more elevated, near Colorado.” In addition, they were also able to distinguish differences between managed and natural systems. Students realized that if cattle were grazing on a prairie, it would change the interrelationships between species and the structure of the ecosystem, saying, “the cattle would probably eat most of the grass and some of the flowers. Then the grass would probably be shorter and there would be less flowers.”

Table 3: Levels of Student Understanding

Low Understanding	Medium Understanding	High Understanding
Students with low knowledge on the topic may not have seen many different landscapes. Students briefly mentioned some of the landscapes they have seen in their state such as a field or prairie. Students did not correctly know how cattle would change the landscape of a prairie.	Students were able to list and describe different landscapes they have seen or learned about. The landscapes they discussed were common landscapes such as forests, deserts, fields, and prairies. Additionally, these students agreed that the role of humans changed natural systems. Students agreed cattle grazing in a prairie would make the grass shorter.	Students with a high understanding on the topic were able to identify and describe systems in the environment. In addition, they were also able to distinguish difference managed and natural systems. Students realized the impact that farmers make on natural systems.

The task model stage focuses on the tasks students perform. During the interviews, students were asked to identify managed and natural systems they see every day or that they have seen. They were asked to describe similarities and differences between managed and natural systems. Students were asked what makes a prairie different than a cornfield. They were also asked how grazing cows would change a

landscape. During the assessment portion, students answered a variety of multiple choice questions regarding managed and natural systems.

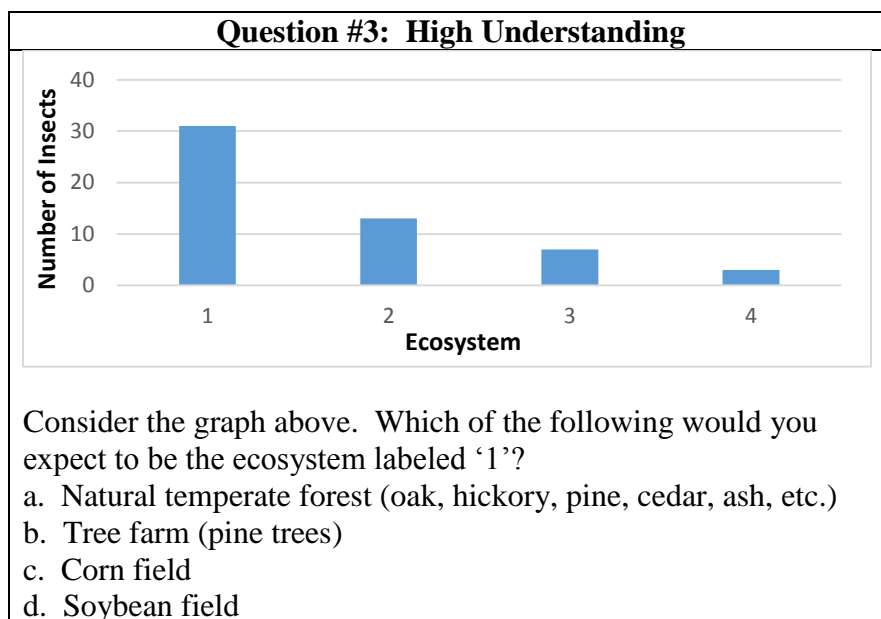
The evidence model is concerned with how to evaluate and analyze student performance. The interviews were open-ended. The purpose of the interview was to gauge student's understanding and have conversation about the topic. The interview was used to refine assessment items. The assessment questions were graded and had a right/wrong answer. There were not open-ended questions on the assessments.

After completing the three steps of the evidence-centered design process, assessment items were constructed for each topic area. Approximately twenty items were created for each standard. Eleven items were constructed for the specific NALO. Assessments items were revised following student interviews. The final assessment included three questions from a specific standard. These questions included a low, medium, and high understanding question. Question 1 simply asks the student to identify who or what is responsible for changing a natural ecosystem into a managed/agricultural system.

Question #1: Low Understanding	Question #2: Medium Understanding
<p>The main difference between a forest and tree farm is _____.</p> <ul style="list-style-type: none"> a. The sun b. The role of humans c. The soil d. The atmosphere 	<p>In a natural ecosystem, which would not occur?</p> <ul style="list-style-type: none"> a) Harvesting plants to produce biofuels. b) Plants using the sun's energy to grow c) Bacteria or fungi decomposing non-living plant and animal matter d) Herbivores consuming producers.

Question #2 builds off of the knowledge that students with low understanding were observed to have. With a baseline understanding of the role of humans in managed systems, students are asked to identify processes through which humans modify natural

systems into managed systems. Students will have to identify which of the activities are performed by humans and not by the natural environment as a part of ecosystem functioning in natural systems.



Question #3

takes student understanding to the highest level. In the interview, students were asked to list plants and animals they might find in various

natural and managed systems. This question asks students to choose which type of system would have the largest variety of insects present. Students will have to recognize that natural systems have greater levels species diversity than a managed system. In addition, students have to analyze and interpret a graph that involves higher-thinking and understanding skills.

Research Question #1

In my first research question, I asked, “Are students more knowledgeable about AgE topics or STEM topics?” To address research question #1, I performed a t-test to compare scores between the AgE and STEM assessments. Results of a paired-samples t-test indicate that upper elementary students are more knowledgeable about STEM topics ($M=.643$, $SD=.019$) than AgE ($M=.596$, $SD=.030$) topics; $t(396) = 2.99$, $p = 0.0015$, $d = 1.87$. These results show that upper elementary students are more knowledgeable about STEM topics than AgE topics. Complete results from the t-test are displayed in Table 4.

Table 4: AgE vs. STEM Assessment Scores

	AgE	STEM
Mean	0.595772	0.642919
Variance	0.02959	0.019435
Observations	206	194
Pooled Variance	0.024666	
Hypothesized Mean Difference	0	
df	396	
t Stat	-2.99304	
P(T<=t) one-tail	0.001468	
t Critical one-tail	1.648711	
P(T<=t) two-tail	0.002935	
t Critical two-tail	1.965973	

After investigating which assessment versions students scored higher on, sub scores were used to further explore specific underlying topics students were the most and least knowledgeable about. Three questions (one for low, medium and high understanding) surrounding each NALO were included on the assessments. A percentage correct was calculated for each question on the assessment. This percentage signifies what percent of students correctly answered the question. Subscores are outlined in

Table 5 for each NALO in the low, medium, and high category as well as an overall score for the NALO.

Table 5: Percentage Correct Scores by NALO and Difficulty

NALO	Low	Medium	High	Total
1. Identify the major ecosystems and agro-ecosystems in their community or region with agro-systems.	83.0%	48.5%	49.0%	60.2%
2. Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production.	79.6%	70.4%	36.4%	62.1%
3. Recognize the natural resources use in agricultural practices to produce food, feed, clothing, landscaping plants, and fuel.	74.3%	85.0%	71.4%	76.9%
4. Identify land and water conservation methods used in farming systems.	87.0%	48.5%	14.1%	49.9%
5. Describe similarities and differences between managed and natural systems.	50.0%	42.2%	55.3%	49.2%
6. Describe how farmers/ranchers increase their outputs with fewer inputs while using the same amount of space.	79.9%	95.9%	57.2%	77.7%
7. Identify examples of how the knowledge of inherited traits is applied to farmed plants and animals in order to meet specific objectives.	83.5%	48.0%	29.4%	53.6%
8. Compare simple tools to complex modern machines used in agricultural systems to improve efficiency and reduce labor.	98.0%	28.9%	51.0%	59.3%
9. Provide examples of science being applied in farming for food, clothing, and shelter products.	62.3%	94.8%	41.7%	66.3%

Overall, students' performance on the assessment and responses to interview questions reinforce their more advanced understanding related to the STEM dimensions of agriculture. For example, NALO #6 asks students to describe how technology helps farmers increase their outputs with fewer inputs while using the same amount of space. Students taking the STEM assessment averaged a score of 77.7% on the technology

questions. Students scored the highest in this category across both assessments. High understanding of this topic was evident from student interviews. Most students agreed that technology was making agriculture easier and better. When asked how farming has changed in the past year, a student responded with, “Like in the 1920s and stuff, it would take a really long time and take a lot of people to get all those corn seeds and stuff and then to water it would be a really big pain. Now, it's not really that bad because we have those pivots and these tractors that can multitask.” Students talked about how computers, GPS, and internet also help farmers be more efficient. Teachers probably place a high emphasis on technology in their classrooms so students are aware of types of technology that exist and how they can use them to make work easier.

Students also scored highly on NALO #6 in the STEM category that asks students to provide examples of science being applied in farming for food, clothing, and shelter products. 66.3% of students answered questions in this category correct. Over half of the students answered the low understanding question correct, and nearly all students answered the medium understanding question correct. Interview conversations support the fact that students fell into the low and medium understanding categories. This NALO is vaguely written so conversations on this topic varied greatly and were very brief. Students in the low understanding category might have just mentioned that agriculture is scientific because “it uses natural resources.” A student in the high understanding category answered the same question by stating that agriculture is scientific because “like looking into their genes and stuff and figuring out how to make a plant be more safer, like from the insects that might want to poison it or eat it, so it will make it rotten and makes people sick that eat it, so they make stuff like pesticide to protect it.” The high

understanding question on the assessment involved students answering a question about how “green” shelters are used to reduce energy. From interview data, it’s evident that most students would not have the knowledge for this highest level question.

However, although results from this study suggest that students are more knowledgeable about STEM topics, students also scored high in some categories of the AgE assessment. Students taking the AgE assessment achieved a score of 76.9% from NALO #3 which is based on natural resources. This NALO asks students to recognize the natural resources used in agricultural practices to produce food, feed, clothing, landscaping plants, and food. Nearly every student was able to identify a few natural resources during the interview. Students typically listed trees, plants, and animals as natural resources. A few students mentioned natural gas and coal as natural resources. When a student was asked why these were natural resources, they replied, “because we don’t make them, the earth does.” Students also recognized that natural resources affect agriculture. A student stated that “natural resources affect farming because you can't really farm without soil, sunlight or water.”

Another AgE NALO that students scored very highly on was NALO #2 which asks students to explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production. 62.1% of students answered the question correctly in this category. 79.6% answered the high understanding question correctly, 70.4% of students answered the medium understanding question correct, and 36.4% of students answered the high understanding question correctly. Good understanding all together on this NALO was evident in the interviews. Students could easily identify what plants and animals need to survive. Students probably learned about

what living things need from science classes. Some students were able to give a more complete description as to why living things need these resources. Students were asked what a corn plant and a goat need to survive. Most of the students were able to list off the basic necessities needed for plants and animals. With the corn plant question, I asked students why corn would need sunlight to grow. Some students were able to mention photosynthesis. This signified high understanding, and the high understanding question on the assessment was concerned with where photosynthesis occurred in a plant. Therefore, it is understandable that only 36.4% of students were able to answer this question correctly.

Comparing scores across assessment not only allowed us to see which topics students were very knowledgeable about, but it also allowed us to see which topics students struggled with. On the STEM assessment, students struggled with the concept of inherited traits. This refers to NALO #7. Student's scores from these questions on the assessment was 53.6%. Findings from the interviews suggested that students struggled with the concept. Students were asked if everyone in their class looked alike and if plants and animals resembled their parents. Students interpreted these questions in many ways including talking about how an ear of corn was very different than a seed and how a butterfly and caterpillar were very different species. Students mainly agreed that knowing about inheriting traits would be important for farmers in order to raise the best crops and livestock.

Students also scored low on NALO #8 on the STEM assessment that asks students to compare simple tools to complex modern machines. 98% of students answered the low understanding question correct, but all together only 59.3% of students

answered questions in this category correct. The interview data suggests that students do have a lower understanding on the topic. Students mentioned a “tractor, shovel, and hoe” as tools farmers use. Most students weren’t able to talk about the complex machinery that farmers are using to efficiently perform tasks. Very few students were aware of the term “simple machine.” The high understanding question asked students to identify a simple machine so it was obvious that students do not possess high understanding on the topic.

On the AgE assessment, students struggled with the concept of conservation in NALO #4. The NALO reads that students will identify land and water conservation methods used in farming systems. Examples of these conservation methods could include wind barriers, conservation tillage, laser leveling, and GPS planting. Scores from the conservation category were a 49.9%. This was the lowest scoring category on both assessments. This was expected based on conversations in the student interviews. Students struggled with comprehending the term “conservation.” To work around this, students were asked what problems a farmer might have and then what could the farmer do to prevent those problems. Responses varied greatly with these questions. Students mentioned “drought and pests.” A few students mentioned crop rotation and windbreaks as conservation methods.

Students also struggled with NALO #5 on the AgE assessment that asks students to describe the similarities and differences between managed and natural systems. Only 49.2% of students answered question correctly in this category. Percentage differences did not exist among questions in the low, medium, and high understanding questions in this category. Differences among understanding was apparent in the interviews though.

Earlier in the results, we presented findings from using the evidence centered design process on this specific NALO. Although scores did not come out with major differences across understanding levels, it can be agreed that students do not know enough about the difference between managed and natural systems and the role humans play in agriculture.

Research Question #2

In research question #2, I ask, “How does students’ agricultural literacy compare among upper elementary grades?” To address research question #2, I conducted a single-factor ANOVA test to compare students’ scores across grade levels. There was a significant effect of grade on students’ assessment scores at the $p < .05$ level for the three grade levels examined [$F(2,397) = 12.43$, $p = .00503$]. This statistically-significant difference between grades shows that differences were apparent among upper-elementary grades. Fifth graders achieved an average score of 65.8% while fourth graders scored an average of 61.4%, and third graders scored an average score of 55.7%. These results are displayed in table 5.

Table 6: Assessment Scores by Grade Levels

Groups	Count	Sum	Average	Variance
5th	182	119.7833	0.65815	0.019401
4th	108	66.31667	0.614043	0.030318
3rd	110	61.35	0.557727	0.023541

These differences were apparent in the interviews. Fifth grade students had the most complex understanding of agricultural concepts, while third and fourth graders’ possessed a limited vocabulary and understanding of agricultural topics. For the most part, fifth graders fell into the high understanding category, fourth grades belonged in the medium understanding category, and third graders possessed a low understanding of the topic. However, exceptions did exist in the interviews and assessments. A table included

in appendix G displays how third, fourth, and fifth graders scored for the low, medium, and high understanding question category for each specific NALO. This table illustrates differences in knowledge that exist between grade levels. The high-level understanding questions seemed to be the most significant component of the assessment that distinguished between grade levels. However, specific questions showed large differences in knowledge across the three grade levels.

NALO #4, which focuses on conservation, and NALO #7, which focuses on inherited traits, were topics that students scored low on as a whole. However, differences in knowledge levels can be observed among grade levels. For example, with the inherited traits NALO, 76.7% of third graders correctly answered the low understanding question while 87.8% of 4th graders answered the same question correctly, and 98.9% of 5th graders answered the question correctly. This also held true for the medium understanding question with the percentages correct rising from 28.3% to 55.8% to 56.3% with each grade level increase. The high understanding also followed this pattern with 3rd, 4th, and 5th graders scoring 26.9%, 28.8%, and 31.8% respectively.

Interview data also supports this pattern. When asked if new plants or animals tend to look like their parents, a fifth grade student mentioned that, “they look very similar because they inherit things from their parents.” When a third grade student was asked the same question, the student responded by just saying “sometimes” offspring resembles the parents with no further explanation given. A fifth grader also explained the passing of traits as, “the grandparents give the traits to the parent that gives it to the child.” A fourth grade student agreed that genetics was an important concept for farmers

to understand because “they would use like the pigs that are healthier to raise more pigs. They would raise those. He would have more healthier pigs.”

Students were also asked questions about how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production in the interviews and assessment for NALO #2. Most students especially those in 4th and 5th grades had a high level of understanding on the topic based on interview conversations. Students could easily identify what plants and animals need to survive. Students probably learned about what living things need to survive from science classes. The high understanding question on the assessment from this NALO showed significant differences across grade levels. The specific question asks students to locate where photosynthesis occurs in a plant. In the interviews, students were not asked directly about photosynthesis. Instead, they were asked why plants needed sunlight. Students who mentioned that sunlight was needed for photosynthesis to occur indicated higher knowledge on the topic. Only 17.6% of third graders got this high understanding question correct on the assessment. However, 30.4% of fourth graders and 45.2% of fifth graders answered this question correctly.

These patterns are also supported from interview conversations. Some students, especially those in higher grades, were able to give a more complete description as to why living things need resources such as sun, water, and soil to survive. In addition to saying a corn plant need water, soil, and the sun to grow, a fifth grade student also included that you would need pesticides “because bugs eat plants and then pesticide kills the bugs.” The student also mentioned that plants would need bees to pollinate them, and sun was needed because “it [the plant] needs nutrients to make food because of

photosynthesis.” A third grade student answered the same question by stating that a corn plant would need “water, soil, and sun.” When asked why the plant would need these, the third graders responses included, “for it to grow” or “so it doesn’t die.”

Another concept that illustrated differences between grade levels was that of ecosystems and agro-ecosystems. On the high-level item for NALO #1, students were asked to identify the major ecosystems and agro-ecosystems in their community of region. On the assessment, students were asked to select which of the following was an agricultural system or “agrosystem.” Student chose from the options of tropical rainforest, cornfield, grassland, and pine forest. 17.6% of third graders, 38.2% of fourth graders, and 60.2% of fifth graders selected a cornfield as the agricultural system. The percentages from this specific question varied greatly among grade levels. This suggests that older students may be familiar with the term “ecosystems.”

In the interviews, students were asked to describe some of the landscapes they had seen or learned about. The terms “ecosystems” and “agro-ecosystems” were not used in the interviews. It was decided that most students, would be confused by this term. In addition, they were asked to describe the type of plants and animals that may be present in fields in their state. Most students talked about prairies and forests. Most students also understood that cattle, corn, and beans were common livestock and crops that may be seen in fields in their state. Third graders were confused by the term “landscapes.” When asked to describe landscapes that they’ve seen in their state or that they’ve learned about, a third grade student said “farms, backyards, playgrounds.” Additional questioning was then used to get students talking about prairies and fields. A fourth grade student not only mentioned prairies as a landscape, but he also mentioned that “a

lot of blue stem and all other types of grasses” and “maybe a few prairie dogs or rattlesnakes” would be present in the prairies. A fifth grade student showed greater knowledge on the topic by stating that “in [their state] I see a lot of flat land and farms and stuff, but in the Sandhills stuff is higher, more elevated, near Colorado.” This student was able to recognize how agriculture is different across the state and how there are a variety of landscapes.

NALO #3 in the AgE category asks students to recognize the natural resources used in agricultural practices. Differences among grade levels existed in the high understanding question. The low and medium understanding questions simply asks student to identify natural resources. The high understanding had students apply this knowledge by asking students why water is needed for crops to grow. 58.8% of third grade students, 69.1% of fourth grade students, and 72.0% of fifth grade students answered the question correctly. This shows that students at a younger age may be able to identify concepts; however, they may lack the knowledge to apply that information and understand the “why and how” behind it. The low understanding question for the NALO asked students to simply circle the natural resources. Results showed that students in fourth and fifth grades scored twice as high as students in 3rd grade when asked to identify natural resources. Only 41.2% of third grade students were able to correctly identify the natural resources while 83.9% of fourth graders and 77.4% of fifth graders were able to answer the question correctly.

Students were asked to name natural resources during the interviews. This was to address NALO #3. A third grade student stated that “soil, water, and the sun” were natural resources. He knew this because “you can find them outside.” A fifth grade

student mentioned that natural resources “could be trees, grass, the sunlight, groundwater and soil.” He knew that these are natural resources because “we don’t make them. The earth does.” This student also showed high understanding by stating that “Natural resources affect farming because you can’t really farm without soil, sunlight, or water.”

A medium understanding question also showed great differences among grade levels. NALO #4 asks students to identify land and water conservation methods. The question on the assessment asks students what the benefits of crop rotation are. Students are supposed to select “all of the above” as making sure the soil has good food for the plants, making sure the plants don’t get sick, and keeping insects away are all benefits of crop rotation. 11.8% of third grade students, 33.9% of fourth grade students, and 65.2% of fifth grade students answered the question correctly. Students struggled from question regarding this NALO on both the assessment and in the interviews. This question was a bit wordy so students in the younger grades may have stumbled with comprehension.

In the interviews, some students talked about how you would “plant beans one year and then corn the next.” No further explanation was given why farmers rotate crops. Students just agreed that it was a good thing. A third grader mentioned the idea of crop rotation and stated that “they’ve done studies on if you use the soil a lot for one crop, it won’t grow as well. You have to change crops every once in a while.” Crop rotation was not greatly mentioned in the interviews, but most students agreed that if I had a corn field, I would plant beans there the following year.

Significant differences also existed in the low understanding question for NALO #4 which focuses on conservation. The question showed students a picture and asked them to identify what had occurred in the field. The picture was of dry, cracked soil and

students were supposed to decide that drought had occurred in the field. From interview data, it was unsure that most students would be familiar with the term drought so on the assessment “the plants didn’t get enough rain” followed the choice of drought. 64.7% of third grade students, 83.3% of fourth grade students, and 95.6% of fifth grade students answered the question correctly. These differences may have existed because students in the higher grades may have more experiences of using pictures to answer questions.

In the interviews, students were asked what kinds of problems a farmer might experience. Most students mentioned not enough rain or pests eating the crops. Many students agreed that drought was a problem, but differences in knowledge became apparent in how students proposed solutions to the problem. Very few students mentioned using a pivot to water the crops. A fourth grade student mentioned that “they [farmers] sometimes use like pivots to water it.” A third grade student mentioned that “you could go out and water them yourself, but that would take a long time.” This statement shows that this student is not familiar with the large size of fields. A fifth grade student decided that “He might use those big silver things [pivots] to squirt water. Or they could use a river, and they could get irrigation pipes.”

NALO #6 deals with technology and asks students to describe how farmers increase their outputs with fewer inputs was a category that students overall scored very highly on the assessment. Student scores were very high for the low and medium questions with at least over 72% of students answering the questions correctly. For the high understanding question, students were asked to identify which of the following was not an example of technology that farmers were using. Students were supposed to select

that a “rake” was not an example of technology. Just over 50% of students across all three grades answered this question correctly.

In the interviews, students were asked how farming has changed over the years and to list specific examples of technology that farmers use. A fifth grade student stated that, “people used to have to go hand pick crops, but now they get to use combines.” Students that mentioned “combines” were then asked follow-up questions regarding the use of combines. The same fifth grade student also mentioned that “it [technology] makes it go way faster. Without technology, you wouldn’t have the sprayers, the combines, or any tractors. You’d just have to do it with your hands.” An example of a third grader’s response to the same question about technology consisted of, “they [farmers] can use big machines or something that helps crops.” However, some third graders possessed a high understanding of the topics. For example, a third grade student indicated that, “a long time ago they [farmers] didn’t have combines and tractors to use to harvest. They had to use shovels and hoes.”

CHAPTER FIVE: DISCUSSION

The purpose of this project was to a) develop and validate new assessments of NALOs and b) investigate elementary students' knowledge of environmental and STEM dimensions of food systems. This mixed methods study was embedded in a broader process of assessment design and development grounded in evidence-centered design (ECD; Mislevy & Haertel, 2006). The long-term objective of this work was the development, validation, and testing of an empirically-grounded assessment instrument designed to measure K-12 students' knowledge about STEM in food production systems. Conducting and analyzing student interviews while using the evidence centered design process resulted in the creation of two assessments tests that were administered to 400 students across the state.

I asked two research questions in this study: Are students more knowledgeable about agricultural/environmental (AgE) topics than STEM topics? How does students' agricultural literacy compare among upper elementary grades? Statistics from the assessment data supported by interview quotes allowed me to answer both research questions. Here, I discuss my results from both research questions as well as discussing the appropriateness of the NALOs.

Students are More Knowledgeable about STEM Topics than AgE Topics

Results from the assessment concluded that upper elementary students are more knowledgeable about STEM topics than AgE topics. This result was expected as many efforts have been made to develop K-12 programs focused on agricultural literacy that are concerned with the STEM foundations. However, agriculture is not a main focus in most elementary or high school classrooms. The National Research Council (1988)

stated that, “Agricultural education in U.S. high schools usually does not extend beyond the offering of an agricultural education program” (p. 2). While it is important to use STEM as a way to introduce agriculture literacy, greater emphasis needs to be placed on agriculture. Students in the 21st Century differ from those of the last century because now well under 5% of the U.S. population live on farms (NRC, 2009). With students disconnected from the farm, it may be difficult for them to grasp agricultural concepts.

Agriculture assessment scores from this study support findings from other researchers. Swortzel (1997) concluded that various researchers have discovered that elementary school children know very little about agriculture, its social and economic significance, and particularly, its links to human health and environmental quality. Even though all students that participated in the study were from an agricultural state, it was concluded that these students were not that familiar with agriculture. Terry, Herring, and Larke (1992) discovered that school age children in Kansas knew little about the food and fiber system. Kansas and the state in which this study was conducted are very similar agricultural states, and this study shows that students are not aware of the agricultural topics affecting their home state. Meischen and Trexler (2003) suggest that children living and going to school in rural areas may have no more ties to agriculture than urban youth. Just because students grow up in a rural state does not mean that they understand the complexity of the food and fiber system.

Hess and Trexler (2011) also concluded that student’s ideas about agriculture were often guesses, underdeveloped, or contradictory to expert conceptions. In the interviews, it was apparent that many students were not familiar with agricultural terms and practices. When discussing the need for fields of crops to have water, students said

that farmers could use “sprinklers” or “bring buckets of water to the plants.” Very few students knew what a pivot was and could imagine the large size of a field of crops. Students talked about agriculture and farming based off of things they had seen on television or read in a book. When talking to students about agriculture, it was obvious that they did not realize how diverse agriculture is. Students mainly talked about corn, beans, and cattle. However, agriculture is very different across the state, nation, and world. This is supported by Hall’s (2011) findings that students failed to convey an understanding of the types and variety of farms, the purpose of farms, or the cultural practices dominating conventional farming. However, one fifth grade student identified the elevation difference across their state, and that different plants were planted in the different areas.

Fifth Grade Students Possess Greater Agricultural Knowledge than Fourth and Third Graders

Results from this study also provide evidence of students’ increasing knowledge about STEM and AgE topics across the upper elementary grades. Fifth graders possessed the greatest agricultural literacy, followed by fourth graders and third graders, respectively. Fifth graders achieved an average score of 65.8%, fourth graders achieved an average score of 41.4%, and third graders scored an average of 55.7%. Differences in vocabulary and language in the interviews also supports this research finding. A majority of the fifth grade students fell into the high understanding category in the interviews. These students were able to give an explanation for the responses they gave instead of just giving a one-word answer. Fifth graders were more familiar with terms such as “photosynthesis,” “ecosystem,” “conservation,” and “inherited traits.”

Many of the NALOs are directly connected to science, technology, engineering, and mathematics topics. The NALOs are directly aligned with the Next Generation Science Standards (NGSS). For example, NALO # 3 asks students to recognize the natural resources used in agricultural practices to produce food, feed, clothing, landscaping plants, and fuel. This closely relates to NGSS Standards 4-ESS3 which has students obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment (NGSS Lead States, 2013).

As students' progress through elementary school, they would have taken more science courses that would prepare them to answer more of the NALO questions. For example, students in fourth grade may have already learned about natural resources and simple machines than a third grader. NALO #2, for example, focuses on how plants and animals depend on the interaction of the sun, soil, water, and weather to survive. Most students probably had conducted an experiment in which they had tried to grow a plant in class or they had taken care of a family pet at home, this allowed them to easily identify what a plant or animal needs to survive. Mabie and Baker (1996) concluded that students who participated in hands-on activities such as gardening had higher agricultural knowledge and understanding. All of these experiences would shape a students' knowledge so the older a student is, the more experiences they would have. It's important that teachers make these connections to agriculture in their classes.

Implications

Results from this study show upper elementary students possess greater levels of knowledge of some dimensions of agriculture than others and illustrate areas for growth

in knowledge related to STEM and AgE topics. Data shows that there are some subjects and topics that students do have an understanding on while there are other areas where students struggle. Students did well when questioned on natural resources and technology but struggled when talking about conservation and inherited traits. Results from this study have important implications for supporting upper elementary students' learning about food systems, including the articulation of agricultural literacy outcomes, curriculum development, and professional development for teachers.

Articulating standards. Some of the NALOs consisted of vocabulary and language that many students were unable to understand. In the first two interviews, the students responded with “what does that mean?” to questions. These questions were comprised of terms included in the actual NALOs. The questions were then revised to begin at the ground level of a topic and work up from there. It's important that students are familiar with the vocabulary present in the NALOs because these terms are also present in other standards such as social studies and science. Understanding the terms included in the NALOs is the first step in enhancing agricultural literacy. Using an empirical study to create or revise the NALOs would provide a better benchmark for agricultural literacy that way researchers can discover what knowledge level students are currently at and then work towards the standards. Descriptions of NALOs with difficult vocabulary are described below.

NALO #1 includes the terms “ecosystem” or “agro-ecosystem.” Students in the first two interviews did not know what an ecosystem was. In the following interviews, students were asked to identify landscapes they had seen or learned about. Then students were asked to describe what kind of livestock and crops they might see in fields in their

state. Ecosystem is a term that students in the upper elementary grades should be somewhat familiar with and a few students were able to define it, but no students were familiar with the term “agro-ecosystem.”

NALO #4 includes the word “conservation.” This NALO aims at getting students to identify land and water conservation methods such as wind barriers, conservation tillage, laser leveling, and GPS planting. Students struggled with identifying the term conservation let alone mentioning any of the suggested conservation methods. From the first two interviews, it was determined that students did not understand the term conservation even with explanation. From there, students were asked to identify problems or challenges a farmer might experience and how they would solve the problem. A few students mentioned a wind barrier and crop rotation; however, the assessment test asked students to identify a picture of terracing. Students scored the lowest on the question.

Inherited traits were the topic of NALO #7. Interview questions were geared at students identifying how everyone in their class was different. Some students mentioned that genetics was why everyone was different, and that they resembled their parents in some way. From there, students were asked if plants or animals resembled their parents. However, struggled with the concept of farmers using this knowledge to increase yields and raise products of better nutrition. Students basically agreed that knowing about traits was important to farmers.

NALO #9 was written very vaguely. It asks students to “provide examples of science being applied in farming for food, clothing, and shelter products.” This was the last NALO that students were asked about during the interviews. Conversations were

very short on this topic. Students talked about technology and repeated what they had said in previous conversations. There wasn't a lot of interview data to construct assessment items; however, three questions were created which focused broadly on science in agriculture. It would be helpful to know what kinds of examples they are looking for in this NALO.

Curriculum development. Integrated curriculum could also be incorporated into elementary school classrooms. Agriculture is founded in STEM principles. Many agricultural resources already exist for teachers to use. National Agriculture in the Classroom, Project Food, Land and People, and the Food and Fibers Systems Literacy are all programs that currently exist to help educators teach about agriculture. Agriculture doesn't need to be introduced as a standalone subject, but it needs to be intertwined into existing lessons (NRC, 1988). Teachers already have enough pressure to focus on the core subject, but agriculture closely relates to all of the core subjects. Luckily, the NALOs are currently closely aligned with the Next Generation Science Standards (NGSS Lead States, 2013). This alignment makes it easy for teachers to teach a science concept but also introduce agriculture. For example, when students are learning about growing plants in science class, teachers can relate that to how farmers grow tons of plants or crops and how soil, water, and sunlight are required for it to grow.

Teacher preparation. Agricultural topics may not be introduced in classrooms because teachers are not familiar or comfortable with teaching agricultural lessons. Teacher education and professional development needs to occur in order for teachers to become familiar with agriculture and the programs and resources that currently exist for them to use. In Terry's (1992) research he concluded that 73.3% of teachers said

agriculture was just “farming and ranching only”. Teachers associated the term “agriculture” with raising plants and animals.” The teachers were tested on their agricultural knowledge. Scores ranged from 5% to 89% with a mean score of 48.4%. Nearly three-fourths of the respondents had a score indicating unacceptably low knowledge about agriculture. Terry’s research suggests that teachers do not know enough about agriculture, and therefore, would imply why teachers are not incorporating agricultural topics into their classrooms. Terry (1991) also states that, “virtually no effort is made anywhere to educate teachers about agriculture, except for the teacher education programs designed for agricultural education teachers” (p. 58).

Studies such as these highlight the need to support teachers to engage in effective instruction around food systems. Preservice and in-service programs that highlight agriculture need to be implemented. Frick (1993) suggests that state education agencies and teacher education programs should design in-service and preservice programs to prepare current and prospective teachers for teaching middle school agricultural education program content. The National Center for Agricultural Literacy is working with the National Agriculture in the Classroom program to fill this void. State Agriculture in the Classroom programs can work with local teachers to introduce agricultural curriculum and activities that they can use in their classrooms. Also Extension Agents would be experts to help with this training (Mabie & Baker, 1996).

Limitations

Population. All students that participated in this study attended elementary school in a single state. Students were not randomly-selected and do not represent a fully representative sample. Students in this study may be more familiar with agriculture than

students in different locations. However, findings from other scholars (as mentioned above) state that students from a rural agricultural state may not be more knowledgeable than students from a state where agriculture isn't as prevalent. All students that took part in the qualitative interviews were from the city. The students that took the assessment were from both urban and rural areas. Demographics of students were not collected in either strand of the study. Student's background plays a huge role in their agricultural knowledge. Collecting this demographic information would have allowed us to see what kind of areas and backgrounds these students were from. Agricultural experience and knowledge would vary greatly based on if someone was raised on a farm or grew up in the city.

Test format. Students took the test on paper during non-core subject class time. Some students left questions blank. Students may have left questions blank if they did not know the answer or if they were confused with the test format. The assessment consisted of true/false, multiple choice, and matching questions. Not having a consistent series of questions may have confused students. If the assessment was administered through an online survey, it could have forced students to answer every question. Vocabulary on the assessment may have also confused some students. In the interviews, students could ask me to explain terms, and then they were able to better answer the question. However, students did not get this benefit on the assessment. Some of the vocabulary on the assessment was geared to see if students were in the high understanding category so some students may have been confused and discouraged with some of the vocabulary.

Use of an empirical study for creating NALOs. No evidence of using empirical research to construct the NALOs is identified. Looking at teaching and learning research on agriculture prior to constructing the NALOs would have been beneficial to researchers. There is room for improvement on the NALOs. By revisiting the NALOs and ensuring teachers are incorporating them in their classrooms, the NALOs have the opportunity to make a big impact on students' understanding and appreciation of agriculture. More research and work should be conducted with the NALOs.

Future Research

This study looked at the NALOs in the upper elementary grade band in the areas of STEM and agriculture and the environment. The NALOs were created for a variety of grade bands such as early elementary, middle school, and high school. Other categories such as social studies and food, nutrition, and health exists for these NALOs. Future research could be conducted to develop instruments and measure student outcomes associated with other NALOs. A similar mixed methods approach grounded in the evidence-centered design process would be appropriate to use to investigate them.

Data from can also be used to create curricular programs, including lesson plans and other instructional resources, based off of the NALOs. Another goal of the National Center for Agricultural Literacy and National Agriculture in the Classrooms is the creation of lesson plans that are available for teachers to use across the nation. Results from this study show what students know and don't know about these particular NALOs. This information can be used to general grade-appropriate lesson plans for students that integrate STEM and focus on agriculture. This data shows which topics students are not familiar with so more emphasize and time can be spent on those topics.

Conclusion

This study contributes to the future of agricultural literacy research. No studies have yet been conducted focused on the National Agricultural Literacy Outcomes (NALOs). Results from this study provide important insights into upper elementary students' ideas about fundamental intersections between agriculture and science, technology, engineering, and mathematics. This study contributes to existing bodies of knowledge about agricultural literacy, STEM learning, and assessment design and development. To date, very few studies focused on agricultural literacy use the mixed methods approach. The use of the evidence centered design process allowed for the creation of assessment tests based on students' understanding. The present study can provide an important foundation for future work to develop empirically-grounded, valid, and reliable assessments of NALOs, as well as inform the revisions of the NALOs themselves.

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APPENDIX

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Appendix A: IRB Approval Letter for Student Interviews



Official Approval Letter for IRB project #14634

February 11, 2015

Cory Forbes
School of Natural Resources
HARH 523, UNL, 68583-0995

Jennifer Melander
Department of Biological Systems Engineering
CHA 248, UNL, 68583-0726

IRB Number: 20150214634EP
Project ID: 14634
Project Title: National Center for Agricultural Literacy

Dear Cory:

This letter is to officially notify you of the approval of your project by the Institutional Review Board (IRB) for the Protection of Human Subjects. It is the Board's opinion that you have provided adequate safeguards for the rights and welfare of the participants in this study based on the information provided. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46). Your project has been approved as an Expedited project, category 7.

Date of EP Review: 12/14/2014 & 02/04/2015

You are authorized to implement this study as of the Date of Final Approval: 02/11/2015. This approval is Valid Until: 02/10/2016.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:

- * Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
- * Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
- * Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
- * Any breach in confidentiality or compromise in data privacy related to the subject or others; or
- * Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

For projects which continue beyond one year from the starting date, the IRB will request continuing review and update of the research project. Your study will be due for continuing review as indicated above. The investigator must also advise the Board when this study is finished or discontinued by completing the enclosed Protocol Final Report form and returning it to the Institutional Review Board.

If you have any questions, please contact the IRB office at 472-6965.

Sincerely,

Julia Torquati, Ph.D.
Chair for the IRB



Appendix B: Letter to Parents and Permission Form for Student Interviews



SCHOOL OF NATURAL RESOURCES

April 22, 2016

Dear Parent:

My name is Cory Forbes and I am a faculty member and Director of the National Center for Agricultural Literacy at the University of Nebraska-Lincoln. I am leading a team conducting a research study at your child's school. We are working to understand what elementary-age students know about agriculture.

Enclosed are two copies of an Informed Consent Document and two copies of the Youth Assent Document. Please read these for additional information about the study. After you read the forms, discuss with your child whether or not he or she will participate in the study.

If you both agree that the student will participate in the study, please sign one copy of the Informed Consent Document in the Parent/Guardian section. Keep the second copy for your records. Please also have your child sign one copy of the Assent Document and keep the second copy for your records. Please return the forms to the project team in the mail using the pre-addressed, pre-paid envelope on the next business day.

If you have any questions about the study, please call or e-mail me using the information listed on the consent form. Please return the forms at your earliest convenience. If we do not hear from you within 1 week, we will send another consent packet home with your child to be returned as described above the day after you receive it.

Thank you for considering participating in this study.

Sincerely,

A handwritten signature in black ink, appearing to read "Cory Forbes".

Cory T. Forbes
Associate Professor and Science Literacy Coordinator
School of Natural Resources
Institute for Agriculture and Natural Resources
University of Nebraska-Lincoln
523 Hardin Hall
3310 Holdrege Street
Lincoln, NE 68583-0995
cforbes3@unl.edu (email)



INFORMED CONSENT DOCUMENT

Project Title: National Center for Agricultural Literacy

Principal Investigator and Contact: Cory Forbes

This consent form describes the research study to help you decide if you will allow your child to participate. This form provides important information about what your child will be asked to do during the study, about the risks and benefits of the study, and about your child's rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your child's participation with anyone you choose such as family or friends.
- Do not agree for your child to participate in this study unless the research team has answered your questions and you decide that you want him/her to be part of this study.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research and development study. The purposes of this project are to measure the level of agricultural knowledge of elementary students. Elementary students in grades K-5 will be interviewed to determine what they know about science and technology in agriculture. The data collected in this study will be used to develop assessment tools that can be utilized nationwide to measure agricultural literacy in elementary students and promote the development of an agriculturally literate society.

HOW MANY PEOPLE WILL PARTICIPATE?

Students in grades K-5 will be asked to participate in this study conducted by researchers from the University of Nebraska-Lincoln. In this project, 40 students will be interviewed.

HOW LONG WILL MY CHILD BE IN THIS STUDY?

If you agree to allow your child to take part in this study, his/her involvement will only include participating in a 20 minute interview with the research personnel.

WHAT WILL HAPPEN DURING THIS STUDY?

If you agree to your child's participation in the study, the research team will conduct a one-on-one interview with your child. Participants will meet with the interviewer in a quiet room in the school building for up to 20 minutes. Participants will be asked to comment on their understanding of a variety of agricultural topics based on the National Agricultural Literacy Outcomes. For example, participants may be asked to comment on how weather affects plant and animal growth for food. The interviews will be audio recorded and transcribed by members of the research team for use as data in this study.

Audio Recording

We will make audio recordings of your child's interviews. We will prepare a transcript of your child's interview from the recording and will destroy the recording after the transcription has been completed and verified.

WHAT ARE THE RISKS OF THIS STUDY?

Your child is unlikely to experience risk from being in this study. However, there may be unknown risks, or risks that we did not anticipate, associated with being in this study. We will not share the audio files or discuss the content of the interviews with anyone outside of the research team.

WHAT ARE THE BENEFITS OF THIS STUDY?

We do not know if your child will benefit from being in this study. We hope that, in the future, other people might benefit from this study because examining what students know and understand about agriculture can be addressed through curriculum and instruction. This may lead to the development of improved professional development seminars for teachers about agriculture and improved student achievement in math and science related to agriculture.

WILL IT COST ANYTHING TO BE IN THIS STUDY?

Neither you nor your child will incur any costs for being in this research study.

WILL MY CHILD OR I BE PAID FOR PARTICIPATING?

Neither you nor your child will be paid for being in this research study.

WHO IS FUNDING THIS STUDY?

This project is funded by the United States Department of Agriculture (USDA), National Institute of Food and Agriculture (NIFA). This means that the University of Nebraska-Lincoln is receiving payments from the USDA to support the activities that are required to conduct the study. No one on the research team will receive a direct payment or increase in salary from USDA for conducting this study.

WHAT ABOUT CONFIDENTIALITY?

We will keep your child's participation in this research study confidential to the extent permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies your child.

- federal government regulatory agencies,
- auditing departments of the University of Nebraska-Lincoln, and
- the University of Nebraska-Lincoln Institutional Review Board (a committee that reviews and approves research studies)

To help protect your child's confidentiality, we will use a number and not your child's name on all of data and records collected during the study, except for this consent form. Digital files will be maintained in a secure password protected computer. We will maintain a list with your child's study number in a file that only people on the research team can access. The consent document will be stored separately from the study data. If we write a report or article about this study or share the study data set with others, we will do so in such a way that your child cannot be identified.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. You may choose for your child not to take part at all. You and your child/legal ward can refuse to participate or withdraw at any time without harming yours and their relationship with the researchers or the University of Nebraska-Lincoln, or in any other way receive a penalty or loss of benefits to which you or they are otherwise entitled. If you decide to allow your child to be in this study, you may halt his/her participation at any time.

WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 to voice concerns about the research or if you have any questions about your child's/legal ward's rights as a research participant. If you have any questions about the research study itself, please contact Cory Forbes 402.472.7844.

This Informed Consent Document is not a contract. It is a written explanation of what will happen during the study if you decide to allow your child to participate. You are not waiving any legal rights by signing this Informed Consent Document. Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to allow your child to take part in this study. You will receive a copy of this form.

Child's Name (printed): _____

Parent/Guardian's Name and Relationship to Child

(Name - printed) (Relationship to Subject - printed)

(Signature of Parent) (Date)

Appendix C: Youth Assent Letter for Interviews



SCHOOL OF NATURAL RESOURCES

ASSENT DOCUMENT

Project Title: National Center for Agricultural Literacy

Principal Investigator and Contact: Cory Forbes

I am doing a research study. A research study is a special way to find out about something. I am trying to find out what students like you know about agriculture.

If you decide that you want to be in this study, I will ask you to talk with me about the things you know about agriculture. The information I learn from our conversation will help me develop tools to measure how much other students know about agriculture. I will tape record our conversation.

We don't know if being in this research study will help you. But we hope to learn something that will help other people someday.

When I am done with the study, I will write a report about what I found out. I won't use your name in the report.

You don't have to be in this study. It's up to you. If you say okay now, but you want to stop later, that's okay too. All you have to do is tell me.

If you want to be in this study, please sign your name.

I, _____, want to be in this research study.
(Print your name here)

(Sign your name here)

(Date)

Appendix D: Interview Questions

Interview Questions for AgE and STEM NALOs

Upper Elementary (Grades 3-5)

Identify the major ecosystems and agro ecosystems in their community or region (e.g., hardwood forests, conifers, grasslands, deserts) with agro-ecosystems (e.g., grazing areas and crop growing regions)

- What are some of the landscapes you've seen in Nebraska or that you see every day?
- What kinds of fields have you seen? Are there plants or animals in the fields?

Describe similarities and differences between managed and natural systems (e.g. wild forest and tree plantation; natural lake/ocean and fish farm)

- What do you know about prairies? Forests? Deserts?
- How do you think a prairie is different if it is grazed by cows? Similar/different prairie to cornfield??

Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production

- Say I want to grow a corn plant. How would I do it? What would the plant need?
- Say I want to raise a goat. How would I do it? What would the goat need?
 - Why does a plant need soil? Sun? Water?
 - Why do animals need feed? Sun? Water?
 - How does weather affect plant growth? Animals?

Recognize the natural resources used in agricultural practices to produce food, feed, clothing, landscaping plants, and fuel (e.g., soil, water, air, plants, animals, and minerals)

- What are some natural resources? Why do you think these are natural resources?
- How do these resources affect plants or animals?

Identify land and water conservation methods used in farming systems (wind barriers, conservation tillage, laser leveling, GPS planting, etc.)

- What are some challenges or problems that a farmer might experience?
- What might a farmer do to protect crops, livestock?
- What kind of role do natural resources play in farming?
 - What is conservation? Why is it important?
 - What are examples of conservation techniques?
 - What is erosion?
 - Describe the importance of a wind barrier.

Identify examples of how the knowledge of inherited traits is applied to farmed plants and animals in order to meet specific objectives (i.e., increase yields, better nutrition, etc.)

- Does everyone in your class look the same? Why not? What's different?
- Do new plants or animals tend to look like their parents? Why or why not?
- How do plants or animals pass their traits on to their offspring?
 - How might farmers use this knowledge to grow/produce more?

Compare simple tools to complex modern machines used in agricultural systems to improve efficiency and reduce labor.

- What kind of tools do farmers use? Would these be simple or complex machines?
- Why do farmers use complex machines?
- Say I was going to move a pile of dirt, what kind of tool would I use? What could you use a shovel for? What couldn't you use a shovel for?
- Would a loader tractor with a scoop in the front make moving the dirt easier? Which tool or machine would help farmers more? Why?
 - How do farmers use more complex machines to make their work more efficient?

Describe how technology helps farmers/ranchers increase their outputs (crop and livestock yields) with fewer inputs (less water, fertilizer, and land) while using the same amount of space.

- How has farming changed in the past years?
- How is technology changing agriculture?
- Can you think of an example of technology that farmers use?
 - How can farmers and ranchers use technology to better themselves?
 - What can farmers and ranchers do to conserve land and water?
 - What kinds of technology can be used to help the farmers and ranchers?

Provide examples of science being applied in farming for food, clothing, and shelter products.

- What's scientific about agriculture?
 - How can applying science in farming improve food?

Appendix E: IRB Approval Letter for Student Interviews



Official Approval Letter for IRB project #15407

August 26, 2015

Cory Forbes
School of Natural Resources
HARH 523, UNL, 68583-0995

Jennifer Keshwani
Department of Biological Systems Engineering
CHA 248, UNL, 68583-0726

IRB Number: 20150815407EX
Project ID: 15407
Project Title: National Center for Agricultural Literacy

Dear Cory:

This letter is to officially notify you of the certification of exemption of your project. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46) and has been classified as exempt, category 1.

You are authorized to implement this study as of the Date of Exempt Determination: 08/26/2015.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:

- * Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
- * Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
- * Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
- * Any breach in confidentiality or compromise in data privacy related to the subject or others; or
- * Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board.

If you have any questions, please contact the IRB office at 472-6965.

Sincerely,

Becky R. Freeman

Becky R. Freeman, CIP
for the IRB



Appendix F: Parent Notification Letters for Assessments



SCHOOL OF NATURAL RESOURCES

INFORMED CONSENT DOCUMENT

Project Title: National Center for Agricultural Literacy

Principal Investigator and Contact: Cory Forbes

This letter describes the research study your child will be participating in. This form provides important information about what your child will be asked to do during the study, about the risks and benefits of the study, and about your child's rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- **If you would not like your child to participate, please notify your child's teacher by signing and returning this form to excuse them from the study.**

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research and development study. The purposes of this project are to measure the level of agricultural knowledge of elementary students. Elementary students in grades 3-5 will be given a written assessment to determine what they know about science and technology in agriculture. The data collected in this study will be used to determine the appropriateness of the National Agricultural Literacy Outcomes (NALOs). Conclusions drawn from this data will promote the development of an agricultural literate society.

HOW MANY PEOPLE WILL PARTICIPATE?

Students in grades 3-5 will be asked to participate in this study conducted by researchers from the University of Nebraska-Lincoln. In this project, up to 2,000 students will be given a written agricultural assessment.

HOW LONG WILL MY CHILD BE IN THIS STUDY?

Your child's involvement will only include completing a written agricultural assessment that will take no longer than a half hour to complete. Your child will take the assessment during non-core subject class time.

WHAT WILL HAPPEN DURING THIS STUDY?

The research team will administer a written agricultural assessment to your child. Questions will be developed from agricultural topics developed from the National Agricultural Literacy Outcomes. For example, participants may be asked questions regarding how natural resources affect plant and animal growth. Questions will be multiple choice, true/false, or fill-in-the blank. The assessment will not take longer than a half hour to complete. The assessment will be completed during non-core subject classroom time.

WHAT ARE THE RISKS OF THIS STUDY?

Your child is unlikely to experience risk from being in this study. However, there may be unknown risks, or risks that we did not anticipate, associated with being in this study. Students will not know their scores from the assessments.

WHAT ARE THE BENEFITS OF THIS STUDY?

We do not know if your child will benefit from being in this study. We hope that, in the future, other people might benefit from this study because examining what students know and understand about agriculture can be addressed through curriculum and instruction. This may lead to the development of improved professional development seminars for teachers about agriculture and improved student achievement in math and science related to agriculture.

WILL IT COST ANYTHING TO BE IN THIS STUDY?

Neither you nor your child will incur any costs for being in this research study.

WILL MY CHILD OR I BE PAID FOR PARTICIPATING?

Neither you nor your child will be paid for being in this research study.

WHO IS FUNDING THIS STUDY?

This project is funded by the United States Department of Agriculture (USDA), National Institute of Food and Agriculture (NIFA). This means that the University of Nebraska-Lincoln is receiving payments from the USDA to support the activities that are required to conduct the study. No one on the research team will receive a direct payment or increase in salary from USDA for conducting this study.

WHAT ABOUT CONFIDENTIALITY?

No confidential or identifiable information will be gathered from the assessment. Students will only record their gender and grade on the assessment. We will keep your child's participation in this research study confidential to the extent permitted by law.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. Teachers will administer the assessments to all students in the class. If students do not wish to participate, their parents can notify their teacher who will excuse them from the study. Choosing not to complete the assessment will not harm your child's relationship with the researchers or the University of Nebraska – Lincoln.

WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 to voice concerns about the research or if you have any questions about your child's/legal ward's rights as a research participant. If you have any questions about the research study itself, please contact Cory Forbes 402.472.7844.

If you **do not** wish to have your child participate, please sign below and return the form to your child's teacher. Your child will be excused from the study.

Child's Name (printed): _____

Parent/Guardian's Name and Relationship to Child

(Name - printed)

(Relationship to Subject - printed)

(Signature of Parent)

(Date)

Appendix G: Subscores for Items Divided by Grade

	3 rd Grade			4 th Grade			5 th Grade		
NALO	Low	Medium	High	Low	Medium	High	Low	Medium	High
1. Identify the major ecosystems and agro-ecosystems in their community or region with agro-systems.	58.8%	41.2%	17.6%	90.9%	37.5%	38.2%	.871%	52.7%	60.2%
2. Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production.	87.5%	56.3%	17.6%	91.8%	.714	30.4%	.835%	72.0%	45.2%
3. Recognize the natural resources use in agricultural practices to produce food, feed, clothing, landscaping plants, and fuel.	41.2%	64.7%	58.8%	83.9%	.946	69.1%	.774%	86.0%	72.0%
4. Identify land and water conservation methods used in farming systems.	64.7%	11.8%	17.6%	83.3%	.339	13.0%	.956%	65.2%	16.5%
5. Describe similarities and differences between managed and natural systems.	52.9%	47.1%	47.1%	44.6%	.519	57.4%	.484%	45.6%	53.8%

6. Describe how farmers/ranchers increase their outputs with fewer inputs while using the same amount of space.	71.7%	92.5%	56.6%	84.0%	98.1%	55.8%	.920%	96.6%	58.4%
7. Identify examples of how the knowledge of inherited traits is applied to farmed plants and animals in order to meet specific objectives.	76.7%	28.3%	26.9%	87.8%	55.8%	28.8%	.989%	56.3%	31.8%
8. Compare simple tools to complex modern machines used in agricultural systems to improve efficiency and reduce labor.	96.1%	42.3%	34.0%	100%	30.8%	57.7%	100%	20.2%	57.3%
9. Provide examples of science being applied in farming for food, clothing, and shelter products.	40.4%	94.3%	50.9%	71.2%	96.2%	25.0%	.708%	94.4%	46.1%

Appendix H: Agriculture and the Environment Assessment



National Center for Agricultural Literacy
Ag and the Environment Assessment

Grade: _____

Gender: _____

Please select the appropriate response for each item below.

1. Prairies are an example of a _____ ecosystem.
 - A. Coral reef
 - B. Forest
 - C. River
 - D. Grassland
2. True or false. Weather does not have an effect on animals.
3. Why is water needed for crops to grow?
 - A. It provides warmth.
 - B. It moves nutrients from the soil into the stems and leaves.
 - C. It spreads the pollen and seeds around.
 - D. It supports the plant.
4. Where do natural resources come from?
 - A. Humans
 - B. Factories
 - C. Nature
 - D. Animals
5. What's the difference between a tree farm and a forest?
 - A. The sun
 - B. The role of humans
 - C. The soil
 - D. The air
6. In a natural ecosystem, which would not occur?
 - A. Harvesting plants to produce food for humans
 - B. Plants using the sun's energy to grow
 - C. Bacteria or fungi decomposing nonliving plant and animal matter
 - D. Herbivores consuming plants

7. How do plants use soil?

- A. Store food
- B. Provide nutrients
- C. Conduct photosynthesis
- D. Attract sunlight

8. Match the plant species with its ecosystem:

_____ Grassland

_____ Deciduous forest

_____ Coniferous forest

_____ Desert

A.



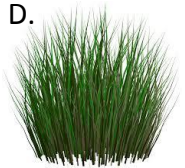
B.



C.



D.



9. Which of the following is an agricultural system (or 'agroecosystem')?

- A. Tropical rainforest
- B. Corn field
- C. Grassland
- D. Pine forest

10. Sunlight makes photosynthesis possible. Where does this process occur in a plant?

- A. Stem
- B. Roots
- C. Leaves
- D. Soil

11. What is a benefit(s) of crop rotation in which different crops are planted in the same space in different years?

- A. Making sure the soil has good food for the plants
- B. Making sure the plants don't get sick
- C. Keeping insects away from the plants
- D. All of the above

12. In the list below, circle all of the words that are natural resources. You may circle more than one.

Plastic

Plants

Soil

Sun

Water

13. What has most likely occurred in the field pictured below?



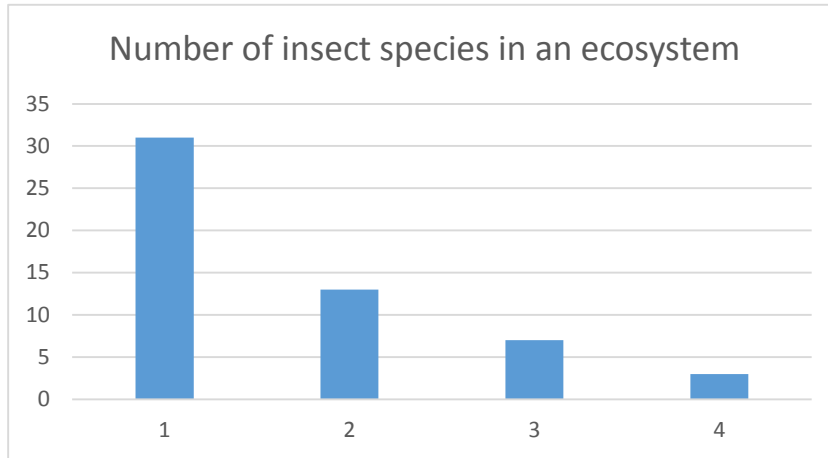
- A. Flood (the plants got too much water)
- B. Drought (the plants didn't get enough rain)
- C. The plants grew too fast
- D. Insects ate the plants

14. What is the type of land conservation practice pictured below?



- A. Cover crop
- B. Grass Waterway
- C. Terraces
- D. Strip cropping

15.



Consider the graph above. Which of the following would you expect to be the ecosystem labeled '1'?

- A. Natural temperate forest (oak, hickory, pine, cedar, ash, etc.)
- B. Tree farm (pine trees)
- C. Corn field
- D. Soybean field

Appendix I: STEM Assessment

National Center for Agricultural Literacy
Science, Technology, Engineering and Mathematics Assessment

Grade: _____

Gender: _____

Please select the appropriate response.

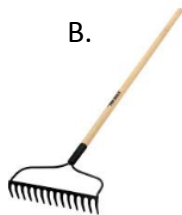
1. True or False. Farmers use computers less today than they did 50 years ago.
2. Science is used to grow cotton and to produce cotton fabric to make:
 - A. Computers
 - B. Buildings
 - C. Clothes
 - D. Plants
3. Which trait could be influenced by the environment?
 - A. Fur color changes with the seasons
 - B. Fur color changes as you get older
 - C. Height is affected by what you eat
 - D. You can stretch to grow taller
4. Farming machines make it _____ for farmers to do their job.
 - A. Easier
 - B. Less efficient
 - C. More time consuming
 - D. Difficult
5. What is a simple machine that uses grooved wheels and a rope to raise, lower, or move a load?
 - A. Lever
 - B. Inclined plane
 - C. Wheel and axel
 - D. Pulley

6. Which one of the following is NOT an example of technology used in agriculture?
- A. GPS
 - B. Rake
 - C. Electric motors
 - D. Pivots
7. Science is used to make “green” shelters to:
- A. Reduce energy needed for heating or cooling
 - B. Make it pretty
 - C. Make it more durable
 - D. None of the above
8. True or False. Parents pass on traits to their children.
9. Predict the outcome of planting several kernels of multi-colored Indian corn.
- A. Every plant will be totally different because one ear of Indian corn has lots of colors
 - B. Every plant will look like the parent plant but there will also be some variations
 - C. Every plant will be exactly the same because it came from the same parent plant
 - D. Every plant will start out differently but will eventually grow to be an identical copy
10. What is a machine?
- A. Any instrument invented by humans
 - B. Any instrument that uses a motor to function
 - C. Any instrument that helps us to do work easily
 - D. Any instrument that helps us move from a place to another place
11. Applying science in farming can:
- A. Ensure a healthy crop
 - B. Help the environment
 - C. Get a more nutritious food
 - D. All of the above
12. Which of the following tools would be the best to use to move a large pile of dirt?

A.



B.



C.



D.

