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Development and Validation of an Agricultural Literacy Instrument Using the National Agricultural Literacy Outcomes

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DEVELOPMENT AND VALIDATION OF AN AGRICULTURAL LITERACY INSTRUMENT USING THE NATIONAL AGRICULTURAL LITERACY OUTCOMES

by

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ABSTRACT

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by

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This quantitative study developed and validated a summative agricultural literacy assessment, for post-12th grade young adults, using the National Agricultural Literacy Outcomes (NALOs) as benchmarks. Research questions also addressed levels of participant exposure to agriculture, self-efficacy related to agricultural literacy, and performance on the assessment. The study employed a modified Delphi model and Programme for International Student Assessment [PISA]-based proficiency scoring for item development. Two expert panels created 45 questions for validation. The validation used a convenience sample to survey 515 Utah State University students between the ages of 18-23, during the fall 2018 semester. The survey was evaluated using factor, item, and discriminant analysis. Results finalized two 15-item instruments and determined both had an acceptable reliability, were adequate for model fit, and were valid agricultural literacy assessments for the NALO benchmarks. The study also determined students who had a “great deal” of exposure to agriculture, also had strong, positive relationships to perceptions of a “good” or higher level of agricultural literacy. Findings show that participants who perceived a “good” or higher level of agricultural literacy shared a positive correlation with performing at either a factual literacy or applicable proficiency level on the assessment. A keystone of the Judd-Murray Agricultural Literacy Instruments (JMALI) is the use of proficiency stages to determine student scoring. A proficiency scale determines if a participant is at either an exposure, factual literacy, or applicable proficiency level of agricultural literacy.

(225 pages)

PUBLIC ABSTRACT

Development and Validation of an Agricultural Literacy Instrument Using the National Agricultural Literacy Outcomes

Rose Judd-Murray

This study was conducted to develop a standardized agricultural literacy assessment using the National Agricultural Literacy Outcomes (NALOs) as benchmarks. The need for such an assessment was born out of previous research, which found that despite numerous programs dedicated to improving agricultural literacy, many students and adults remain at low or very low levels of literacy. Low literacy levels lead to negative associations with the production and processing of food, clothing, and shelter, as well as misinformed public perceptions and policies. Agricultural literacy researchers recognized that the development of a standardized assessment for post-12th grade, or equivalent, could unify both research and program development efforts.

The assessment was developed by forming two groups of experts. Teaching experts and agricultural content experts worked together in an iterative process. They crafted 45 questions using research methods and models. The 45 items were placed in an online survey to be tested for validity by a participant group. During the Fall 2018 semester, 515 Utah State University students between the ages of 18-23 years old participated in the online assessment. The participant data assisted in determining which questions were valid and reliable for determining agricultural literacy, as aligned to the NALO standards. Additional demographic information was also collected from participants. The demographic items asked students to self-report their level of exposure to agriculture and their self-perceived level of agricultural literacy.

The study concluded that two separate 15-item Judd-Murray Agricultural Literacy Instruments (JMALI) were valid and reliable for determining agricultural proficiency levels based on the NALOs. Participant scores were reported as a single proficiency stage: exposure, factual literacy, or applicable proficiency. The study also determined that students who had a “great deal” or higher level of exposure to agriculture also had a strong, positive correlation with a “good” or higher level of agricultural literacy. Findings show participants who reported a “good” level of agricultural literacy shared a positive correlation with either performing at a factual literacy (middle) or applicable proficiency (highest) level on the assessment.

The results suggest JMALI instruments have the potential to assist in improving current agricultural education endeavors by providing a critical tool for determining the agricultural literacy proficiency stages of adult populations.

DEDICATION

For Jeff, Lachlan, Jack, and Louisa. Thank you for letting me have a big dream. This is something we accomplished as a team. *We Stick Together*. #teammurray

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This journey started with direct encouragement and support from my committee chair, Dr. Brian Warnick. His willingness to go from the beginning to the end has supported this entire effort and at times been the strength to keep me going. It is impossible for me to repay him for his kindness, mentoring, expertise, and consistent advice. It is a privilege to work with him.

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I started this program with the intent to be a better teacher but have never gotten over what it has taught me about friendship. My cohorts, John Louviere, Mitchell Colver, and Travis Thurston: I am deeply appreciative for your willingness to text messages of support. Kari Lamoreaux-Phillips: you’re unstoppable. Your formatting skills saved me from disaster. I love you for it, and I owe you at least two trips to Maui. For 20 years, Rebecca Hatch and Brooke Lambert have been my biggest supporters. I love you for believing that I could accomplish this goal; please don’t ever let me do another degree. My sisters and parents, who don’t understand any of it, but supported me anyway. I hope in some small way this inspires each of my sisters (and our kids) to reach for impossible dreams.

Finally, my family. My little squad of people. There is so much of this experience I hope you can forgive and forget. I am entirely overwhelmed by your ability to keep going when your mother is completely out-of-sorts. Do not ever forget what can be accomplished with love and a lot of work. Jeff, thank you for being patient and a true partner. I cannot express what it means to me to know that you put my needs first so many times—I share all the success with you.

Rose Judd-Murray

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CHAPTER I

INTRODUCTION

Agriculture provides food, clothing, and shelter for a global population. The production of these human essentials makes up a vast contribution to the economic foundation for many nations and people (U.S. Department of Agriculture, Economic Research Service, 2017). Beyond the essentials, agriculture—its products and the people who grow, sell, and buy them—contributes significantly to most of the world's cultural, environmental, political, and even religious parameters. Remarkably, relatively few people work directly in the field of agriculture. Only "about 2% of Americans are involved in production agriculture" (American Farm Bureau Federation, 2017, para. 4), which means 98% of Americans are doing something else. Ultimately, the consideration for where human essentials are from and how they are produced, processed, marketed, and sold may be as limited as the actual number of production growers.

To illustrate this point, consider two survey examples. Most Americans believe organic produce is better for one's health than conventionally grown produce (Greene, Wechsler, Adalja, & Hanson, 2016). Those surveyed, however, were unable to convey, beyond believing that it was healthier, any specific advantages or disadvantages (Funk & Kennedy, 2016). The consumer perceptions and understanding are in direct contrast to the considerable scientific debate that exists over whether organic foods actually provide a nutritional boost over eating conventionally grown foods (Dangour et al., 2009). In another scenario, Americans knew "only a little about genetically modified foods" and perceived that scientists did not have a depth of understanding regarding the health risks of GM foods (Funk & Kennedy, 2016). The misconceptions run counter to "more than 25 years" of science and meta-analysis conducted by scientists on the human health risks related to genetic modification of food that showed "there were no differences between GM food and conventionally grown food for human intake" (American Association for the Advancement of Science [AAAS] Board of Directors, 2013, para.2). The disconnect between the scientific community and public consumers is consistent in nearly all areas related to agricultural literacy, including understanding about life cycles, environment, animal health, human nutrition, and food safety (Lawson & Weser, 1990; Rajeev Gowda, Fox, & Magelky, 1997; Redmond & Griffith, 2003; Savory & Parsons, 1980; Wilcock, Pun, Khanona, & Aung, 2004).

Proportional to these points, agricultural literacy is not only needed for the sake of consumer knowledge, it is needed to drive adult perception and attitudes. Research shows that people who are agriculturally literate are more likely to trust information from scientists and see scientific research findings in a more favorable light (Funk & Kennedy, 2016). In an era where combating "fake news" has become a bulwark for educators and researchers, it is more important than ever that scientists are recognized as legitimate and reliable sources for knowledge and information. The National Academy of Science reiterated this point by stating, "agriculture is too important a topic to be taught to only a relatively small percentage of students considering careers in agriculture and pursuing vocational agricultural studies…agricultural understanding should go beyond the basics [because] agricultural literacy is important for all mankind" (National Research Council, 1988, p. 8). In short, the scientific and contextual understanding of agriculture has a profound effect upon modern society through the attitudes, perceptions, and choices made by American consumers (U.S. Department of Agriculture, Economic Research Service, 2017).

Therefore, within this context, it is necessary to acknowledge that agricultural literacy is more than knowing the scientific, environmental, social, and cultural contexts of how food is produced and how it is consumed. Literacy means having the ability to construct, interpret, communicate, and transfer those contexts (Gee, 2015). It includes the ability to understand so that one may formulate questions, analyze information and form personal interpretations. Agricultural literacy is the link that allows adults to recognize and interpret agricultural information relevant for their own health, global environments, public policy, and economic benefit.

Statement of the Problem

The absence of agricultural literacy generated efforts to improve the amount and type of agricultural education for students and adults. Literacy benchmarks and assessment instruments were developed to determine the level of literacy obtained or maintained by K-12 student populations (Frick, 1993; Leising, Pense, & Igo, 2000; Powell, Agnew, & Trexler, 2008). However, relevant literature showed a lack of consistency regarding what criteria and constructs determined literacy levels. Furthermore, although validated assessment instruments were found in the literature (Leising et al., 2000), they are based on an older framework and definition not designed to meet current needs. The recent development of the National Agricultural Literacy

Outcomes (NALOs; Spielmaker & Leising, 2013) and the National Agricultural Literacy Logic Model (NALLM; Spielmaker, Pastor, & Stewardson, 2014) established a valid framework to provide consistency for determining the literacy level of adults (post high school or grade 12 completion). Prior to the current study, a validated assessment instrument for adults based on the NALOs had not yet been developed.

Purpose of the Study

The NALLM uses the NALOs as the framework for determining age-appropriate agricultural literacy benchmarks. The NALOs integrate with the curriculum of the national education system to provide a way for agricultural education to be incorporated through the K-12 structure. The NALO's standards and indicators (see Appendix A) are based in relevant theory and peer-reviewed research (Frick, 1990, 1993; Leising et al., 2000; Powell et al., 2008). Brandt (2016) emphasized that the NALO benchmarks should be used to increase uniformity in any future K-12 agricultural literacy assessments. Therefore, guided by the NALO framework, the first purpose of this study was to develop an instrument to measure agricultural literacy in adults. The adult population identified were post high school or grade-12 completers who were enrolled in university courses. A second purpose of this study was to test the validity of the Judd-Murray Agricultural Literacy Instrument (JMALI). The overall objective of the project was to develop and validate an agricultural literacy assessment instrument, based on the NALOs, for students who have completed the 12^{th} grade (or equivalency) in the U.S.

Primarily, the instrument is a summative assessment for students approaching the completion, or post-completion of the 12th grade or equivalency. Secondarily, the instrument may be used as a formative assessment for 9- to 11th-grade students. For these students, JMALI can be used as a pre-assessment tool to gauge baselines of understanding, identify information gaps, and serve as an indicator of exposure regarding each of the five NALO themes. The NALO benchmarks serve as criterion reference points for critical understanding that are beneficial for young adults entering the workforce or post-secondary education. The design of the summative assessment for this age group will capture the agricultural literacy levels of adults of any age, but the questions specifically to address the knowledge obtained through K-12 education endeavors.

Assessing agricultural literacy levels of young adults between the ages of 17-early 20s assists researchers and educators in gaining imperative information about how adult attitudes, perceptions, and peer influences affect their choices related to food, environment, and agricultural policy. Future research may also be able to indicate how a lack of information in specific areas leads to apathy, misconceptions, or other negative societal outcomes related to poor agricultural literacy. “An individual’s age is one of the most common predictors of differences in attitudes and behaviors” (Pew Research Center, 2015, para. 2), age also denotes an individual’s place in the life cycle and their membership in a group of individuals born in a similar time. These latter components allow researchers to track groups of people and their formative experiences over time. The future impact of this assessment includes enabling organizations, educators, stakeholders, and researchers to determine the level of understanding, comprehension, and application of agricultural concepts by a generation of adults. The formative capacities of JMALI allow for the opportunity to shape future generations of adults by establishing data points for improving agricultural instruction, pedagogy, and efforts related to desired societal outcomes. Knowing what drives individual and generational differences strengthens our understanding of how public attitudes and perceptions of agriculture are shaped. A well-designed, valid, and reliable assessment tool is necessary to determine the agricultural literacy of the millennial generation. According to the Census Bureau, millennials are the largest living generation (Pew Research Center, 2015). Their influence on agricultural policy will be even greater than that of other previous and future generations. Agricultural stakeholders who recognize the magnitude of data-driven and analytical assessment will meet the needs of this generation and set the stage for the generations that succeed it. Therefore, to meet the demand for current and future diagnostic requirements, the goal of this research was to design an assessment tool that can unify the field by using contemporary contexts, well-rounded definitions, and standardized benchmarks. Furthermore, the scaled measures will allow for progressive measurement over time in both formative and summative evaluation.

Research Questions

This study addressed the following questions.

1. Does JMALI summatively measure the grade 12 benchmarks of agricultural literacy as defined by the National Agricultural Literacy Outcomes?
2. Is JMALI a valid and reliable measure of proficiency stages of agricultural literacy?
3. Is there a significant correlation between the amount of a participant's

agricultural instruction and their perceived level of agricultural literacy?

4. Is there a significant correlation between the perception of a participant's level of agricultural literacy and actual proficiency on JMALI?

Definition of Terms

The following terms and definitions are used throughout this study.

Agricultural Literacy is the ability of a person to understand and communicate the source and value of agriculture as it affects quality of life (Spielmaker et al., 2014).

Judd-Murray Agricultural Literacy Instrument (JMALI): the agricultural literacy instruments based primarily on grade-level indicators and proficiency-scale measures of the NALOs. The JMALI can be used to determine three distinct levels of proficiency (i.e., exposure, factual literacy, applicable proficiency) in post-K-12 adults through summative evaluation.

National Agricultural Literacy Outcomes (NALOs) represent a published agricultural literacy framework organized by five themes, by grade level benchmarks (K-12), and aligned with the national education standards (Spielmaker & Leising, 2013).

Limitations

Measuring agricultural literacy is complex. It requires individuals to integrate different types of knowledge. It cannot be expected that a singular assessment taken at one point in time could determine one's agricultural literacy. This research attempts to minimize the potential limitations by building a progressive instrument—using a model that shows a stage of progression toward agricultural literacy. The progressive nature allows for educators and researchers to acknowledge learning stages, rather than a singular answer that one is either agriculturally literate or not.

Limitations of the study also exist in the use of factor analysis to determine the validity of the questions. Factor analysis is ideal for measuring latent variables or items that cannot be directly measured. The factors that appear can only come from the answers to the questions asked of the study participants. The questions were directly associated with the NALOs. These factors were naturally correlated, not independent. Therefore, multicollinearity was a risk. Measures of covariance among the latent variables were analyzed, but confirmatory factor analysis (CFA) results should be treated with caution. Lastly, the preparation, development, and selection of good assessment questions is complicated. It was inevitable that some of the questions developed were poor and required modification or removal from the assessment. Therefore, using a discriminant analysis (DA) enabled determining whether significant differences existed among the learning stages. The use of DA defined the degree to which the instrument differentiated between the constructs.

Basic Assumptions

The NALO design ensures students reach the highest levels of agricultural literacy by the time they complete the 12^{th} grade. The JMALI assessment focuses on the themes and indicators relevant for 9^{th}- through 12^{th}-grade students to capture the agricultural literacy levels of an adult (post-high school or grade 12) population. It is assumed that students at Utah State University will have completed high school or grade-

12 education to be enrolled in higher education. Finally, the study made the JMALI assessment available to students via Qualtrics as an electronic survey. It was assumed that enrolled college students were capable of accessing an online survey and completing it correctly.

Significance of the Research

Any form of learning is reliant upon assessment to determine its authenticity. Feedback from evaluation is also essential for making program judgments about performance, funding, and quality assurance. A key component of an effective and modern educational organization is demonstrating and meeting, through data measurement, desired educational outcomes. The question, “are we teaching what we think we are teaching?” may be the difference between perception and performance. Consequently, the development and validation of the JMALI instrument provides the means for agricultural programs nationwide to assess the end of K-12 driven agricultural instruction.

There are agricultural education programs in all 50 states. Educators at state and local levels direct some agricultural programs. Many are run by nonprofit organizations, and a half-dozen dedicated volunteers operate a final few—but all are lacking valid and reliable evaluation tools (Brandt, 2016). The Food and Fiber Systems Literacy (FFSL; Leising, Igo, Heald, Hubert, & Yamamoto, 1998) instrument has been an important part of agricultural assessment, but it is outdated and not connected to the most current definition and benchmarks of literacy (Brandt, 2016). When combined with the research-based frameworks of the AITC and National Center for Agricultural Literacy (NCAL) logic model and NALOs, JMALI has the potential to assist educators and program administrators in identifying learning gaps, program deficiencies, funding priorities, and growth potential.

CHAPTER II

LITERATURE REVIEW

Despite the agricultural abundance and productivity of the U.S., there is a perpetual need for agricultural education and literacy efforts to ensure that citizens obtain the "ability to understand and communicate the source and value of agriculture as it affects our quality of life" (National Agriculture in the Classroom, 2014). Consequently, the National Agricultural Literacy Outcomes (NALOs), an agricultural literacy framework, were generated to integrate with the curriculum of the national education system to ensure that agriculture is incorporated throughout the K-12 structure. These benchmarks and indicators allow researchers to build upon the foundation of previously developed, and peer reviewed, agricultural literacy frameworks (Frick, 1993, 1990; Leising et al., 2000; Powell et al., 2008) and offer data that reflect a current cross-disciplinary approach to student knowledge and understanding. Researchers now agree it is critical to construct K-12 instrumentation using the NALO benchmarks as a uniform method of assessment (Brandt, 2016). The complex systems of agriculture, with numerous stakeholders and educators, require a way and means to assess student levels of factual literacy and determine how that understanding may extend into practical and applicable proficiencies.

For this study, the author reviewed the contemporary authoritative and scholarly literature on the importance of agricultural literacy, the seminal frameworks and vocabulary that have defined what it means to be agriculturally literate, and how literacy assessment is used to develop programs, evaluate curriculum, and move the needle toward a society that understands and values agriculture. The author also reviewed secondary research to provide a foundational base for this research. In this chapter, the author presents a review of agricultural literacy assessment both from the perspective of the examination of past frameworks and benchmarks and the need for a current literacy instrument based on NALO benchmarks.

Loss of Agricultural Literacy

America is a nation long recognized for its ability to provide an abundance of agricultural goods and services. The successes of the land and people afforded the population opportunities for continued growth, development, education, and prosperity. Today, “[less than] 2% of the population is directly involved in production agriculture” (American Farm Bureau Federation, 2018, para. 4). 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” (Arkansas Foundation for Agriculture, 2006, para. 1). A self-reported study showed 72% of surveyed American consumers said they “constantly thought about food production…but knew nothing or very little about farming or ranching” (U.S. Farmers & Ranchers Alliance [USFRA], 2011, para. 1), Bob Stallman, chairman of USFRA, acknowledged that, “While Americans think about food production regularly, they continue to have many questions about where food comes from, how it is raised, and if it is good for their health long term” (USFRA, 2011, para. 4).

The knowledge gap associated with agricultural illiteracy positively correlates with the development of negative stereotypes about agriculture and agricultural processes (Birkenholz, Harris, & Pry, 1994). Stereotypical understandings contribute to common misunderstandings and the increased valuation of "truthiness" or "fake news" within an industry that must rely upon the awareness and application of good science. "This, in turn, leads to the public's questioning of agricultural production methods, animal well-being in farm animal systems, the environmental impact of agriculture, the utilization efficiency of resources in agriculture, and the safety of the food supply" (Nordstrom, Wilson, Kelsey, Maretzki, & Pitts, 2000, p. 1). Our global society deserves a well-educated American public that bases decisions on scientific principles, which contributes to the success of a safe and affordable food system. The American food system remains the backbone of a global infrastructure attempting to feed over nine billion people by 2050 (U.S. Department of Agriculture, 2012). Moreover, the millennial generation, based simply upon its vast numbers (Fry, 2016), is set to become the largest population of new policy makers since before the Boomers. Agriculturally literate policy makers may have a greater capacity to create responsible regulation that supports our economic, societal, and environmental needs. The development of policy that supports these three areas can be viewed as sustainable policy; policy that supports and values the availability of natural resources for current and future generations of global citizens.

Another significant challenge pertains to the standard dictionary definition of agriculture. Merriam-Webster's online dictionary defines Agriculture, "The science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products." This is a definition difficult for today's average citizen to comprehend. For modern agriculturists, this definition lacks connection to a global economy and environment (Feenstra et al., 2016). When viewing from this perspective, in combination with educational pedagogy, it becomes clear that agriculture should not be learned as a definition to a singular object or theme. Comparatively, the definition of agricultural literacy also seeks to show that individuals should understand and have the ability to communicate the source and value of agriculture in daily life (National Agriculture in the Classroom, 2014). Therefore, agricultural education and literacy efforts must encompass both content and value knowledge.

Defining Agricultural Literacy

The development of the current agricultural literacy definition and educational outcomes has evolved. It began with the realization that the absence of agricultural literacy generated a national effort to improve the type and amount of agriculture-based education for youth and adults. In 1985, a study on agricultural education in secondary schools was initiated due to declining international profits and competitiveness of American agriculture (North Central Association of State Agricultural Experiment Station Directors (NCA-24), 1987). In a foundational move, the National Research Council (1988) established secondary agricultural education standards to address the needs of students and to ensure the future vitality of the nation's food and fiber systems. The committee recognized that Americans knew very little about agriculture and its social and economic significance and agriculture's connection to human health and environmental quality. They focused on reporting two main aspects of the study—agricultural literacy and vocational agriculture. The council's definition of agricultural literacy encompassed knowledge of "food and fiber production, processing, domestic and international marketing, and nutrition to make informed choices about diet and health" (National Research Council, 1988, p. 9). They envisioned that an agriculturally literate person would understand the food and fiber system, including its history and current economic, social, and environmental significance in America. The findings established the first initial step toward a modern definition of agricultural literacy.

Since then, organizations such as the American Farm Bureau Federation; 4-H clubs; universities; the U.S. Department of Agriculture (USDA); nonprofit organizations such as Food, Land and People; and state and national Agriculture in the Classroom (AITC) programs sought to build educational programs to improve agricultural literacy. Over time, both organizations and researchers scrutinized agricultural literacy efforts to increase learning and efficacy. In a key modification, Frick (1990) stated that the initial definition only provided a "rudimentary conceptualization of agricultural literacy" (p. 3). Through a survey development project, he refined the definition of agricultural literacy. The definition included language posing that "individuals possessing knowledge would be able to synthesize, and analyze, and communicate basic information about agriculture" (p. 52). The committee also determined eleven conceptual areas of importance: (1) agriculture's important relationship with the environment; (2) processing; (3) public policy; (4) relationships with natural resources; (5) production of animal products; (6) societal significance; (7) production of plant products; (8) economic impacts; (9)

marketing; (10) distribution; and (11) global significance.

Defining Agriculture is Conceptual

Frick’s (1990) modifications captured a conceptual understanding of agriculture that has continued to shape the exploration and comprehension of agricultural literacy. Teaching content and value are efficacious when agriculture is examined as a concept. Agriculture is a concept of all things grown worldwide. Its definition expands as one examines the influence agriculture has upon transportation, culture, tradition, housing, and climate—just to name a few key associations.

Concepts are used as mental representations in education. Educators use mental models to help learners develop and build existing schema. They are crucial to cognitive and psychological processes such as memory, learning and decision-making (Margolis & Laurence, 2014). Individuals who develop a conceptual picture of agriculture are better able to understand not only the role of agriculture, but the role persons play as daily consumers of agriculture (Frick, 1990).

So, whom or what represents a conceptual picture of agriculture? The AITC program shares with students the analogy of “The 5 Fs of Agriculture” (National Agricultural Literacy Curriculum Matrix, 2019"). The 5Fs are farms, food, fabric, forestry, and flowers. The 5Fs encompass everything associated with those anchoring words. Figure 1 is an example of how these five areas are conceptually connected to agriculture. Figure 2 is a conceptual expansion showing the connections for one food item to production, processing, and purchasing. The key to understanding “What is

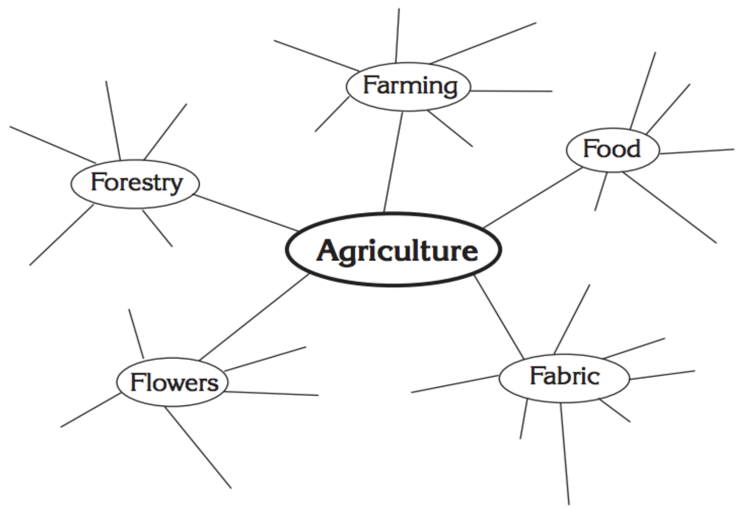

Figure 2. The 5Fs of Agriculture, a conceptual understanding from the National Agricultural Literacy Curriculum Matrix, 2019. Reprinted with permission.

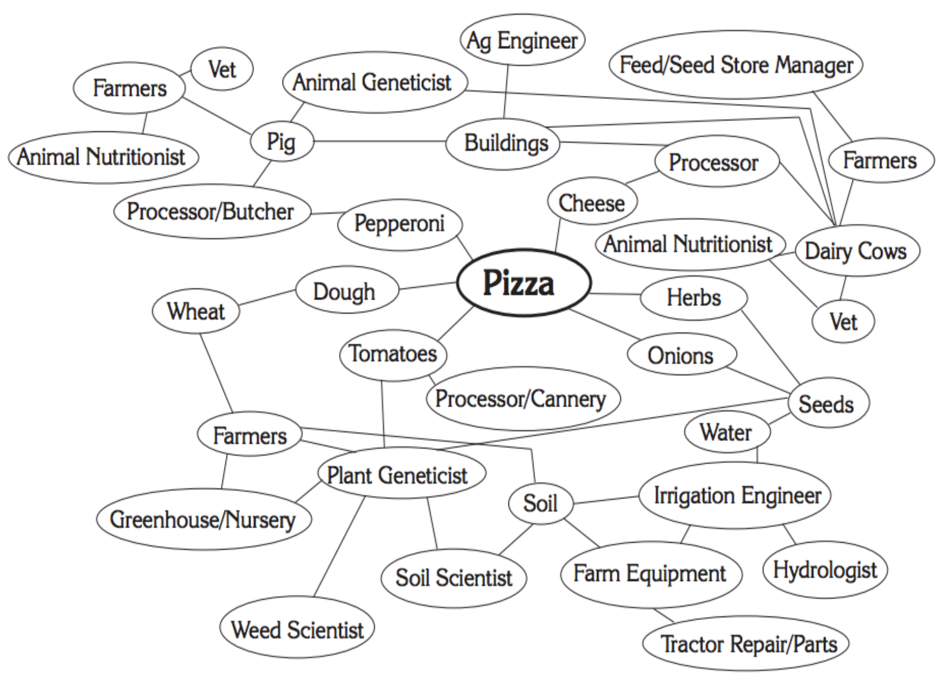

Figure 1. Using a single food item to show conceptual understanding of agriculture from the National Agricultural Literacy Curriculum Matrix, 2019, “My Farm Web.” Reprinted with permission (see Appendix G for all permission letters and guidelines for use).

agriculture?" lies in the fact that the term is a compilation of all five of those words and their accompanying expansions. Indeed, knowing about agriculture and coming to value its significance in everyday life, is more than knowing what a cow produces or the definition of production. In summary, Frick (1990) recognized that the sophistication of a modern-day civilization required a conceptual, well-rounded comprehension of how people are connected to agriculture and how agriculture is connected to all living and nonliving systems.

The definition for this research is associated with the work done by Spielmaker et al. (2014) and the creation of the NALLM. The NALLM was developed based on the priority needs of the National Research Agenda for Agricultural Education (Roberts, Harder, & Brashears, 2016), which included areas of scientific focus related to the demonstration of the impact of agricultural literacy efforts. To support the model, an agriculturally literate person was defined as "A person who understands and can communicate the source and value of agriculture as it affects our quality of life" (National Agriculture in the Classroom, 2014, para. 1). This definition incorporated the historical approach to viewing agriculture as a concept and used values to help broaden the definition. Additionally, there is a depth to the definition as it associates "quality of life" to satisfying our societal, economic, and personal needs. Finally, by incorporating both knowledge and communication skills it views literacy as composed of skills, abilities, factual knowledge, procedures, concepts, and metacognitive capacities.

Past Agricultural Literacy Assessment

Defining agricultural literacy is the first step for determining how to assess agricultural understanding. The second is building an assessment framework. Birkenholz et al. (1994), Boatner (2004), Leising and Zilbert (1994), and Nunnery (1996), were a few of the early developers of agricultural literacy assessment frameworks. They based their frameworks on Frick's (1990) definition and determined by expert panels and Delphi construction what students should know about agriculture.

Leising et al. (1998) developed the now seminal Food and Fiber Systems Literacy (FFSL) Framework. It outlined the literacy expectations for K-12 system graduates. The FFSL framework utilized progressive standards in five thematic areas of agriculture (1) understanding agriculture; (2) history, geography & culture; (3) science & environment; (4) business & economics; and (5) food, nutrition & Health. The theoretical framework established criterion benchmarks. They determined what students should understand about how food and fiber systems related to their daily life, and because the standards were grade-grouped into benchmarks it provided a means of progressively addressing agricultural literacy (Pense & Leising, 2004). Criterion-referenced assessments measure student performance against a fixed set of pre-determined criteria—what students should know and be able to do based on their grade level (Van der Linden, 1980).

Increasingly, case studies showed the FFSL framework standards were effective for assessing elementary students' knowledge about agriculture (Leising et al., 2000), which led to the development an instrument for assessing grades 9-12 literacy levels (Pense & Leising, 2004). However, despite literacy efforts in grades K-8, most school program completers were not agriculturally literate (Kovar & Ball, 2013). Since then, several other researchers have conducted agricultural literacy assessments using the FFSL framework and instrumentation (Colbath & Morrish, 2010; Crawford, 1998; Hubert, Frank, & Igo, 2000; Jones, 2013; Pense, Leising, Portillo, & Igo, 2005; Powell & Agnew, 2011). While some of these studies indicated there were areas of improved student engagement or greater awareness of agriculture (Crawford, 1998), others found agricultural literacy scores still significantly below average (students scoring < 50% on the instrument; Colbath & Morrish, 2010; Jones, 2013; Pense et al., 2005).

It is important to note that national and state Agriculture in the Classroom (AITC) programs have also used the FFSL curriculum framework, as well as other frameworks that support concepts related to agriculture, to determine literacy accomplishments (Pense et al., 2005). AITC programs are critically important state programs that seek to improve the understanding and appreciation of agriculture by integrating with K-12 core curriculum concepts. The AITC programs are readily recognized by agricultural educators and agricultural literacy proponents as one of the key platforms for providing curriculum, materials, resources, teacher training, and student research information (American Farm Bureau Federation, 2017).

Beyond FFSL instrumentation, numerous small-scale studies were conducted focused on a specific grade level, a single state, or population (Birkenholz et al., 1994; Hess & Trexler, 2011; Mabie, 1996; Meischen & Trexler, 2003; Terry, Herring, & Larke, 1992; Trexler, 2000). Most of these studies developed and used their own instrumentation based on relatively similar principles and definitions. These studies formulate some scope of the level of student achievement in agricultural literacy, but there are limitations for the generalization of this information across a wider population. The research from Birkenholz et al. (1994), Colbath and Morrish (2010), and Jones (2013) is particularly relevant for this project as it relates directly to the literacy levels of first-year college students, with Birkenholz using an instrument designed by Delphi model and based on Frick's (1990) definition. It can also be noted that Kovar and Ball (2013) conducted a synthesis of agricultural literacy research. They determined that while agricultural literacy programs were found to be successful in increasing literacy rates when used by teachers, volunteers, and programs, there remained a significant portion of studied populations that remained agriculturally illiterate.

Researchers also observed that although many programs, materials and resources were readily available to improve agricultural literacy of students and adults, there lacked a common thread in the materials (Terry et al., 1992). Grade-level benchmarks for assessments also had limitations, reported Trexler, Hess, and Hayes (2013), as they were often created by "best guesses" rather than systemic research into the proper development for children of different ages. Meischen and Trexler's (2003) findings conveyed the agricultural benchmarks developed by both agriculture and science educators had not been thoroughly tested for suitability to the age groups. Last, Jones (2013) among other researchers, acknowledge that the FFSL needed to be modernized to include current aspects of sustainable agriculture, alternative energy, climate change, and environmental literacy.

In summary, since the initial National Research Council (1988) report, several federal, state and local programs worked to improve agricultural literacy. Many of those efforts involved the development of assessment frameworks. Those frameworks were based on past definitions, some standardized benchmarks, and “best guess” efforts. The assessments yielded a wide array of results for varying populations. However, despite some success, research showed that the overall number of agriculturally literate students or adults remained low or very low (Kovar & Ball, 2013; Mercier, 2015). Unmistakably, there remains a need for continued assessment based on a current definition and standardized framework to provide consistency across programs and populations.

National Agricultural Literacy Outcomes (NALO) Framework

The development of current agricultural literacy benchmarks based on foundational principles of learning theory is of critical importance because it provides both a common language and facilitates greater continuity in purpose. Accordingly, deepening the understanding of agricultural literacy requires attention to two specific gaps. First, there is limited knowledge about what people, on a regional and national scale, understand and can communicate about agriculture. Second, although a multitude of programs and materials exist for agricultural literacy, there is an evident lack of consistency in how the level of individual and classroom literacy is determined (Brandt, 2016; Kovar & Ball, 2013). To address these gaps in student literacy and assessment consistency, using a framework is essential (Chalhoub-Deville, 1997).

The National Center for Agricultural Literacy (NCAL) relies upon the NALLM (Spielmaker et al., 2014) to determine program goals. The USDA-National Institute of

Food and Agriculture (NIFA) and the National AITC organization, established NCAL in 2015 to “change how the world thinks about agricultural systems related to STEM, their quality of life, and our environment” (NCAL, 2017, para. 2). Objectives include the development of evaluation instrumentation that can be used to assess the knowledge of diverse segments of population, assess attitudes and perceptions, and determine agricultural literacy program impacts. The program works closely with national and state AITC programs to increase teacher access to curriculum and resources. Agricultural literacy achievement of K-12 students is one of their primary goals. The educational resources recommended for agricultural literacy are identified in a Curriculum Matrix aiming to provide both educators and programs with curriculum that is consistent in standard, objective, and grade-level appropriateness.

The NALLM utilized by NCAL and AITC programs, employs the National Agricultural Literacy Outcomes (NALOs) as the framework for determining age-appropriate agricultural literacy benchmarks. The NALOs integrate with national education curriculum to provide for agricultural education to be incorporated into the K-12 structure. The NALO standards and indicators (see Appendix A) are based in relevant theory and peer-reviewed research (Frick, 1990, 1993; Leising et al., 2000; Powell et al., 2008). Brandt (2016) emphasized that the NALO benchmarks should be used to increase uniformity in any future K-12 agricultural literacy assessments.

The NALO Development Process

The NALO framework authors, an organized panel of experts, were composed of practicing K-12 educators, the National AITC organization, the agricultural education specialist from the U.S. Department of Education, and the National Program Leader at the U.S. Department of Agriculture. Throughout the development of the NALOs, the panel recognized the importance of creating a framework, including the most current research on both agricultural literacy and national educational standards (Spielmaker et al., 2014). Thus, the NALOs operate by using the national grade level benchmarks (K-12) and national educational standards for science, social studies, and health, organized through the lens of agricultural literacy. Figure 3 illustrates how the national education standards for science, social studies, and health provide the cornerstones for the NALO

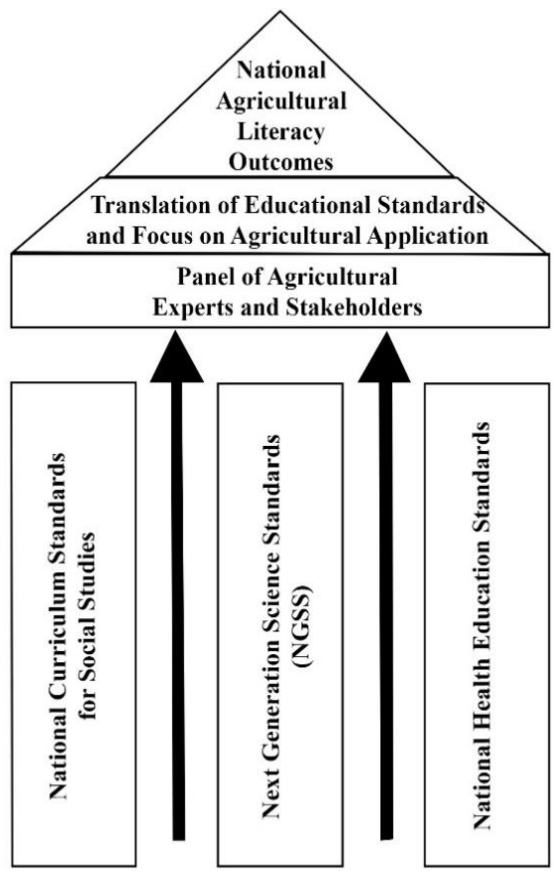

Figure 3. NALO development model. Describes a modified Delphi model of development based on national education standards, teams of experts, and agricultural application (Longhurst, Judd-Murray, Coster, & Spielmaker, 2019).

benchmarks; the NALO framework rests upon the translation of those standards by agricultural experts to incorporate the lens of agricultural literacy and education.

The NALO development team (Spielmaker et al., 2014) used a modified Delphi method to ensure the benchmarks met the definition of agricultural literacy. They modeled the development process after the conceptual model used to create national education standards (Next Generation Science Standards [NGSS] Lead States, 2013). Figure 4 shows the conceptual process model used to develop the benchmark standards and the development timeline. The NALOs reflected prior research (Leising et al., 1998)

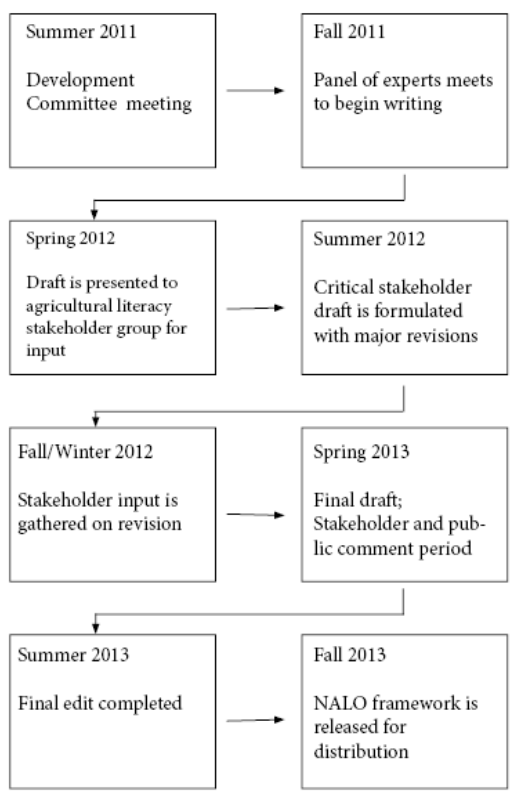

Figure 4. Conceptual model for NALO development. The model development timeline, showcasing the modified Delphi Method. Adapted from meeting minutes taken by Dr. Debra Spielmaker, 2013. Printed with permission.

by using five cross-disciplinary themes: (1) agriculture and the environment; (2) plants and animals for food, fiber & energy; (3) food, health, and lifestyle; (4) science, technology, engineering & math; (5) culture, society, economy & geography. The iterative design of the framework allowed for dynamic, ongoing, and evolving effort, allowing the benchmarks to continue to define and provide structure for future agricultural literacy efforts.

NALO Instrument Validity

If the NALOs are to be used as criterion benchmarks for future assessment, it is necessary to identify the validation process used in their construction. A Delphi model was used to develop the NALOs with a three-level rotation, measured by the stability of subjects' responses. The Delphi is a good choice for designing agricultural literacy assessment because of the complexity of the content. Purely model-driven statistical options are neither available in past literature, or a practical option moving forward. Delphi items, based on existing literature, lead to outcomes that match the standards, are appropriate for the grade level and context, and are consistent in tone and scope. It also allows space for assessment items that may not achieve consensus by the group. When this happens, an item may be discarded or saved for later revision.

The Delphi technique is a widely used and accepted method for gathering data from experts in their domain. The process is known to be well-suited for building assessments, policy, or organizational resources. The Delphi, in contrast to other forms of consensus building, "employs multiple iterations designed to develop the consensus of opinion" (Hsu & Sandford, 2007, p. 2). The iterative process of the Delphi allows for experts to provide initial feedback, reassess their initial judgments, and modify statements or reviews from other panel members. These characteristics are designed to offset the shortcomings of collecting group opinions and ideas, such as eliminating noise, feeling pressure to conform, and the influence of dominant perspectives (Dalkey, Rourke, & Lewis, 1972). A Delphi is conducted by selecting groups of experts. The experts follow the instructions to either comment on or develop content for anonymous review by the group. The group continues to refine and review the submitted content until a consensus is reached that meets the original goal of the panel, and the needs, desires, or perspectives of the experts. Theoretically, a Delphi process can be continued between panels indefinitely, but a synthesis of research indicates that "three iterations are sufficient to collect the needed information and to reach a consensus in most cases" (Hsu & Sandford, 2007, p. 2). Determining agreement on an outcome can be subject to interpretation, such as if a majority of votes is obtained, or by ranking items rated on a Likert-type scale. However, Scheibe, Skutsch, and Schofer (1975) suggest that a more reliable alternative is to measure the stability of subjects' responses in successive iterations or the stability of group opinion.

Delphi selection is the most important part of the process because it determines the quality of the items (Jacobs, 1996; Judd, 1972; Taylor & Judd, 1989). Panel members should be selected on their consistent ability to demonstrate proficiency in the content or contextual domain of the project. Generally, specialists, professional staff members, top decision makers, and positional leaders should be nominated for participation in a Delphi panel. These types of individuals are invested in the work as stakeholders, which increases their interest in producing high-quality results. Ultimately, panel selection is vital because content validity is achieved by properly defining the domain area of the assessment, and selecting experts in the knowledge area (Okoli & Pawlowski, 2004; Winkler & Poses, 2004). Goodman (1987) echoes the literature presented by adding that if panel members' knowledge is illustrative of the area of content and people are known as "informed individuals, the content validity can be accepted" (p. 731). Furthermore, Messick (1993) and Sireci (1998) state that content validation also adds verification and key mechanisms of construct validity. Clearly, the use of experts does not create new knowledge, but rather uses the collective wisdom of the panels to access the best available data and provide a measure of content and construct validity.

NALO Summary

The National Center for Agricultural Literacy relies upon NALOs for determining agricultural literacy benchmarks. The NALOs were constructed to serve as a tool of assessment unification for agricultural literacy stakeholders. The development framework consisted of past literature, national education standards, current definitions, and the use of a Delphi method to ensure content and construct validity. NALOs consist of five benchmark themes: (1) agriculture and the environment; (2) plants and animals for food, fiber & energy; (3) food, health, and lifestyle; (4) science, technology, engineering & math; (5) culture, society, economy & geography. Along with the themes, indicators are also included to illustrate specific alignment to grade-groupings and national education standards. Past literature indicates that NALOs should be used as benchmarks for future assessment research (Brandt, 2016; Longhurst & Judd-Murray, 2019).

Building the JMALI Assessment

Developing a new assessment begins with a determination of *What must students know, or be able to do with the information they have learned to be proficient in the NALO standards?* A student who is proficient in agriculture has a knowledge of the terms, knowledge of facts, knowledge of rules and principles, knowledge of processes and procedures, the ability to make translations (or to express the information in new ways), the ability to make applications, and skills in analyzing and synthesizing the benchmark material (Guskey, 2005). In this context, the NALOs serve as both a curriculum framework and a tool for constructing a summative assessment because they specify the knowledge and skills to be acquired and are related to the goals for instructional processes and assessment techniques (National Forum on Education Statistics, 2005). They provide the information necessary to assess literacy. The *mastery* of literacy is moving from simply reading to learning to doing—or using a guide to accomplish specific goals (Chall & Read, 1967). Building efficient literacy skills requires direct knowledge and skill instruction, as well as repetitive practice to build fluency (Bransford, Brown, & Cocking, 1999; Curtis & Kruidenier, 2005). The NALO standards (or themes) are goals for what students should learn and teachers should teach. They represent the broad vision for learning. The performance indicators help emphasize the specifics of student performance…the actions and behaviors required to meet [national education standards]" (Sanders & Kearney, 2008).

Summative Evaluation with Proficiency Scale Results

Generally, summative assessments are associated with end-of-level or standardized testing to determine what students do or do not know. They determine what a student knows at a specific point in time, relative to benchmarks or standards of information. The greatest limitation of some standardized testing is that students receive a score related to a pass or fail. A failing student score conveys the message that the student "knows nothing," or does not have a basic understanding. Rather, the National Research Council (2009) suggests assessment should determine where a student is along a sequence of progressively more "scientific" understandings that includes more applications of practices and cross-cutting concepts.

Based on this literature, JMALI seeks to be a summative evaluation, relying upon a "proficiency" reporting scale because it finds what a student can do within levels or stages of development, rather than producing a standardized score. The JMALI model is adapted after Programme for International Student Assessment (PISA) that "assesses students and used the outcomes of that assessment to produce estimates of students' proficiency in relation to the skills and knowledge being assessed in each domain" (OECD: PISA, 2016, p. 276). The PISA framework is well defined. For each domain, the skills are determined, each ranging from very low levels of proficiency to very high levels. The easiest PISA items tend to focus on content knowledge and relation to scientific phenomenon. The most difficult items draw on interrelated ideas and concepts that require an understanding of events, consequence, and processes (OECD: PISA, 2016, p. 282). A student's ability level determines their place on the proficiency scale, ranked by how frequently they answer questions correctly that are more or less difficult in either knowledge or application. Participants who complete tasks at a specific level would be *more* likely to complete tasks at or below a similar skill or knowledge level. They are increasingly *less* likely to complete tasks above their skill or knowledge level. The central dogma of PISA assessment is this: If a student's proficiency level exceeds the item's difficulty, the probability that the student can successfully complete that item is high, and if the student's proficiency is lower than what is required by the item, the probability for student success on that item is low (OECD: PISA, 2016, p. 279). Figure 5 illustrates the relationship between the assessment items and student proficiency.

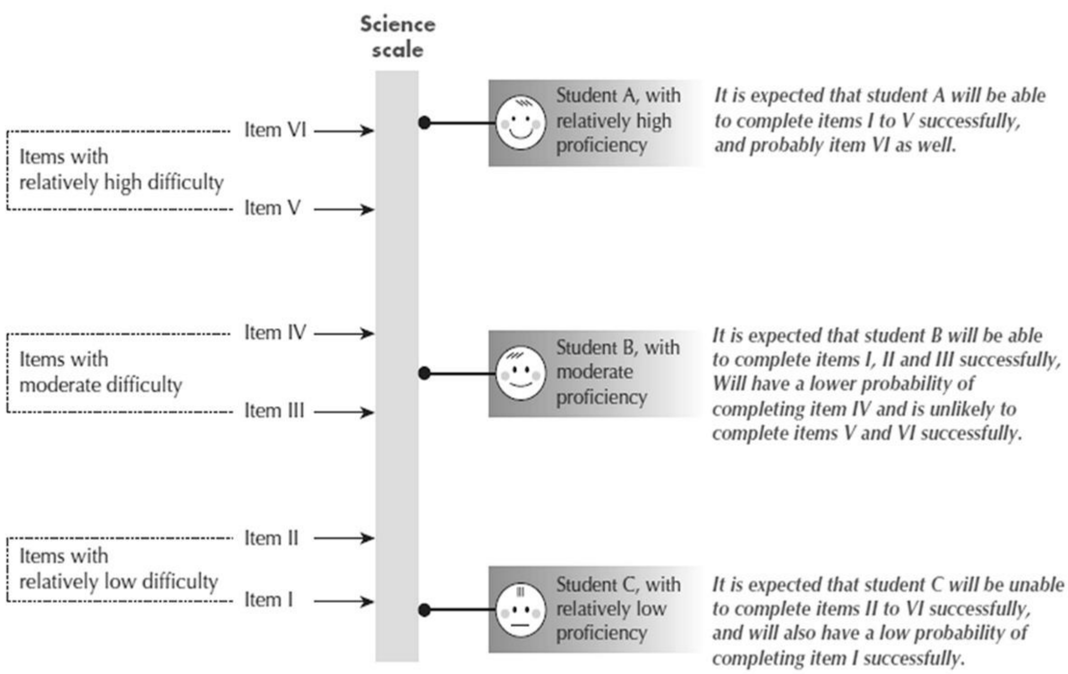

Figure 5. Simplified relationship between items and students on a proficiency scale from PISA 2015: Technical Report, Scaled Proficiency.

The contextual relevance of this adapted model is a critical part of determining proficiency for JMALI, as these are the components that relate to application and societal values. They are also central components of the NALO benchmarks themselves, which were developed in an overlapping and interrelated fashion. Modeled after the Next Generation Science Standards (NGSS; 2013), the NALOs appear as sets of performance expectations that relate to a core theme. As students move through the curriculum from 9^{th} through 12^{th} grade, the content transfers from everyday knowledge to more sophisticated content engaging students in the complexities of a global food system. The benchmarks identify content appropriate for grade levels and indicator statements that offer additional detail and examples.

The grand challenge of designing valid and reliable agricultural literacy assessments hinges on the integration of practices, using research-based assessment, and focusing on core principles that define a discipline (National Research Council, 2009). Conclusively, the adapted PISA model allows for two important JMALI elements: 1) for the development of question items that represent an increase in skill and ability across all five NALO themes, and 2) for the evaluation of students on a scale more representative of an understanding that is moving toward progression, rather than identifying a singular point in time.

Supporting Literature for the Proficiency Scale Model

Historically, there is a precedent for using proficiency scale modeling for agricultural education and assessment. Pense et al. (2005) first showed that the FFSL framework addressed multiple concepts of Dewey's Experiential Learning Theory (1938) by providing students with multiple opportunities for the transfer of information between grade-levels and the overlap of complementary concepts. The NALOs have incorporated grade-grouping benchmarks to progressively address literacy standards (see Appendix A). The grade-grouped approach and alignment with national educational standards crafts a mechanism for developing what Dewey (1938) referenced as, building new experience on past experience and what D. A. Kolb (1984) referenced as the process of creating knowledge. Dewey "developed the concept that students of all ages are not *tabula rasa*, that is they enter the classroom with knowledge from their prior experiences, and can draw on that knowledge for their metacognition" (Gross & Rutland, 2017, p. 3). Each NALO indicator builds on the information from previous grade levels to give students a progressive learning process.

Other agricultural researchers indicated the significance of measuring learning by scale or stages. According to Joplin (1981), the first stage of learning is the focus or

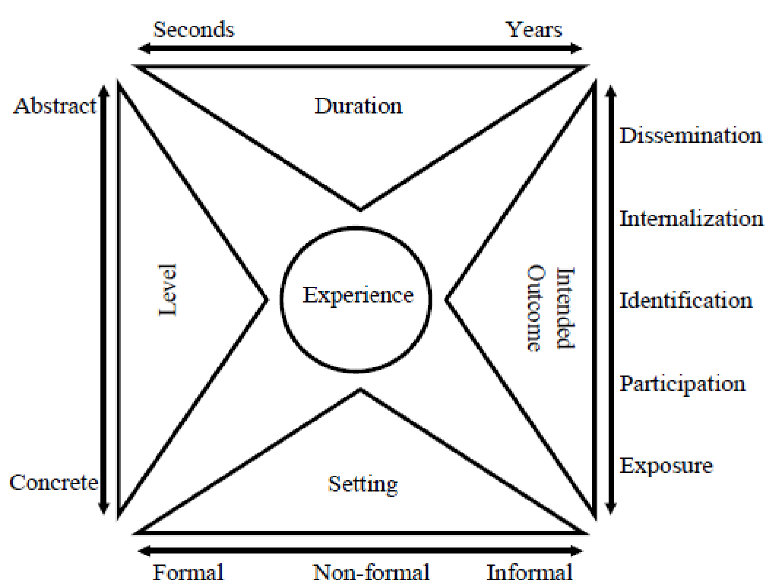

Figure 6. Model of experiential learning contexts. Reprinted with permission from *Journal of Agricultural Education* (Boone, 2018)

exposure level, a level of learning that captures the student's attention. The second stage should challenge students with process skills such as ordering, sorting, analyzing, and moving knowledge. The final stages involve "debriefing" where students recognize, articulate, and evaluate what they have learned. Joplin's model expresses that students do not enter the learning model as a "blank slate." Similarly, Roberts' (2006) model shows students learn in stages, through formal and nonformal experiences in both abstract and concrete ways. The intended outcomes (shown on the right side of Figure 6) graduate in stages, like Joplin's adaption. The lowest or beginning levels of learning are called exposure, through the highest where students communicate, articulate and display proficiency in understanding.

These past frameworks shaped the development of JMALI. Especially, at the post-secondary education level, one cannot assume adults "do not know anything about agriculture." Consequently, adult assessment scores should reflect a spectrum of exposure to proficiency. These historical adaptations are significant because JMALI uses these interpretations of learning theory to formulate questions that seek to determine *stages* of agricultural literacy proficiency. To accomplish this, questions for each of the five themes were written to identify student knowledge at the exposure level, a factual literacy level, and an applicable proficiency level. Because the NALO standards are grade-grouped, JMALI items were written for best understanding at the highest grade level within that group (i.e., written for understanding at grade-12). Students who have not completed high school (or equivalency) may still use the assessment, but it is anticipated they may only be able to answer questions written at or below the exposure level. Hence, a student who can only answer questions correctly at the exposure level would have the most limited understanding of the agricultural literacy standard; a student who can answer questions at the factual literacy level would display understanding related to content knowledge or the challenge skills Joplin (1981) identified; and a student who can answer questions at the applicable proficiency level would display agricultural literacy at a level where they could communicate understanding and the value of the standard—the highest performance level of comprehension (Roberts, 2006). Noted in this theoretical framework, is the discernment that there is not a “zero exposure” level. Students who cannot answer any questions on the instrument are placed on the learning continuum at an exposure level. Joplin and Roberts’ models aligned with Dewey’s (1938) theory that experiential learning is an ongoing and continual process and further, the notion of learning as it relates to *tabula rasa* has been shown to be short-sighted (Collins, Greeno, & Resnick, 2001). The framework presented here supports the analysis that a continuum of learning exists and that all learners are somewhere on that scale.

Last, a proficiency scale model is supported by previous literature because of the lack of baseline data. Kovar and Ball (2013) wrote that “baseline data are needed to ascertain what students [and adults] are learning about agriculture to provide key indicators of progress being made toward the achievement of program goals” (p. 175). They also detailed that research reaching beyond elementary-aged teachers and students is limited and that an expansion to high school and adult audiences would be a better indicator of those making impactful decisions. A proficiency-scaled target reflects growth if used formatively, or a minimum to maximum expectations if used for summation. For this reason, proficiency models do not require a baseline preassessment or trend data to be useful. Prodigiously vital information, because it eliminates a huge burden for stakeholders who must "begin where they are." The JMALI model offers an assessment that targets critical weaknesses in previous measures, while providing information that begins the process of longitudinal data collection. Figure 7 illustrates the theoretical framework for the assessment.

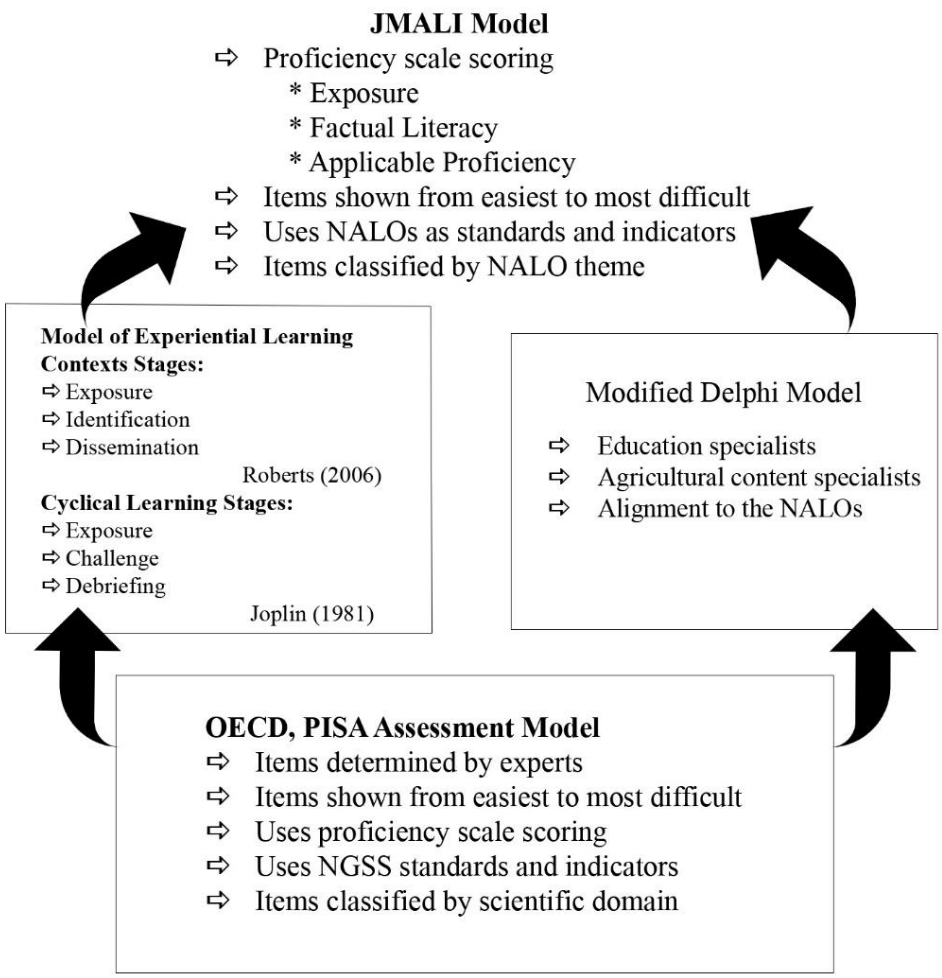

Figure 7. Theoretical framework for the JMALI. Adapted from Longhurst et al., 2019.

Summary

A global society benefits from a populace that understands and can communicate the value of agriculture. It is evident many people are agriculturally illiterate and do not understand agricultural concepts. Despite agricultural literacy programs, there is still a need to improve the assessment tools available. Previous research showed agricultural literacy assessments provided critical information about what students and adults know about agriculture. Foundational criteria and frameworks led to the development of the NALLM and NALOs. The NALO benchmarks were foundational for development of an assessment instrument that can adequately measure student and adult agricultural literacy levels.

More importantly, the multidisciplinary approach of the benchmark themes allows for the evolution of curriculum, content, and assessment of the NALOs to be meaningful in numerous ways. “This type of design assists educators with the opportunity to contextualize content for multidisciplinary integration and provides for an interdisciplinary approach to teaching and learning” (National Agriculture in the Classroom, 2014, para. 6). The cross-cutting techniques also provide a continuum for transdisciplinary knowledge application to solve real-world problems (Vasquez, Sneider, & Comer, 2013). The iterative design of the NALOs allows for a dynamic, ongoing, and evolving effort that will ensure that the benchmarks continue to define and provide structure for future agricultural literacy efforts.

Finally, the JMALI model was constructed using the NALOs and criterion-reference benchmarks to create standardized uniformity for all stakeholders. The framework was based on the NALOs, past literature, and modified Delphi methods to offer summative results determined on a proficiency scale. Furthermore, the progressive design shows agricultural literacy is not something you “do or do not have.” It interprets the evolution of learning through stages of comprehension. The literature concludes a theoretical framework based upon progressive learning is most suitable for grasping and transforming information (Dewey, 1938; D. A. Kolb, 1984; Lewin, 1951; Piaget & Cook, 1952). Ultimately, participants displaying proficiency are most prepared to build upon existing knowledge without gaps in understanding or ability (Bransford et al., 1999; Curtis & Kruidenier, 2005).

CHAPTER III

METHODOLOGY

This chapter discusses the methodology for validating the JMALI. It details the research design, participants (sample), instrumentation, data collection, plan for validation, and data analysis procedures. The research questions are reviewed below.

1. Does JMALI summatively measure the grade 12 benchmarks of agricultural literacy as defined by the National Agricultural Literacy Outcomes?
2. Is JMALI a valid and reliable measure of proficiency stages of agricultural literacy?
3. Is there a significant correlation between the amount of a participant's agricultural instruction and their perceived level of agricultural literacy?
4. Is there a significant correlation between the perception of a participant's level of agricultural literacy and actual proficiency on JMALI?

Research Design

There are two problems emphasized in the focus area of this study. The first is the literature showed a lack of consistency regarding what criterion and constructs determined literacy levels. The second is that while validated instruments have been developed in the past, they are outdated and limited in scope and definition for current need. To attend to the problems identified and continue with the purpose of this research, the researcher has presented four questions. Those questions were answered in three design phases to address the intended outcomes of the study. The three phases also address components of validity. The researcher attempted to survey approximately 600 young adults enrolled at Utah State University and utilized multivariate statistics to evaluate the validity of this instrument. For these reasons, the scope and focus of this research is quantitative.

Development and Validation of the JMALI

JMALI is an agricultural literacy instrument that attempts to measure an individual's proficiency stage (i.e., exposure, factual literacy, and applicable proficiency) by using an adaptation of the PISA model (OECD: PISA, 2016) and the NALO benchmarks as criterion measures. The NALOs were developed based on past literature, research-based techniques, and current educational standards (Spielmaker et al., 2014). The NALOs (see Appendix A) represent the domain of interest for the study. There are five topic areas or themes (1) agriculture and the environment; (2) plants and animals for food, fiber and energy; (3) food, health, & lifestyle; (4) STEM (science, technology, engineering and math); and (5) culture, society, economy, and geography. The NALOs have been organized by grade level groupings; this study focused on the 9th- through 12th-grade grouping. The overlapping nature of the themes as they move from one grade level to the next, allows for students to learn in a constructivist manner. It also supports assessment that evaluates progress on a proficiency scale. For this reason, JMALI is both a formative and summative assessment. Primarily, it serves as a summative assessment for adults who completed the 12th grade or an equivalent. The summative evaluation will allow agricultural education and literacy stakeholders to determine the efficacy NALO-based curriculum, teacher training, classroom pedagogy, and field experiences. As a formative assessment it determines a baseline of achievement or growth potential, for 9th-

through 12th-grade students.

The conceptual framework is based on research that validated a K-5 grade agricultural literacy assessment (Longhurst, Judd-Murray, Coster, & Spielmaker, 2019). The K-5 study items were developed using the NALO benchmarks for criterion reference, Delphi methods for validation, and PISA-type proficiency scoring. The instrument was validated using second- and fifth-grade grade students (N= 800) in seven states, in four regions of the U.S., namely Maryland, Pennsylvania, North Carolina, Florida, New Mexico, Colorado, Wisconsin, and Nebraska. Longhurst et al. showed this framework is effective for determining valid instrumentation in agricultural literacy.

Comparatively, this research surveyed a single university population, rather than a multi-state population, but the final instrument can be validated both regionally and nationally in future research. Comparatively, it also differs in the form of administration. The elementary students were surveyed using a paper and pencil instrument. Qualtrics analytics is a better mode of administration for adults because of the ease of use for both researchers and study participants. It was assumed by the researcher that adults who were enrolled in university courses would be able to use the electronic survey without training or intervention.

Research Phases

The following three phases present the path in validating JMALI. Phase one describes the construction and conceptual framework of the instrument and subject selection. Phase two addresses the administration of the instrument. Phase three presents how criterion, content, and construct validity were analyzed. The three phases are illustrated in Figure 8.

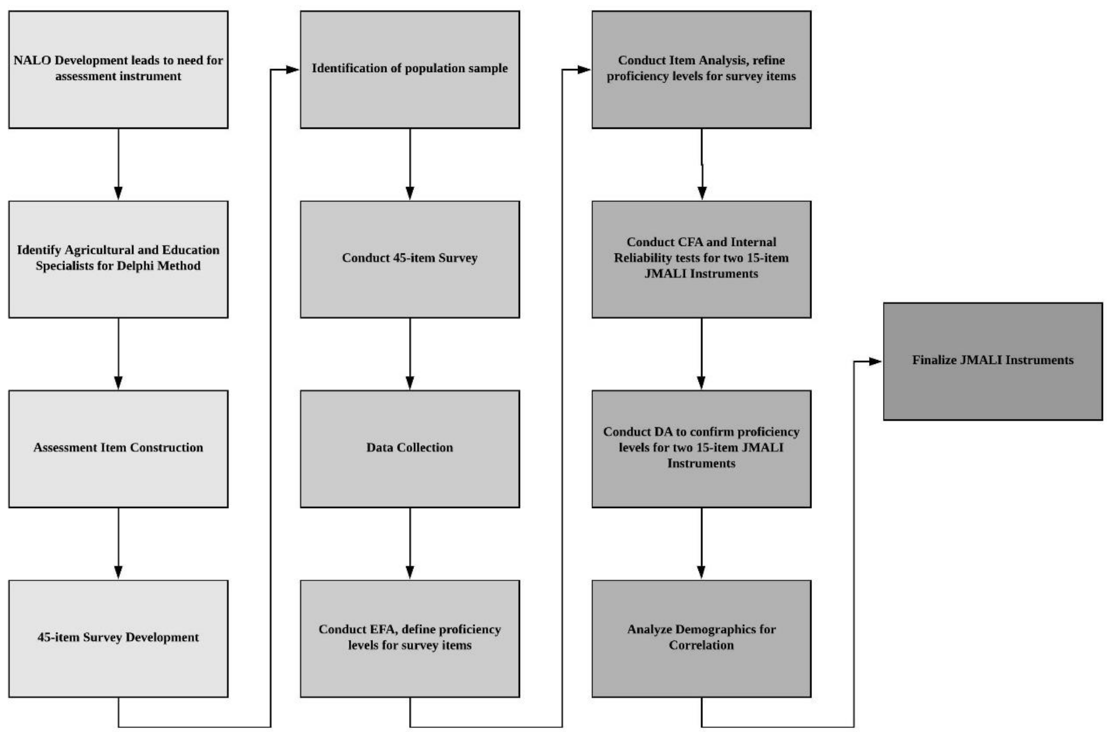

Figure 8. Methodological flow chart for JMALI.

Phase One: Instrument Construction

In phase one of the development of the JMALI, the researchers formed two expert committee panels and used a Delphi method, like the models used to develop the K-5 instrument and the NALO benchmarks, to construct and refine the instrument questions. The first panel consisted of teaching and instruction specialists, individuals who have direct expertise in high school and post-secondary education. The teaching experts were selected from multiple states and regions of the U.S., to best reflect diversity in the type and scope of educational expertise. The teaching panel was determined through nomination by the primary researcher and confirmed by dissertation committee members and leading stakeholders. Nominations were determined by examining the individual teaching achievements, advanced degrees or teaching certifications, and commitment to instructional excellence. These specialists performed the role of determining content and construct validity for instrument items as they related to proficiency stages, benchmark understanding, and item construction.

During the spring of 2018, the group of educators received instruction on the conceptual and theoretical frameworks and the domain requirements of the 9-12 level NALOs. These specialists were coached to focus the question development on meeting the NALO benchmarks as the primary objective. The teaching specialists were instructed to only use NALO indicators as a guide for determining how the content is approached via the public national school system. Teaching specialists received instruction before creating items via video presentation and video conferencing. Each were tasked with creating 3-4 questions in each learning stage (i.e., exposure, factual literacy, and applicable proficiency) for each NALO theme. The total number of constructed questions from the teaching panel was 49. The first-round questions were then reviewed and ranked by a second panel of agricultural experts.

The agricultural expert panel consisted of five content specialists. These individuals were stakeholders who were well-informed in agricultural content, scientific understanding, and modern agricultural applications. Many of the agricultural specialists had advanced degrees in agricultural education, agricultural or scientific policy, or agribusiness. Each committee member was selected for their individual contribution, knowledge of, and significant participation as a current stakeholder in agricultural literacy. They reviewed the 49 items for agricultural application, scientific precision, policy correctness, and direct alignment to the corresponding NALO theme. Agricultural specialists received the same instruction via video presentations as the teaching experts to gain understanding regarding how the items were developed. They also received instruction to review the items for agricultural accuracy, content, and direct relation to the NALO theme for which they were developed. Experts used a spreadsheet format to mark a rubric to accept, reject, or rewrite for each question. Both panels of experts ranked the questions based on the NALO requirements and their expertise. Agricultural specialists were required to use specific notation for question rejection and detail necessary revisions to represent agricultural perspectives or content. The anonymous remarks and rankings made by the panels were collected, refined, and redistributed to the teaching panel. The teaching specialists reviewed the remarks from the agricultural specialists and made the first round of revisions. These questions were revised by the teaching experts and resubmitted to the agricultural specialists. Following this stage of development, the questions were again ranked by the teaching specialists. The best questions from each theme, and for each proficiency stage were ranked 1 (strongest question) through 8 (weakest question). The rankings allowed for the strongest questions in each proficiency stage, for each theme to be identified. Only the highest-ranking questions were submitted back to the agricultural specialists for additional review where they were ranked from strongest to the weakest. The revision and ranking processes of the Delphi continued until the questions met the requirements of the researcher and both expert committees agreed on the strongest instrument items. The final iteration required that the panels identify the single best question in each proficiency stage, for each of the five NALO themes. Items that did not meet the expectations of either expert panel (ranked too low) were either discarded or saved for future revisions in subsequent research. All Delphi correspondence between panel members was conducted via email, by phone, and interactive online documentation. Additionally, minor revisions to the instrument were made by the researcher and the research committee to reflect best assessment practices.

The minimum number of questions required for JMALI is fifteen; one question per learning stage for each of the five themes. For example, in Theme 1 (Agriculture and the Environment) three questions are required in the final instrument; one question for each of the three learning stages (i.e., exposure, factual literacy, and applicable proficiency). The panels of experts identified and refined 45 questions for the student survey. It was clearly beneficial to analyze more questions to increase the chances of getting the best questions aligned for the final version. However, it was determined by the research committee that the maximum number of NALO-content questions should not exceed 45 because the online survey would also include an additional 12 questions (See Appendix B). Those additional 12 demographic questions were associated with obtaining consent (two questions) and demographic collection (10 questions). It was determined approximately 45 questions would be the maximum number that could successfully be answered in a 20-minute timeframe by participants. An extended number of questions was expected to increase participant fatigue, the difficulty of obtaining course instructor consent, and a lack of participant willingness to complete the full survey. The limitations on the number of questions were placed to limit some of the negative effects.

Phase Two: Data Collection

Participants. The target research population was 600 (N= 600) college students (age 18-23) from Utah State University, Logan, Utah. Students were identified via convenience sample by participation through their enrollment in several courses offered during the fall 2018 semester. The courses included (1) Science, Technology, and Modern Society (ASTE 3440), (2) Food Matters, Honors section (ASTE 2900), (3) The Science and Application of Human Nutrition (NDFS 1020), and (4) Integrated Life Science (USU 1350). Students were not identified for personal information or for scoring the instrument. Any student who accessed the Qualtrics survey received a small amount of extra credit from their course instructor.

The study team consisted of six teaching and five agricultural specialists who collaborated with researchers in item construction. University course instructors were not involved in the research either as participants or as members of the study team. Their participation was voluntary, and they were not deemed to be significant stakeholders in agricultural literacy or research promotion. They were asked for verbal consent to distribute the link to their students via university email and course announcements.

Due to the use of factor analysis for validation, the study requires factor loadings that can be classified based on their magnitude. To achieve a factor loading of .55 (significant magnitude), with a power of .80, a sample size of 100 participants is needed. General recommendations for a minimum sample size in factor analysis were stated by Comrey and Lee (1992) who recommended the Rule of 500. They estimated that samples of 500 or more were very good or excellent. MacCallum, Widaman, Preacher, and Hong (2001) reviewed their recommendations and determined that the minimum level of *N* was dependent upon (1) communality of the variables; (2) degree of overdetermination of the factor; (3) size of the loading; and (4) model fit (*f*). Therefore, these sample estimations account for a conservative measure of reviewed literature and are based upon what can be reasonably obtained within the given the constraints of this research.

Due to the design of the NALOs, and their reliance upon U.S. national education standards in science, social studies, and health, it was critical for stakeholders that the instrument was administered in the U.S. Other sample size requirements for ANOVA, regression, correlation, and Goodness-of-Fit range between 30-60 participants (determined by G*Power analysis). The larger sample sizes for these secondary analyses will give greater power to the results. Priority for sample size and regional location were determined by the factor analysis requirements due to its importance within the study.

Survey administration. The 45-Delphi-constructed questions and 12-consent and demographic questions were finalized and placed in a Qualtrics survey format. The questions were constructed in a variety of styles, including multiple choice, true/false, matching components, and graphic interpretation. Furthermore, the questions were marked for researcher identification of the NALO theme and the proficiency stage. For example, an item marked *1.12.E.2* could be identified by the researchers as an item in NALO Theme 1, grade 12, exposure level, question number 2. Figure 9 shows examples of the question types from the survey and the corresponding identification numbers (see the full survey, Appendix D).

Determine if the statement is true or false: *There are few incentives for agriculturists to protect the environment and natural resources. 1.12.E.3*

- ☐ The statement is true
- ☐ The statement is false

Select all the factors that affect food choices for people. *2.12.L.3*

- ☐ Cost
- ☐ Culture
- ☐ Convenience
- ☐ Access and/or availability

Select all the food labels that indicate the style of production used on the farm that produced the item. *3.12.P.3*

Figure 9. Examples of the types of items (45 questions) presented in the JMALI Student Assessment 2018, including the identification numbers. Full assessment in Appendix D

In August of 2018, several professors, course instructors, and adjunct faculty members were identified and contacted by either email or in face-to-face meetings to determine their willingness to have their students participate in the assessment. The courses were selected because of the number of first-year students frequently enrolled and the convenience of working with instructors who were familiar with the research team. Course instructors were encouraged by the researcher to offer a small amount of extra credit to the students for their voluntary participation. The researcher and research committee members extended face-to-face invitations to the students, prior to the opening of the survey, in each of the pre-determined courses. Students were asked for their consent to participate in the assessment in the first statement of the Qualtrics survey. Students who did not consent, or who self-reported that they were not between the ages of 18-23 years old did not have access to further survey questions. The student survey was conducted for three weeks in September of 2018. During this period, students, on their own time, accessed the survey via a link directly emailed to them through their university email account. The surveys were conducted in Qualtrics but monitored by the privacy system SONA at Utah State University. The use of SONA to protect student identities is required by the Internal Review Board (IRB) for research project approval. Two reminder emails were sent to students on weekly intervals through their university course email to encourage students to participate. The survey was closed to respondents on October 5, 2018.

Phase Three: Instrument Validation

The researcher analyzed the instrument results for validity using Delphi model construction, factor analysis and reliability measures. The quantitative analysis included: exploratory factor analysis (EFA), confirmatory factor analysis (CFA), item analysis, discriminant analysis (DA), and estimates of reliability (internal consistency) among the test items. Results determined revisions to, or removal of items from the final instruments. The final two instruments each consist of 15 questions. There are three questions for each of the five NALO themes, with each of those three questions representing a proficiency level (i.e., exposure, factual literacy, and applicable proficiency). The Delphi model determined the items best suited for the final instrument based on how those questions connected to the NALO themes. Exploratory factor and item analyses allowed the researchers to determine if discriminating proficiency stages could be identified for each survey item. Confirmatory factor and discriminant analyses determined the questions best suited for the final instruments based on how those questions met proficiency levels and were consistent with cross-validation results.

Validity is the “degree to which evidence and theory support the interpretations of test scores entailed by the proposed uses of tests” (American Educational Research Association [AERA] & National Council on Measurement in Education [NCME], 2014, p. 34). Generally, validity is “an overall evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of conclusions drawn from some form of assessment” (as cited in Bryant, 2000, p. 101). The analysis of the results determines the validity, not the structure or wording of the instrument. The constituent elements of validity include content, criterion, construct, and face validity. Using methods such as EFA, CFA and DA, researchers confirmed that the data obtained reflected the measure it was intended to measure. Establishing the validity of an instrument substantiates the claims of those who are using the information in their research, evaluation, or literacy examination (Stewart, 2009).

The frequency groups were first examined for participant scores, for both total and partial credit scoring. The levels of proficiency within this instrument were determined by using thresholds to hold variables constant as they were measured against the groups of students in each learning stage. No survey participant obtained a perfect score (45). Based on the recommendations of best statistical practice, the highest score on the assessment was used as the maximum score (38, or 84.4% of the total). Students who scored greater than or equal to 80% of the highest score were deemed within the applicable proficiency level. Students who scored between 79-50% of the highest score were deemed to be within the factual literacy level, and students who were below 50% of the highest score were deemed to be within the exposure level. Partial credit scores were then used to determine the efficacy of individual items and item selections, particularly within the multiple-choice questions. The partial credit scores were allocated by only counting the number of correct choices students selected. Students were not penalized for selecting any additional incorrect choices. Finally, the best remaining items were evaluated using both CFA and DA to determine which questions best fit together for the final version of assessment. Only the items that scored the highest for validity were analyzed with the two final forms of analysis. There were some themes where only one question remained effective in each proficiency stage, while other themes had multiple items. Nevertheless, the final assessment only incorporated the single question from each level that best reflected a good fit for the instrument.

Fit indices or measures of fit within the proposed model were determined using SAS (SAS Version 9.4). To provide additional substantiation to the validity of the instrument, the researcher measured the internal consistency using Cronbach's Alpha. It should be recognized that in this model, Cronbach's Alpha is not as reliable for measuring internal consistency, as the instrument scores are recorded as either 0 (not correct) or 1 (correct). This limits the effectiveness of reviewing an alpha value between 0 and 1. Therefore, other analysis measures and their corresponding cross-validation measures will remain the most significant forms of scrutiny.

Data Analysis and Procedures

The data were analyzed using the following steps of completion.

1. The survey data were organized, cleaned for non-responses, and recoded in an Excel spreadsheet according to question number, theme, and proficiency stage. Survey items were coded 0 or 1 for a total correct or non-correct response. A correct or non-correct response code was also given for separate answer choice, to show how each participant answered every portion of the question.

2. Items were analyzed for simple means and SD for correct or non-correct responses. The highest scores and partial scores were calculated.

3. The initial EFA analysis was conducted in SAS. The frequencies of the relationships between the proficiency stages were measured to determine the latent constructs. These factor loadings determine the influence of the proficiency groups on the scores associated with each survey item.

4. Following the EFA, questions were eliminated that proved to be either too easy, too difficult, or poor questions based on the frequency results. The study relied upon the frequency parameters established in the K-5 agricultural literacy assessment (Longhurst et al., 2019) and the PISA model (OECD: PISA, 2016). Namely, if all proficiency stages have a frequency greater than or equal to 80% correct, it indicates the item is too easy without enough variability between the groups to indicate a level of statistical knowledge. If all proficiency stages have a frequency lower than 70% correct it indicates that the question may be either too difficult, or poorly written. The range for prime indication of a question that loads the factors sufficiently is between 70-80% correct. These percentages indicate adequate knowledge at the appropriate level of proficiency. It should be noted that there were questions that scored less than or equal to 70% and were still considered for subsequent analysis. The justification for exception was based on the following: 1) a good

question with a single poor answer choice that could be eliminated; or 2) a question based on a topic that consistently scored low (indicating a specific gap in population knowledge).

5. Item analyses were conducted on several items that had inconsistent frequencies or were being considered for further measurement based on the justification factors. Item analysis was also conducted to determine if the EFA frequencies improved when specific answer choices were eliminated. Careful determinations were made in these cases to ensure that the context of the question did not change with the elimination of an answer choice.

6. The questions with the best frequency numbers for each NALO theme and proficiency stage were determined. These items underwent CFA and DA.

7. The final items were selected for two separate JMALI instruments (see Appendix C). The results and discussion sections explain how to conduct JMALI and interpret student or adult results.

8. The demographic information from participants was measured for correlation using SPSS (Version 25) against the final JMALI items. The non-parametric correlations required Spearman's rank-order to determine effect size (strength and direction of association) between the two variables.

Summary

This chapter explained the methodology; instrumentation, sample, research design, and data analysis procedures used to examine the assessment survey (JMALI). The analytical procedures are congruent with the constructivist approach to learning and assessment design, and a consensus-based evaluation framework. In the following chapters, the results of the data analysis will be used to answer and discuss the dissertation questions.

CHAPTER IV

RESULTS

The purpose of this research study was to develop and validate an agricultural literacy instrument based on the NALOs. The results of four research questions determine the viability of the instrument and potential for future use. To answer the questions of validity and reliability, each of the five NALO themes, in the 9th- through 12th-grade level, was evaluated for content and construct validity. The content and construct of NALO standards were design keystones for agricultural and teaching experts. Experts developed items to be summative at grade 12. In this study, proficiency stages (i.e., exposure, factual literacy, applicable proficiency) must be independent and statistically different via the factor and discriminant analysis results. Post-hoc scores have been used to determine the reliability of the instrument. When applicable, effect size score has been used to determine the impact or the magnitude of any statistically significant differences. Both JMALI instruments have been validated (Instrument 1 and 2), and while developed at the same time, they function as separate instruments to measure the same agricultural literacy parameters. The two instruments can be found in Appendix C, the JMALI Student Assessment (survey) items and key can be found in Appendices B, D, and E.

The study participants were college students (ages 18-23) from Utah State University. The assessment items were created by using a Delphi method between two panels of experts. Data were collected through an online survey conducted at the beginning of the fall 2018 semester (September-October). Qualtrics reported that 580 students accessed the survey. Of those, 526 completed the survey and 48 did not complete the survey. Based on the anticipated N = 600, the survey yielded an 89% participant response rate. Demographic information revealed that 468 (88.81%) of participants had attended 0-2 years of college. Fifty-nine participants had attended between 3-4+ years of college (11.2%). Unfortunately, it was determined after the survey was conducted that “years of college” could be interpreted by the participants in a variety of ways. Some participants may have included “years of college attendance” as a part of their concurrent enrollment during high school. So, for this reason, further analysis focused on using the age restrictions (18-23 years old) to maintain participants were young adults and relatively uninfluenced by extensive life experience when determining their agricultural literacy. Only participants who fully completed the survey have been included in the analysis (N = 515).

It is noted that the demographic results from the student survey are representative of the larger student body of Utah State University for the fall 2018 semester on the Logan, Utah, main campus. The comparative information is available in the following tables. Table 1 provides further information on the demographic data from the JMALI Student Assessment. Table 2 provides demographic data from Utah State University relative to the information collected in the student survey. Utah State University is average in overall diversity when compared with national measures (Utah State University, 2018). Comparatively, student numbers rank above the national averages in the number of females attending and geographic representation. The university ranks below the national average in ethnic diversity. The lack of ethnic diversity at USU and in the sample is recognized as a significant limitation in JMALI results.

Table 1

Demographic Data of JMALI Student Assessment 2018

Data measures	*n*	%
Ethnicity		
White	504	93.68
Black or African American	5	.93
American Indian or Alaska Native	4	.74
Asian	7	1.30
Native Hawaiian or Pacific Islander	1	.19
Other	12	2.23
Do not wish to identify	5	.93
College completion		
0-1 year	375	71.16
2 years	93	17.65
3 years	52	9.87
4 years	5	.95
4+ years	2	.38
Geographic location of hometown		
Urban	74	13.98
Suburban	333	63.30
Rural	73	13.79
No response	46	8.93

Note. Ethnicity (N = 538), all other areas (N = 526).

The results provide agricultural literacy stakeholders with a standardized tool of assessment. The JMALIs add to the agricultural literacy literature in significant ways for student and adult populations (discussed further in the next chapter) and helps to further research within agricultural education.

Research Question 1

The first research question was “Does JMALI summatively measure the grade-12 benchmarks of agricultural literacy as defined by the National Agricultural Literacy

Table 2

Demographic Data of Utah State University, Fall 2018 Semester

Data measures	*n*	%
Ethnicity		
White	14,322	86.04
Black or African American	118	.70
American Indian or Alaska Native	65	.40
Asian	214	1.30
Native Hawaiian or Pacific Islander	45	.27
Hispanic	851	5.11
Other	1031	6.20
Gender		
Male	8666	52.06
Female	7980	48.00
Age of student body		
Under age of 21	-	50.00
Under age of 24	-	80.00
Geographic location of hometown		
Utah	-	77.20
Idaho	-	10.0
Other areas, including international	-	12.80

Note. Logan main campus (*N* = 16,646), public record data from Utah State University, Academic and Instructional Services. https://ais.usu.edu.

Outcomes?" It addresses the content and construct of JMALI items as they reflect the benchmarks defined by the NALOs. The validity of the content and construct for each item is determined by the effectiveness of the two panels of specialists who used a Delphi method to design each question. Each panel member was selected for their expertise, knowledge, and understanding of agricultural education and agricultural literacy. Furthermore, each panel member can be identified as a stakeholder in improving agricultural literacy to lend credibility for their desire to accomplish sound composition.

Each expert was instructed in how to interpret the NALO benchmark and indicators. They were advised that the instrument should be formed as a summative assessment for the end of high school, secondary education, or equivalency of, the 12th grade. Furthermore, teaching specialists received instruction on skills-based criteria to assist in developing questions for each proficiency stage. The skill areas were based on research by Joplin (1981) and Roberts (2006) and the PISA technical report (OECD: PISA, 2016). Based on these parameters, panelists individually reviewed the NALOs and identified key areas that should be addressed within the assessment for each theme and learning stage. Table 3 offers a summary of proficiency stage descriptions for JMALI.

Table 3

Summary Descriptions of the Proficiency Levels for JMALI

Proficiency level	General proficiencies students should have at this level
Exposure	Students at this level can recognize terms; recall singular facts, especially ones that draw upon their personal or familiar experiences; recognize simple cause and effect relationships; select simple explanations with relevant or cueing support.
Factual literacy	Students at this level can order, sort, analyze, and move/transfer knowledge from one area of application to another; can draw upon moderately complex facts and ideas to construct explanations; can make simple predictions; can identify the relevancy of facts in context.
Applicable proficiency	Students at this level can recognize, articulate, and evaluate what they have learned; can use abstract ideas or concepts to explain a complex phenomenon; demonstrate competency in information that may be unfamiliar or novel; draw on a range of inter-related ideas; can construct complex predictions; internalize the significance of facts in relation to ‘real-world’ application.

Note. Proficiency levels adapted from the works of Joplin (1981), Roberts (2006), and the PISA technical report (OECD: PISA, 2016).

Following the submission of items, each question was reviewed for specific content knowledge, or systems, as well as context. Items that needed clarification or revision were flagged for reconstruction. The items were ordered in level of difficulty, with the easiest questions at the top, and the most difficult questions at the bottom (i.e., exposure, factual literacy, and applicable proficiency). The easiest items tended to require the application of recall skills or every-day-content knowledge. The more difficult to most difficult items drew on interrelated agricultural concepts and understanding that required skills of evaluation, analysis, and higher learning processing skills. A total of 49 items were submitted for review to the agricultural specialists for critical examination of their relation to modern agriculture and connection to the NALO benchmarks. The agricultural panel analysis resulted in the rejection of four items and the requested revision of 26 items by the teaching committee. The teaching specialists revised the 26 items based on the recommendations. The research team also reviewed and ranked the questions for association to the proficiency descriptions, agricultural facts, best practices for assessment, spelling, and grammar. Following the third review round, each of the specialist panels agreed that the items could proceed to the student assessment.

Summative Evaluation of the NALOs

The 45 items submitted to the survey were examined in detail by the specialists and researchers. Keywords, ideas, phrasing, context, and modes of application were identified in each question and how they related to the NALO benchmark demands. Table 4 shows the analysis for Instrument 1: Theme 2 as an example of the process. The example shows each question was analyzed for both item content, its connection, and relevance to the NALO demand.

Following the factor and discriminant analysis of the survey, two agricultural literacy instruments were finalized. Each instrument contains 15 agricultural assessment

Table 4

Instrument 1: Theme 2, NALO Construct Analysis

Item number	Assessment item content	NALO demands
$2.12.E_1$	Identify examples of organic nutrients.	Lifecycles of plants and animals; distinguish between renewable and non-renewable resources; importance of soil nutrients; compare natural cycles in comparison to managed lifecycles within agriculture; how organic and inorganic nutrients affect plant growth and development.
$2.12.L_1$	Identify the factors (including cost, culture, convenience, access, and taste) that affect population food choice.	The variety of year-round food choice; food distribution networks and transportation systems; major factors in food and feed choices for people and animals are cost, culture, convenience, and access; examine viewpoints on production methods and practices; impacts of transporting food due to location, climate, and geography; consumer demand influences what is produced and how it is processed and marketed; explain how food production systems are influenced by consumer choices.
$2.12.P_1$	Determine agricultural practices that balance production and conservation (e.g., using modern science and technology).	Importance and stewardship of natural resources in delivering agricultural products and maintaining environment; understand the concept of stewardship for soil, water, plants and animals; examine viewpoints on production methods and practices.

Note. NALO demands are cumulative K-12 when evaluating the knowledge, understanding and application for a grade-12 summative assessment.

items. Appendix F details an example of the direct connections each question has to the NALO benchmarks. It illustrates that both JMALIs align to the NALO standards and can provide data concerning these themes of agricultural literacy.

There are guidelines for summative assessment. If the JMALIs are to perform as summative tools, they must hold the characteristics and functions of this type of evaluation. Most frequently, a summative evaluation provides end-of-project data or uses high-stakes testing that results in a quantitative score. JMALIs do not provide a standardized score, instead they provide a simple, but objective scaled-measure of participant proficiency. However, they maintain relevance because of their effectiveness in determining either individual or group data pertaining to the end-of-instruction performance. The standardized nature of the NALOs, in combination with the defined measures of the proficiency scale, provide the consistency required for obtaining and maintaining trend data, one of the critical functions of summative processes. Lastly, even though participants will receive a score related to a proficiency stage, there is nothing to prevent instructors, program directors, or stakeholders from also reviewing partial score information. Partial scoring involves reviewing data beyond the "total correct." For example, partial scoring reviews all the participant's choices within a multiple-choice question. By analyzing this data, the instructor may see that a participant selected two of the three correct choices. Then, through further questioning determine if a student simply overlooked a correct answer or has a gap in understanding. This type of post-project evaluation is critically important when calculating for accountability. Table 5 gives a bulleted viewpoint of how the JMALIs align with the determinant factors of summative evaluation.

Based upon the results of the Delphi method, using two specialist panels to develop assessment items, and the connection to factors of a high-quality summative evaluation, it was concluded that both JMALIs are able to summatively measure the grade-12 agricultural literacy benchmarks of the NALOs.

Research Question 2

The second research question was "Is JMALI a valid and reliable measure of proficiency stages of agricultural literacy?" The complexity of the question was

Table 5

Summative Evaluation

Components	Determinant factors of summative evaluation	Summative factors of JMALI
Fundamental elements	• Aligns goals with expected outcomes • Requires consistent criteria • Quantitative, qualitative, or mixed • Evaluates whether goals/objectives/outcomes have been reached • Comes at the end of learning • Focuses on outcomes not output • Used post-project • Show which areas need improvement • Determines what is known at the end of instruction. • Measures knowledge at one point in time (may be used for pre/post assessment comparisons) • Uses a rubric • Requires performance tasks relative to the audience	• Aligns items with multiple NALO benchmarks • Determines outcome from single proficiency score. • Determines which themes, constructs, and content are understood and where gaps in knowledge exist • Used for formative or summative evaluation • Uses NALO benchmarks and indicators for K-12 as rubric determinants • Incorporates appropriate student skills for general proficiencies at the 12th grade level
Outcome evaluation	• Used for accountability • Provides insight into unintended consequences • Quantifies changes to better track impacts • Does not improve instruction *during* the learning process if used as a post project • Used to examine trends in the data	• Assists in determining project outcomes • Provides quantitative data for each individual student • Responds to partial scoring to evaluate knowledge gaps • Provides standard benchmarks for trend data collection

addressed using multiple statistical measures shown in four segments, (1) descriptive measures, (2) exploratory factor and item analysis, (3) confirmatory factor analysis, and (4) discriminant analysis.

Descriptive Measures

Following data collection, survey responses were coded for each item. Correct responses were coded 1, incorrect responses were coded 0. Items were analyzed for descriptive statistics using SPSS (IBM SPSS Statistics Version 25) and cross-validated using SAS (SAS Version 9.4). Results for means, standard deviation, and partial correct responses are shown in Table 6. The partial correct responses are calculated by reporting only the correct answers marked by the participants, deductions were not made to items for incorrect answers. Descriptive results showed the highest score obtained for total correct responses on the student survey was 34 out of 45 questions (*max* = 34, *min* = 4, *M* = 21.34, *SD* = 5.44, *N* = 515). The maximum score was used to determine the participant proficiency stages, based on the proficiency scale from PISA literature (OECD: PISA, 2016, pp. 280-281), standardized testing parameters, and statistical best practices. Participants who scored ≥ 80% of the maximum score (≥ 27) represented proficient participants; participants who scored between ≥ 50% and 79% of the maximum score (≥ 17) represented factual literacy participants; participants who scored < 50% of the maximum score (< 17) represented the exposure level of proficiency. Figure 10 summarizes the scoring ranges that define the proficiency groups and Table 7 shows the proficiency scoring range and the number of students in each level.

The significance of the partial correct percentages shown in Table 6 should not be overlooked. They are indicative of the percentage of students who answered some portion of the question correctly. Partial scores measure the degree of difficulty. From an initial analysis standpoint, the partial scores help determine if a question is on-the-whole too difficult, or if there are only portions of the multiple-choice selections that may be too difficult. It is particularly important when several multiple-choice questions require the selection of multiple answers (i.e., select all that apply). For example, T112P10 shows a

Table 6

Descriptive Statistics of JMALI Student Assessment 2018

Item	*M*	*SD*	Partial correct %
T112E20[a]	.43	.50	.43
T112E30	.84	.37	.84
T112E40	.94	.24	.94
T112L10	.01	.08	.54
T112L20	.81	.39	.86
T112L50	.43	.50	.43
T112L60	.50	.50	.50
T112P10	.46	.50	.86
T112P30	.04	.21	.69
T212E10	.91	.29	.91
T212E20	.36	.48	.79
T212E50	.81	.40	.81
T212L30	.88	.33	.95
T212L40	.21	.41	.70
T212L50	.11	.32	.70
T212P10	.40	.49	.66
T212P30	.10	.30	.54
T212P40	.65	.48	.75
T312E10	.87	.34	.87
T312E30	.87	.34	.96
T312E50	.65	.48	.35
T312L10	.32	.47	.89
T312L40	.90	.31	.90
T312L50	.96	.20	.97
T312P30	.09	.28	.92
T312P50	.79	.41	.96
T312P60	.18	.39	.75
T421E10	.87	.36	.87
T412E20	.81	.39	.81
T412E40	.80	.40	.80
T412L20	.30	.46	.76
T412L40	.10	.30	.59
T412L50	.13	.34	.71

(*table continues*)

Item	*M*	*SD*	Partial correct %
T412L60	.08	.27	.72
T412P20	.32	.47	.72
T412P50	.38	.49	.38
T412P60	.10	.30	.66
T512E10	.37	.49	.37
T512E30	.90	.30	.90
T512L30	.33	.47	.73
T512L40	.30	.46	.30
T512L50	.51	.50	.79
T512P20	.12	.32	.68
T512P40	.34	.48	.74
T512P50	.07	.26	.52

Note. (*N* = 515, *M* = 21.34, *SD* = 5.44, *max* = 34). The partials were calculated with the consideration that students were not penalized for selecting a wrong answer, and only credited for selecting correct responses. The difficulty index can be determined by multiplying the mean by 100 to produce the mean proportion correct.

[a]T112E20 can be interpreted as Theme 1, grade 12, exposure (proficiency) level, question 2.

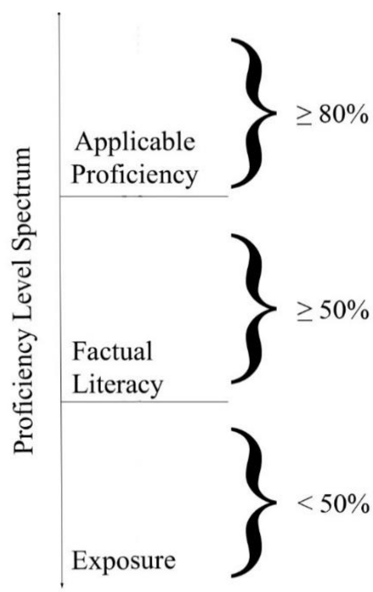

Figure 10. Proficiency scale. Survey scoring ranges to produce the participant proficiency groups.

Table 7

Participant Proficiency Stage Results Following Descriptive Measures

Proficiency stage	Scoring range	*n*	%
Exposure	< 17	87	16.90
Factual literacy	17-26	347	67.40
Applicable proficiency	≥ 27	81	15.73
Total		515	100.00

Note. Proficiency stages were based on the maximum score (*max* = 34) obtained on the student survey. (*N* = 515).

mean percentage of 46% total correct. It is a relatively low average, which on the surface, appears to be a difficult (perhaps too difficult) question. The partial correct percentage, however, is 86%, which indicates that most students got some portion of the question correct. These results indicate the question has potential and warrants continued evaluation through factor and item analysis. Specifically, the item analysis can examine each individual answer and determine its efficacy within the question.

The difficulty index is also another discriminatory tool used for the review of a measure of difficulty for each question. Referring to Table 6, one can determine the difficulty index percentage or proportion or probability that students answered the item correctly by multiplying the mean by 100. The mean proportion correct is really the difficulty index, but both the partial correct percentages and the difficulty index serve as critical indicators for establishing baseline measures before proceeding to the factor and item analysis.

Exploratory Factor and Item Analysis

The participant proficiency stage results defined the parameters for exploratory factor analysis (EFA). EFA reduces data to a smaller set of summary variables to explore a theoretical model. The linear equation model used for both EFA and Confirmatory Factor Analysis (CFA) is shown in Figure 11. Three factors or latent variables, representing each of the three proficiency stages, were analyzed against each of the five NALO themes (*L* = factor loadings, *C* = covariance, *VAR* = variance). The EFA technique shows the relationships between the proficiency stages when measured against the number of correct and incorrect responses, while controlling for the variables related to the NALO themes. EFA assumes that any indicator or measured variable may be associated with any factor, so it does not decide the adequacy of the structural equation model (SEM). The adequacy of the model and goodness of fit are governed using CFA, Post-hoc, and discriminant measures.

The EFA results determined which survey items were in the correct proficiency stage. For example, item stages were initially defined by the expert panels, but post-EFA, the item proficiency levels were revised to more accurately define item alignment. Using parameters developed by Longhurst et al. (2019) each item should show most participants within the stated learning stage can answer it correctly. If there are significant differences between stages, each item may also reveal the correct or incorrect proficiency level. Ideally, if a survey item shows between 70-80% of participants can answer correctly, it reveals that the learning stage is properly aligned. If > 70% of participants cannot answer the question correctly it indicates either a poor question, the disclosure of a learning gap (lack of knowledge), or a problem with one of the item answers. Clearly, these item allocations to proficiency stages require a judgment call. A researcher can examine them further using item analysis, which allows for the consideration of responses to individual

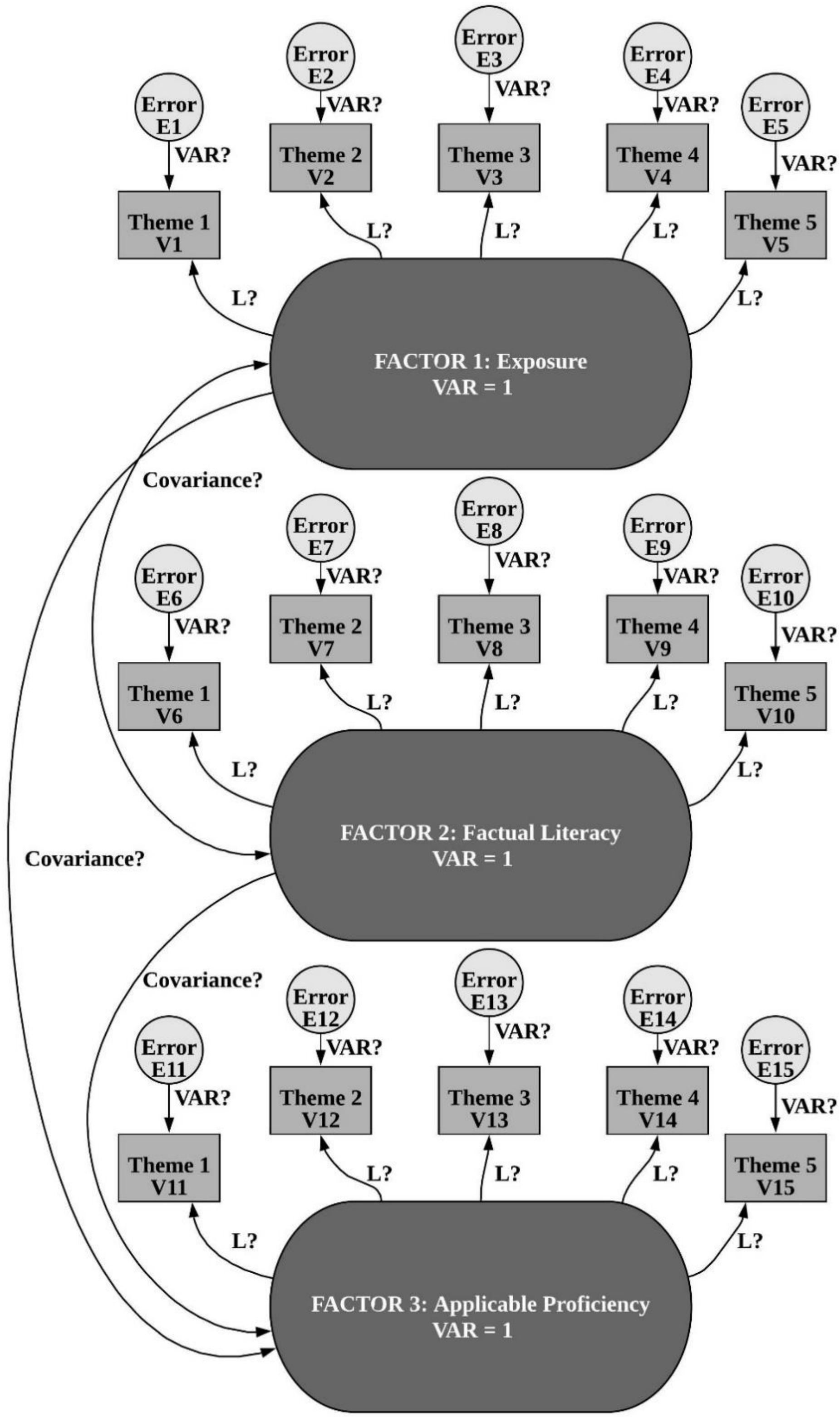

Figure 11. JMALI linear equation model, the theoretical framework.

answer choices, or they may review the question in context to determine participant knowledge levels. If indicators for a knowledge gap exist, it may be most beneficial to allow the question to remain in the assessment because if > 80% of participants in all learning stages answer the question correctly, it indicates that the question is too easy and cannot be distinguished statistically between the levels of proficiency.

Based on these results, the researcher determined whether each item should: (1) maintain the original proficiency level, (2) be revised based on the predetermined parameters, (3) submit for item analysis, (4) be discarded, or (5) be given a proficiency level based on predetermined parameters and special considerations.

The examination of item T112L20 in Table 8 shows how the parameters function. This item shows only 51.72% of exposure-level participants (n = 45), in comparison to 84.44% of literacy-level (n = 293) and 98.77% (n = 80) of proficiency-level participants were able to answer the question correctly. The item was labeled literacy-level by the panel of experts and due to the EFA analysis, therefore, it is a good stage-fit for the item. Visibly, there is a significant difference between the exposure-level and the literacy-level participant knowledge. This specifies that if an educator uses this item for assessment it accurately depicts (based on an incorrect or correct response) the proficiency level of the participants.

The examination of item T212P30 in Table 8 shows the significance of using both parameters and judgment by the researcher. This item shows 4.60% of exposure-level participants (n = 4), 7.20% of literacy-level participants (n = 25), and only 29.63% of proficiency-level participants (n = 24) were able to answer the question correctly. From a parameter standpoint, this question appears to be either too difficult or poorly constructed, however, the researcher judged that this question should remain in the assessment at the proficiency-level. The determination was based on literature from the multi-state K-5 instrument (Longhurst et al., 2019). It suggests students have significant learning gaps in STEM-agriculture-related information, especially pertaining to the understanding that agriculturists use computers, drones, and other modern technologies to perform their work. The consideration of this information combined with the observation that survey participants also scored very poorly on half of the STEM-agriculture-related items (more than any other theme) suggests the learning gaps identified in K-5 assessments may not be "filling in" by the time students complete the 12th grade. Furthermore, the question does not contain more than four multiple-choice answers, or other factors that may hinder application or understanding. It is always a concern when non-statistical analysis is used to justify a conclusive result. However, it should be expressed that pre-determined parameters cannot possibly account for all the determining factors of a good assessment item. Table 8 presents the EFA results for all survey questions, based on the maximum score and participant proficiency stages. It also shows the recommendations due to the EFA analysis.

Overall, 16 items were identified for item analysis, three items were discarded, and eight items were selected for further analysis using both pre-determined parameters and the judgment of the researcher. Item analysis is valuable because it increases the ability to evaluate assessment construction. It identifies localized areas needing greater emphasis or clarity. In the case of this assessment, discriminating poor questions versus

Table 8

Exploratory Factor Analysis Based on the Maximum Score and Participant Proficiency Stages

	E		L		P		
Item	*n*	%	*n*	%	*n*	%	Recommendations
T112E20	11	12.64	150	43.23	60	74.01	P
T112E30	53	60.92	300	86.46	78	96.30	L
T112E40	68	78.16	335	96.54	81	100.0	E[a]
T112L10	1	1.15	1	.29	1	1.23	Needs item analysis
T112L20	45	51.72	293	4.44	80	98.77	L
T112L50	23	26.44	141	40.63	57	70.37	P
T112L60	21	24.14	188	54.18	50	61.73	Item discarded
T112P10	7	8.05	169	48.70	63	77.78	P
T112P30	0	0.00	13	3.75	10	12.35	Needs item analysis
T212E10	68	78.16	319	91.93	80	98.77	E[a]
T212E20	15	17.24	128	36.89	41	50.62	Needs item analysis
T212E50	67	77.01	279	80.40	69	85.19	E[a]
T212L30	52	59.77	320	92.22	79	97.53	L
T212L40	4	4.60	58	16.71	44	54.32	Needs item analysis
T212L50	1	1.15	33	9.51	24	29.63	Needs item analysis
T212P10	8	9.20	137	39.48	62	76.54	P
T212P30	4	4.60	25	7.20	24	29.63	Needs item analysis
T212P40	13	14.94	244	70.32	79	97.53	L
T312E10	55	63.22	314	90.49	77	95.06	L
T312E30	56	64.37	313	90.20	77	95.06	L
T312E50	43	49.43	221	63.69	69	85.19	P
T312L10	12	13.79	116	33.43	35	43.21	Needs item analysis
T312L40	50	57.47	330	95.10	81	100.00	L
T312L50	70	80.46	342	98.56	81	100.00	E
T312P30	2	2.30	26	7.49	17	20.99	Needs item analysis
T312P50	37	42.53	293	84.44	77	95.06	L
T312P60	2	2.30	64	18.44	27	33.33	Needs item analysis
T421E10	55	63.22	314	90.49	80	98.77	E[a]
T412E20	36	41.38	303	87.32	78	96.30	L
T412E40	35	40.23	297	85.59	80	98.77	L
T412L20	1	1.15	95	27.38	60	74.07	P
T412L40	1	1.15	37	10.66	14	17.28	Needs item analysis
T412L50	5	5.75	42	12.10	22	27.16	Needs item analysis
T412L60	1	1.15	25	7.20	14	17.28	Needs item analysis

(*table continues*)

	E		L		P		
Item	*n*	%	*n*	%	*n*	%	Recommendations
T412P20	9	10.34	124	35.73	31	38.27	Needs item analysis
T412P50	20	22.99	128	36.89	47	58.02	P[a]
T412P60	1	1.15	28	8.07	24	29.63	Needs item analysis
T512E10	24	27.59	116	33.43	53	65.43	Item discarded
T512E30	48	55.17	337	97.12	80	98.77	L
T512L30	4	4.60	110	31.70	55	67.90	P[a]
T512L40	22	25.29	87	25.07	47	58.02	P[a]
T512L50	9	10.34	199	57.35	56	69.14	P[a]
T512P20	2	2.02	42	12.10	17	20.99	Needs item analysis
T512P40	5	5.75	123	33.42	48	59.26	Needs item analysis
T512P50	3	3.45	27	7.78	7	8.64	Item discarded

Note. (N = 515, *max* = 34). Proficiency stages were determined using a participant's percentage of the maximum score to form the following participant groups: Exposure < 50%; Factual literacy ≥ 50%; Applicable proficiency ≥ 80%.

[a]Proficiency stage modified due to additional factors examined by the researcher.

questions needing simplification was a significant issue. Many items had numerous multiple-choice correct options, and participants were at times required to get more than three, and as many as five or six, selections correct. This presented a formidable challenge in determining if some of the items could be preserved by limiting some of the multiple-choice answers, without compromising the contextual understanding intended by the experts.

Item analysis revealed 14 of the 16 items could be simplified by removing some of the most problematic multiple-choice answers, without changing the context or intent of the original question. Those fourteen altered items were then rescored using descriptive measures (N = 515, M = 22.49, SD = 5.76, *max* = 35, *min* = 4) and EFA to determine the proficiency stages. Post-EFA revealed that two of the revised items could statistically determine a proficiency stage, and three showed some measure of parameter change and could be justified based on further evidence by the researcher. Table 9 lists the 14 items and their subsequent recommendations.

Table 9

Exploratory Factor Analysis for the Revised Items (Post-Item Analysis) Based on the Maximum Score and Participant Proficiency Stages

	E		L		P		
Item	*n*	%	*n*	%	*n*	%	Recommendations
T112L10	3	3.45	18	5.19	13	16.05	No change, discard
T112P10	15	17.24	199	57.35	66	81.48	P
T112P30	0	0.00	18	5.19	11	13.58	No change, discard
T212L40	10	11.49	74	21.33	47	58.02	P[a]
T212L50	1	1.15	33	9.51	24	29.63	No change, discard
T312L10	12	13.79	117	33.72	36	44.44	P[a]
T312P60	5	5.75	81	23.32	34	41.98	No change, discard
T412L40	1	1.15	39	11.24	15	18.52	P[a]
T412L50	10	11.49	71	20.46	37	45.68	No change, discard
T412L60	2	2.30	33	9.51	18	22.22	No change, discard
T412P20	12	13.79	167	48.13	45	55.56	No change, discard
T412P60	6	6.90	85	24.50	35	43.21	No change, discard
T512P20	9	10.34	98	28.24	31	38.27	No change, discard
T512P40	19	21.84	268	77.23	75	92.59	L

Note. (*N* = 515, *max* = 35). Proficiency stages were determined using a participant's percentage of the highest correct score to form the following participant groups: Exposure < 50%; Factual literacy between ≥ 50%-79%; Applicable proficiency ≥ 80%.

[a]Proficiency stage modified due to additional factors examined by the researcher.

Confirmatory Factor Analysis

Exploratory analyses resulted in the construction of two assessment instruments (see Appendix C). Each instrument contained three questions for each of the five NALO themes. The three questions are staged from the easiest (exposure level) to the most difficult item (proficiency level) for each theme.

To accurately examine the CFA results, return to the linear equation model shown in Figure 11. The model is nonorthogonal because more than one of the independent variables (NALO themes) are correlated. They are interconnected in function, purpose, and application. Due to the correlation, non-orthogonal models have several ways to run statistical tests, and the results are more complicated to interpret. Additionally, survey results were calculated using 0 or 1 coding, which reduces the validity of CFA results. This adds complexity when examining correlations that are also measured for 0/1 items. The big picture is that CFA determined an observed correlation matrix of all 15 items, by forcing them to load on each of the factors (proficiency levels) while deliberately ignoring the structure of the independent variables (NALO themes). Essentially, it treated themes as if they "did not exist," to estimate how well the proficiency levels fit within the model. The model fit measures how well the conceptual model captures the covariance between the measures or items in the model. A poor model fit indicates some items are measuring on multiple factors, or that some items within a factor are more related to each other than others. It is important to note that a "good model fit" only indicates the plausibility of the model. A good proportion of both variance and covariance is likely not accounted for, so these measures were merely a guideline for acceptance of the structure. Table 10 is a CFA fit summary for the three proficiency levels (factors) based on the total number of correct items in each of the 15-item assessments.

An examination of this table clarifies that the SEM for both instruments is fitting adequately. This is determined by appraising the following table components. First, the

Table 10

Confirmatory Factor Analysis Fit Summary Based on Total Correct Items

Fit summary	Instrument 1	Instrument 2
Chi-square χ^2	131.80	124.26
Chi-square *df*	87	87
Variance estimate χ^2/df	1.51	1.43
Adjusted Goodness-of-Fit (GFI)	.95	.96
RMSEA estimate	.03	.03
RMSEA lower 90% confidence limit	.02	.02
RMSEA upper 90% confidence limit	.04	.04
Bentler Comparative Fit Index	.94	.93
Bentler-Bonett Non-normed Index	.93	.92

Note. Root mean square error of approximation (RMSEA).

chi-square ratio estimates (χ^2/df = 1.51 and 1.43), where a value of < 2.0 indicates an acceptable close fit of the data to the theoretical model (Figure 11). The model is regarded as acceptable because the observed covariance, or the covariance of the matrix is adequately predicted by the model. An acceptable Adjusted GFI (*GFI* = .95 and .96), should be > .9 to show that the observed data matches the values expected by the model. The RMSEA analyzes the discrepancy between the model and sample covariances, with smaller values < .05 indicating a satisfactory model fit. The RMSEA results for both instruments show satisfactory results within the lower and upper confidence limits. The comparative fit index (CFI) is also known as the Bentler Comparative Fit Index. It also represents the difference between the observed covariances and the predicted covariances. A model is regarded as acceptable if the CFI exceeds .90. Lastly, the non-normed fit index (NNFI), also known as the Bentler-Bonett Non-normed Fit Index, varies from 0 to 1, where 1 is ideal. An NFI of .93 (Instrument 1) and .92 (Instrument 2) indicates the data fits the theoretical model adequately.

After performing a CFA, it is beneficial to conduct a regression analysis to explore the relationship between the latent variables, this time estimated by their own CFA. This lends structural relevance to the model by showing that each item has a relationship to it. Table 11 displays the *p* values for each JMALI instrument item. The *t* value refers to the *t* test of the (intercept/estimate) divided by the standard error of that estimate. The results show that the predictor variables of JMALI instrument items are significantly, or nearly significantly, associated (load) on their respective proficiency stage factor. It is important to note that extremely low *p* values are most desirable when measuring these types of predictor variables.

The consideration of covariance is an important component in this linear SEM. Models are drawn to identify direct and indirect effects. Direct effects are shown with straight arrows from one "causing" variable to another "effect" variable. The exogenous variables, or the variables not influenced by other variables, connect with a curved line to indicate relationships among covariances where causality is not stated. In a null model, we presume that these factors are uncorrelated (covariances = 0). Obtaining covariance estimates between variables allows for the estimation of direct and indirect effects with other variables, particularly in complex models with many parameters. Consequently, the covariance values were tested to see if their differences from zero were significant. In this case, all of them were, as indicated by the *p*-values below .0001. Table 12 lays out the *t* test for the covariance coefficients. The standard error is the standard deviation of the estimate. The *p* values less than alpha allow for the rejection of a null hypothesis zero covariance (correlation), meaning there is a strong association from stage to stage.

Table 11

Confirmatory Factor Analysis Effects and p Values for Linear Equations

Variable	Estimate	Standard error	*t*	*p*
Instrument 1				
$T112E_1$	.30	.05	5.87	***
$T212E_1$	.15	.05	2.89	.004
$T312E_1$	.49	.05	9.92	***
$T412E_1$	.42	.05	8.32	***
$T512E_1$	.67	.05	13.48	***
$T112E_2$	.30	.05	6.21	***
$T212E_2$	.52	.04	11.08	***
$T312E_2$	.44	.05	9.23	***
$T412E_2$	.45	.05	9.49	***
$T512E_2$	.63	.05	13.73	***
$T112E_3$	.39	.05	7.57	***
$T212E_3$	.14	.05	2.71	.007
$T312E_3$	.15	.05	2.96	.003
$T412E_3$	.36	.05	7.014	***
$T512E_3$	.46	.05	8.67	***
Instrument 2				
$T112E_1$	.30	.05	5.71	***
$T212E_1$	.09	.05	1.64	.10
$T312E_1$	.49	.05	9.53	***
$T412E_1$	.44	.05	8.61	***
$T512E_1$	.68	.05	13.09	***
$T112E_2$	.34	.05	6.76	***
$T212E_2$	.57	.05	11.43	***
$T312E_2$	.36	.05	6.89	***
$T412E_2$	.15	.05	2.91	.004
$T512E_2$	.59	.05	11.83	***
$T112E_3$	.34	.06	5.69	***
$T212E_3$	.27	.06	4.63	***
$T312E_3$	.17	.06	3.01	.003
$T412E_3$	.18	.06	3.10	.002
$T512E_3$	.43	.06	6.87	***

$df = 513$.

$^{***}p < .0001$.

Table 12

Covariances Among Exogenous Variables

Variable Interaction	Estimate	Standard error	*t*	*p*
Instrument 1				
Factor (E) x Factor (L)	.89	.05	17.83	***
Factor (E) x Factor (P)	.80	.08	9.90	***
Factor (L) x Factor (P)	1.04	.08	13.87	***
Instrument 2				
Factor (E) x Factor (L)	.84	.05	14.79	***
Factor (E) x Factor (P)	.56	.09	5.94	***
Factor (L) x Factor (P)	.88	.10	9.19	***

***$p < .0001$.

The inclusion of information from Table 13 examines the error variance using the coefficient of determination (R^2). The very low R^2 values indicate very little, to almost non-existent, shared variance among the variables. This leads to considerable amount of *unique* variance among the variables. From the widest perspective, it appears that items related to Theme 5 seem to have the most shared variance among the residual components.

Internal Consistency

The Cronbach's alpha was administered to be a measure of scale reliability and a measure of internal consistency, or how closely related the assessment items were as a group. Cronbach's alpha is a function of the number of test items (N = 15) and the average inter-correlation among the items. It is meant to demonstrate that the items of each scale (proficiency level) are a reliable measure of that factor. The formula is shown in Figure 12.

Table 13

Determining Unique Error Variance Using the Coefficient of Determination (R^2) for JMALI Instrument 1 and Instrument 2

Variable	Error variance	R^2
Instrument 1: Exposure		
$T112E_1$	.91	.09
$T212E_1$	.98	.02
$T312E_1$	.76	.24
$T412E_1$	.83	.17
$T512E_1$	.55	.45
Instrument 1: Factual Literacy		
$T112L_1$	.91	.09
$T212L_1$	.73	.27
$T312L_1$	.81	.19
$T412L_1$	.80	.20
$T512L_1$	.60	.40
Instrument 1: Applicable Proficiency		
$T112P_1$	.84	.16
$T212P_1$	.98	.02
$T312P_1$	.98	.02
$T412P_1$	.87	.13
$T512P_1$	.79	.21
Instrument 2: Exposure		
$T112E_2$	.91	.09
$T212E_2$	.99	.008
$T312E_2$	.76	.24
$T412E_2$	.80	.20
$T512E_2$	.53	.46
Instrument 2: Factual Literacy		
$T112L_2$	.88	.12
$T212L_2$	.68	.32
$T312L_2$	.88	.12
$T412L_2$	.98	.02
$T512L_2$	.66	.34
Instrument 2: Applicable Proficiency		
$T112P_2$	.88	.12
$T212P_2$	.95	.07
$T312P_2$	.97	.03
$T412P_2$	.97	.03
$T512P_2$	.81	.19

$$\alpha = \frac{N * C}{V_a + (N - 1) * C}$$

N = number of items
C = average covariance among items
V_a = average variance

Figure 12. Cronbach’s alpha formula.

Cronbach’s alpha is not a statistical measure but is rather a coefficient of reliability or internal consistency. A reliability coefficient of $\alpha \geq .7$ is most widely acceptable, however, in educational research it can be difficult to construct a reliability estimate of an instrument because of the changes in circumstances and experiences happening between the participants during survey administration. In fact, a very high reliability may indicate that the assessment items are redundant. Due to these circumstances, there are some ranges of acceptability for labeling a result. Taber (2018), lists ranges for educational research from various authors from acceptable (.45-.98), to sufficient (.45-.96), to be not satisfactory (.4-.45), suggesting a lack of clear consensus on definitively describing an alpha outcome. Furthermore, the consideration of the size (length) of the JMALI instruments, less than 20 items, limits the alpha and complicates the process of unpacking the internal reliability. Nevertheless, Table 14 highlights the alpha numbers for each proficiency stage, including the alpha measures for partial scoring. The partial scorings have higher alpha measures because they have a greater range of possible responses. They are relevant as results because they identify that when questions are not scored as strictly right or wrong, they lead to a greater understanding of

Table 14

Cronbach's Coefficient of Reliability Across Proficiency Stages for JMALI Instrument 1 and JMALI Instrument 2

Variable	*N*	Cronbach's Alpha α	Partial scoring: Cronbach's Alpha α
Instrument 1			
Exposure	515	.46	.55
Factual literacy	515	.58	.62
Applicable proficiency	515	.37	.65
Instrument 2			
Exposure	515	.48	.50
Factual literacy	515	.47	.54
Applicable proficiency	515	.29	.38

Note. *α* >.70 is acceptable for internal consistency, table reflects standardized alpha measures.

where student understanding is. In other words, they "shine the light" on instrument results based on the current level of student understanding.

Based on these numbers, it is likely that the alpha numbers are low due to multiple themes for each factor. Some of these factors are known (NALO themes) and are further addressed by trying to identify them and analyze them with CFA and DA. Other factors are "hidden" and require further analysis and observation to identify.

A Pearson's product-moment correlation was used to assess the relationship between the proficiency stages and each of the five NALO themes. Table 15 shows all the items and stages for both instruments, and with a single exception were positively correlated. A positive correlation indicates that as one item increases, on average, so does the other item. The most significant correlations in Instrument 1 at the exposure level were associated with a small to weak positive correlation among the exposure level questions between Theme 5 and Theme 3, $r(513) = .35$, $p < .0001$, with the themes explaining 12.30% of the variation within the item; and again with Theme 4 and Theme

Table 15

Pearson Correlation Coefficients for Exposure stage, JMALI Instrument 1 and JMALI Instrument 2

	Theme 1		Theme 2		Theme 3		Theme 4		Theme 5	
Variables	*r*	R^2	*r*	R^2	*r*	R^2	*r*	R^2	*r*	R^2
Instrument 1: Exposure										
$T112E_1$	1.00		.02	.0004	.15	.02	.07	.005	.19[a]	.04
$T212E_1$	.02	.0004	1.00		.06	.004	.06	.004	.05	.003
$T312E_1$	.15	.02	.06	.004	1.00		.18	.03	.35[a]	.12
$T412E_1$	.07	.005	.06	.004	.18[a]	.03	1.00		.31[a]	.10
$T512E_1$	.19[a]	.04	.05	.003	.35[a]	.12	.31[a]	.10	1.00	
Instrument 1: Factual literacy										
$T112L_1$	1.00		.23[a]	.05	.13	.02	.13	.02	.14	.02
$T212L_1$	.23[a]	.05	1.00		.24[a]	.06	.16	.03	.31[a]	.10
$T312L_1$	.13	.02	.24[a]	.06	1.00		.22[a]	.05	.28[a]	.08
$T412L_1$	.13	.02	.16	.03	.22[a]	.05	1.00		.34[a]	.12
$T512L_1$	.14	.02	.31[a]	.10	.28[a]	.08	.34[a]	.12	1.00	
Instrument 1: Applicable proficiency										
$T112P_1$	1.00		.11	.01	.06	.004	.15	.02	.18[a]	.03
$T212P_1$	.11	.01	1.00		.04	.002	.17	.03	-.002	.96
$T312P_1$	.06	.004	.04	.002	1.00		.17	.03	.08	.01
$T412P_1$	.15	.02	.17	.03	.17	.03	1.00		.11	.01
$T512P_1$	.18[a]	.03	-.002	< .0001	.08	.01	.11	.01	1.00	
Instrument 2: Exposure										
$T112E_2$	1.00		.04	.002	.15	.02	.07	.005	.19[a]	.04
$T212E_2$	.04	.002	1.00		.04	.002	.12	.01	.09	.008
$T312E_2$	.15	.02	.04	.002	1.00		.18[a]	.03	.35 [a]	.12
$T412E_2$	.07	.005	.12	.01	.18[a]	.03	1.00		.31 [a]	.10
$T512E_2$	.19[a]	.04	.09	.008	.35[a]	.12	.31[a]	.10	1.00	
Instrument 2: Factual literacy										
$T112L_2$	1.00		.19[a]	.04	.13	.02	.04	.002	.18 [a]	.03
$T212L_2$	.19[a]	.04	1.00		.24[a]	.06	.09	.01	.34 [a]	.12
$T312L_2$	.13	.02	.24[a]	.06	1.00		.007	< .0001	.18 [a]	.03
$T412L_2$	.04	.002	.09	.01	.007	< .0001	1.00		.11	.01
$T512L_2$	.18[a]	.03	.34[a]	.12	.18[a]	.03	.11	.01	1.00	
Instrument 2: Applicable proficiency										
$T112P_2$	1.00		.07	.005	.12	.01	.003	< .0001	.15	.02
$T212P_2$	.07	.005	1.00		.07	.005	.10	.01	.15	.02
$T312P_2$	.12	.01	.07	.005	1.00		.005	< .0001	.03	.001
$T412P_2$	.003	< .0001	.10	.01	.005	< .0001	1.00		.05	.002
$T512P_2$	.15	.02	.15	.02	.03	.001	.05	.002	1.00	

$N = 515$, $df = 513$

[a] $.18 \le |r| \ge .3$, indicating a weak or small relationship

5, $r(513) = .31$, $p < .0001$, with the themes explaining 9.60% of the variation within the item. Similar observations were seen within the factual literacy items, however, there were fewer significant correlations within the applicable proficiency items. Instrument 2 demonstrates the same small to weak relationships for the exposure and factual literacy stages, with the applicable proficiency stage suggesting all positive relationships, but none with a substantial association size. Overall, the Pearson correlations provide a rough estimate that to some degree, individual assessment items are measuring the same thing as the rest of the items within the theme. When interpreting these results, it is important to consider that the r values will be lower in this assessment because the content areas for each theme are not necessarily homogeneous. The topics are broad, and these discrimination indices must be interpreted within the context of using NALO themes simultaneously connected to each other in context, but far ranging in content. Real world assessment items seldom exceed $r \geq .50$ because of the way items are created and the scores are distributed. “Tests with high internal consistency consist of items with mostly positive relationships with total test score” (Office of Educational Assessment, University of Washington, 2019, para. 4). The JMALI instrument’s results reflect interpretation of good internal relationships.

Ultimately, the CFA analysis showed enough evidence to substantiate the model is fitting adequately for the three proficiency stages using the five NALO themes as indicators. There are limitations to the factor analysis stemming from the complexities of educational analysis, the coding structure, and the small number of assessment items. These limitations also affect the reliability coefficients and estimations. Despite limitations, however, the α values verify there is a positive correlation with a small or weak relationship within the proficiency stages. Both results are encouraging for the JMALI instruments.

Discriminant Analysis

The final portion of this question's research uses discriminant analysis to better understand the results from the CFA. Can the items identified in JMALI Instrument 1 and Instrument 2 determine the learning stages of participants? Discriminant analysis (DA) uses linear combinations of independent variables to discriminate between the categories of the dependent classification variable (i.e., exposure, factual literacy, applicable proficiency). It examines the significant differences among the groups and evaluates the accuracy of the classification. To compute the discriminant functions, each of the learning stages must be classified into the known populations within the proficiency scale, using the totals over the five NALO themes. Within discriminant analysis, the weight of each item becomes the same, showing an equivalent outcome without weighting the final scores. It offers a simplified 1-15 item scoring system, within the proficiency scale, that doesn't require users to weigh each individual item.

This was done by determining the maximum score achievable on both instruments (*max* = 15) and then using the proficiency scale to determine the stages. The proficiency scale (see Figure 10), used for EFA, was also used for calculating the DA measures. Ideally, the stages should have a minimum of 70% proper classification in each category. Table 16 shows the classifications of each learning stage and the percentage of the known population accurately placed in each of those stages. The cross-validation is provided to

Table 16

Discriminant Analysis: Resubstitution Summary Using Linear Discriminant Functions

Proficiency stage	*n*	%	Error estimation	Cross-validation %	Cross-validation error estimation
Instrument 1					
Exposure	74	97.37	.02	97.37	.03
Factual Literacy	261	98.86	.01	98.86	.01
Applicable Proficiency	175	100.0	.00	100.0	.00
Total	515	100.0	.0097*	100.0	.0097*
Instrument 2					
Exposure	90	91.84	.08	91.84	.08
Factual Literacy	317	97.24	.03	97.24	.03
Applicable Proficiency	91	100.0	.00	93.41	.00
Total	515	100.0	.033	100.0	.045

Note. Proficiency stages were determined using the maximum high score (*max* = 15) to form the following participant groups: Exposure < 50% (< 8); Factual literacy ≥ 50% (≥ 8); Applicable proficiency ≥ 80% (≥ 12).

df = 514.

**p* < .01.

estimate misclassification probabilities. The results confirm predicted expectations, that all classification percentages for JMALI Instrument 1 are exceptionally high (Exposure = 97.37%; Factual literacy = 98.86%; Applicable proficiency = 100%) in their classification accuracy, and well-within the range of $p < .05$. The results for JMALI Instrument 2 are not as good, with the Exposure proficiency stage showing an error rate of $p = .08$. Notwithstanding, the Exposure stage is justifiably above the minimum requirement (Exposure = 91.84%; Factual literacy = 97.24%; Applicable proficiency = 100%), with the other stages scoring remarkably high.

Last, discriminant indices were computed for each item on each instrument for the three groups as previously defined based on a total score out of 15 on a given instrument:

P = applicable proficiency, L = Factual literacy, and E = Exposure. The discriminant index, for a specific item, is the difference in proportion correctly answering the question between each pair of groups: P vs L, P vs E, and L vs E. In general, a discriminant index above (about) 0.5 indicates the item, individually, does a good job at discriminating between the two groups, a discriminant index between (about) 0.2- 0.5 suggests a moderate ability of that item to discriminate, while an index below 0.2 implies weak ability to discriminate. Table 17 provides the discriminant indices results and shows that many items were good at discriminating between the proficiency and exposure levels, especially with Instrument 2, which would be anticipated for this type of assessment given that P and E groups are furthest apart on total score. Enough items were moderate-good at discriminating between the L and E groups to suggest both instruments would be effective at separating L and E. Very few questions were effective individually at discriminating between the P and L groups, which again reflects the fact that scores for P and L subjects were quite close. Overall, these indices suggest that both instruments would provide good discrimination between each of P and L versus E, and moderately effective discrimination between P and L.

Summary

The second research question seeks to determine if the JMALIs are a valid and reliable measure of proficiency stages of agricultural literacy. The process and steps of the EFA to accurately define the proficiency stages, the confirmatory measures to analyze the model fit and internal reliability, and finally the discriminatory measures to confirm the correctness of the proficiency stages within the model have been conducted using

Table 17

Difficulty Indices for Instrument 1 and Instrument 2 Between Each Proficiency Group

Item	P vs L	P vs E	L vs E
Instrument 1			
$T112E_1$	.06	.21	.15
$T112L_1$	.15	.36	.21
$T112P_1$	.37	.71	.33
$T212E_1$	.27	.43	.16
$T212L_1$	.07	.53	.46
$T212P_1$	.15	.18	.03
$T312E_1$	.01	.20	.19
$T312L_1$	.13	.57	.44
$T312P_1$	.31	.40	.09
$T412E_1$	.11	.41	.30
$T412L_1$	.14	.59	.45
$T412P_1$	.45	.61	.16
$T512E_1$	.05	.47	.42
$T512L_1$	.26	.85	.60
$T512P_1$	.30	.74	.43
Instrument 2			
$T112E_2$	.02	.24	.16
$T112L_2$	.14	.50	.34
$T112P_2$	.41	.64	.27
$T212E_2$	.07	.13	.07
$T212L_2$	.24	.84	.58
$T212P_2$	.38	.49	.12
$T312E_2$	.01	.27	.17
$T312L_2$	.06	.40	.34
$T312P_2$	.28	.43	.18
$T412E_2$	.07	.48	.32
$T412L_2$	.17	.26	.07
$T412P_2$	.34	.46	.17
$T512E_2$	.01	.58	.39
$T512L_2$	.16	.91	.57
$T512P_2$	.49	.75	.23

Note. P = Applicable Proficiency, L = Factual Literacy, E = Exposure. Discriminant Index for 15 items using groups split across three proficiency stages, based on the total score. Median score = 10.

reliable statistical measures and practices. There is little evidence based on the outcomes of DA that the proficiency stages are improperly classified. The DA is the most definitive conclusion the items have been aligned correctly for each of the five NALO themes, indicating users can accurately use either JMALI instrument to determine student's proficiency level in agricultural literacy. Discriminant analysis also enables a simplified scoring system within the proficiency scale model. It should be noted that the two validated instruments are separate but equal in efficacy. Each instrument can be used individually, or they can be used together to measure a pre-post-type intervention of agricultural literacy. The instruments do have some questions that are present in both versions, but the items cannot be "mixed and matched" between them to meet evaluation needs. Both have been independently validated in this research study, which means that either instrument is effective in determining a proficiency level of agricultural literacy. Users should not deem one instrument more effective or difficult than the other.

Research Question 3

The third research question was "Is there a significant correlation between the amount of a participant's agricultural instruction through classes and clubs and their perceived level of agricultural literacy?" Returning to the original demographic information, first shown in Table 1, the remaining content is defined in Table 18. Looking to provide a baseline for future research, do experiences directly or indirectly related to agricultural literacy positively influence an individual's perceived agricultural literacy skills? The null hypothesis states level of exposure to agricultural experiences are

Table 18

Agricultural participation and perceived literacy levels of JMALI Student Assessment 2018

Item	*n*	%
Participation in middle or high school agricultural course		
Yes	105	19.96
No	421	80.04
Participation in any agricultural-related club or group		
Yes	86	16.32
Maybe	29	5.50
No	412	78.18
Participation in any environmental-related club or group		
Yes	43	8.17
Maybe	40	7.60
No	443	84.22
Indicate which of the events you have experienced		
Attending a state or county fair	445	84.60
School or home/family gardening	413	78.85
Traveling to a farm or touring a farm	392	74.52
Traveling to a garden or botanical event	230	43.73
Farm-related events	212	40.30
Working on a farm/ranch, greenhouse, timber, or other agricultural industry	180	34.22
Listening to guest speakers who spoke about an agricultural topic	174	33.08
Involvement in local food programs	95	18.06
Reading books about agriculture	87	16.54
Listening to volunteers or being a volunteer who shares agricultural information	77	14.64
Farm to School or Community food programs	55	10.46
Other	37	7.03
None of these choices	5	.95
Rate your level of exposure to agriculture		
A great deal	35	6.65
A lot	59	11.22
A moderate amount	190	36.12
A little	214	40.68
None at all	28	5.32
Rank perception of agricultural literacy		
Excellent	29	5.51
Good	78	14.83
Average	231	43.92
Poor	149	28.33
Terrible	39	7.41

Note. (*N* = 526). Participants could select multiple agricultural experiences.

not related to self-reporting a higher level of agricultural literacy ($H_0 = 0$). The alternative hypothesis, $H_1 > 0$ identifies that experiences (i.e., classes and clubs) and a participant self-reporting a higher level of agricultural literacy are related. The results are important to the study because, indeed, the correlation of actual agricultural-specific instruction and participation and a student's efficacy perceptions can define how JMALI is used and interpreted by agricultural stakeholders.

To begin interpreting the results, it is important to acknowledge that most study participants did not take a middle or high school agricultural course (n = 421, 80%). Nor did many study participants undergo activity in agricultural or environmental-related clubs (n = 412, 78%; n = 443, 84%). In fact, the most widely experienced event for participants was attending a state or county fair (n = 445, 85%), a relatively, non-informative and self-directed event. It was followed by the experiences of various forms of gardening and visiting or touring a farm (n = 412, 79%; n = 392, 75%). Only 34% of study participants (n = 180) claimed working directly in an agricultural job. The amount of instruction received at any of the top three experiences cannot be quantified, so it is enough to assume that some knowledge may have been acquired. Based on the overall confidence of participants, however, it is safe to assume that these short-term, non-instruction-based events have not improved the self-perception of agricultural knowledge or the willingness to state that one "knows a great deal" about agriculture. In fact, the highest percentage of students (40%) stated that they "knew a little" about agriculture and self-reported an "average" level of agricultural literacy (44%).

A correlation technique was used to analyze the self-reported data with the SPSS

(Version 25) program. Table 19 presents the Spearman's rho correlation coefficients identifying possible relationships between student experiences with an individual's self-perception, the levels of exposure, and agricultural literacy.

The results indicate a few key findings. First, there is a strong, positive correlation

Table 19

Spearman's Rho Correlations to Determine Student Experiences and Individual Perception of the Levels of Exposure and Agricultural Literacy

Variable	Course	Ag Club	Env Club	Exposure: Great	Exposure: Lot	Exposure: Moderate
Experiences						
Ag course	1.00	.44**	-.03	.32**	.18**	.002
Sig. (2-tailed)		.000	.55	.000	.000	.01
Ag club	.44**	1.00	.05	.36**	.31**	-.06
Sig. (2-tailed)	.000	-	.23	.000	.000	.21
Env club	-.03	.05	1.00	.06	.005	.04
Sig. (2-tailed)	.55	.23	-	.17	.90	.41
Level of Exposure						
Great deal	.32**	.36**	.06	1.00	-	-
Sig. (2-tailed)	.000	.000	.17	--	-	-
A lot	.18**	.31**	.005	-	1.00	-
Sig. (2-tailed)	.000	.000	.90	-	-	-
Moderate	.002	-.06	.04	-	-	1.00
Sig. (2-tailed)	.97	.21	.41	-	-	-
Level of Literacy						
Excellent	.35**	.35**	-.01	.70**	.05	-.18**
Sig. (2-tailed)	.000	.000	.81	.000	.24	.000
Good	.12**	.20**	.09*	.11*	.42**	-.036
Sig. (2-tailed)	.01	.000	.05	.02	.000	.42

Note. Participants could only select one option for perceived levels of exposure and literacy; overlapping choices have been eliminated from the table. *Env* is shortened for environmental club. Proficiency stages were determined by using the sums of all five items from each learning stage

$N = 515$.

$df = 513$.

*$p < .05$.

**$p < .01$.

between students participating in agricultural courses and agricultural clubs, $r_s(513) = .44$, $p = .000$. This finding is not unusual, as the most common agricultural course also has a direct affiliation to a national club, the Future Farmers of America (FFA). More interesting, is the finding that students stated their affiliation with an agricultural club had a greater effect on their perception of exposure to agriculture. There is a stronger, positive correlation with agricultural clubs and having a "great deal of exposure," $r_s(513) = .36$, $p = .000$, than the relationship between agricultural courses and having a "great deal of exposure," $r_s(513) = .32$, $p = .000$. Both are statistically significant, but there is a difference between the two relationships. Results for levels of exposure also revealed agricultural courses and clubs were positively correlated with perspectives of "knowing a lot" about agriculture, $r_s(513) = .18$, $p = .000$, and $r_s(513) = .31$, $p = .000$. Similarly, students involved with clubs revealed a higher self-perception of their exposure at this level than through agricultural coursework.

The correlation table also exposes that students who participate in either an agricultural course or an agricultural club have a strong, positive and statistically significant relationship with a self-perception of an "excellent level of agricultural literacy," $r_s(513) = .35$, $p = .000$. This leads to the most highly correlated relationship in the survey, students who perceived they had a "great deal" of exposure were extremely correlated with students who felt they had an "excellent" level of agricultural literacy, $r_s(513) = .70$, $p = .000$. Comparatively, there is a significant drop in the connection between exposure and literacy when viewing students who stated they had an "excellent" level of agricultural literacy, but only had "a lot" of exposure to agriculture, $r_s(513) = .05$, *p* = .24. The correlation becomes both significant and negatively associated when viewing students who stated an "excellent" level of literacy, but only "moderate" exposure to agriculture, $r_s(513) = -.18$, $p = .000$. Clearly, students identify the amount and type of personal experiences with their own perceptions of agricultural literacy.

Those results are verified by examining the next level of agricultural literacy. Students who reported they had a "good" level of agricultural literacy also revealed positive correlations with agricultural courses and clubs, and the only positive and significant relationship to an environmental club, perhaps suggesting students involved in environmental clubs see an indirect relationship to agricultural knowledge, $r_s(513) = .09$, $p = .05$. A "good" knowledge of agricultural literacy is soundly associated with having "a lot" of exposure to agriculture, $r_s(513) = .42$, $p = .000$.

Based on these results, the null hypothesis is rejected. There is a significant relationship between a participant's activity in courses or clubs and their self-reported perception of agricultural literacy. While only 35 students indicated they had "a great deal" of exposure to agriculture, and only 29 students reported they had an "excellent" level of agricultural literacy, their experiences drove those statements.

Research Question 4

The final research question was "Is there a significant correlation between the perception of a participant's level of agricultural literacy and actual proficiency on JMALI?" This question is designed to address how closely actual proficiency is aligned to how a student perceives their own knowledge. The null hypothesis states no relationship between the perception of a participant's self-reported level of agricultural literacy and actual proficiency on the JMALI survey instrument ($H_0 = 0$). The alternative hypothesis, $H_1 > 0$ states there is a significant relationship between these factors. The relevancy of this question is based on information that perceptions can be either good or poor indicators, based on whether students have obtained good information or have knowledge filled with misconceptions.

The results of the Spearman's rho correlation coefficient calculations suggest several significant relationships. To begin, the strongest correlation is between students who stated they had a "good" level of agricultural literacy were negatively related to scoring at the exposure stage, $r_s(513) = -.14$, $p = .002$. Comparatively, it aligns well with the significance of students with a "poor" understanding of agricultural literacy and achievement at the proficiency level, $r_s(513) = -.11$, $p = .01$. When you contrast those results with the strongly positive associations of students with a "good" understanding and placement in the proficiency stage, $r_s(513) = .13$, $p = .005$, and students with a "poor" understanding and placement in the exposure stage, $r_s(513) = .12$, $p = .009$, it is easy to decipher that students with some foundational knowledge feel "good" is an accurate description. The relationships between "excellent" understanding and the literacy and proficiency stages are weaker, but still positively correlated, which may suggest that students feel less confident stating they have obtained a level of excellence. Table 19 features other nonsignificant results that supplement these results. All these factors render the resolution that students have an acceptable or passable determination of their own level of agricultural literacy.

Table 20

Spearman's Rho Correlation Coefficient to Show Relationships Between Participant's Perceived Level of Agricultural Literacy and Their Survey Proficiency Stages

Participant proficiency stage	Literacy: Excellent	Literacy: Good	Literacy: Average	Literacy: Poor	Literacy: Terrible
Instrument 1					
Exposure	-.06	-.14**	.004	.12**	.04
Sig. (2-tailed)	.15	.002	.94	.009	.36
Factual Literacy	.007	-.001	-.003	.006	-.008
Sig. (2-tailed)	.87	.99	.94	.90	.86
Applicable Proficiency	.05	.13**	.001	-.11*	-.03
Sig. (2-tailed)	.28	.005	.99	.01	.55
Instrument 2					
Exposure	-.05	-.05	-.02	.08	-.001
Sig. (2-tailed)	.29	.24	.70	.06	.99
Factual Literacy	.02	.04	.02	-.04	-.03
Sig. (2-tailed)	.74	.39	.65	.32	.53
Applicable Proficiency	.03	.006	-.02	-.02	.04
Sig. (2-tailed)	.45	.89	.70	.59	.41

Note. Proficiency stages were determined by using the sums of all five items from each learning stage.

N = 515.

df = 513.

* p <.05.

** p < .01.

The researcher determined these primary correlations could be enhanced by also examining connections to a participant's perceived level of exposure to agriculture and actual levels of proficiency. Furthermore, the researcher posited that due to the significance of student participation in agricultural courses and clubs increasing the perceived levels of exposure and literacy there may also be some connection to actual proficiency scores. Tables 21 and 22 are the correlation compilations of these ancillary ideas. The results of the secondary analysis revealed little in terms of statistical

Table 21

Spearman's Rho Correlation Coefficient to Show Relationships Between Participant's Perceived Level of Exposure to Agriculture and Their Survey Proficiency Stages

Participant proficiency stage	Exposure: Great	Exposure: Lot	Exposure: Moderate	Exposure: Little	Exposure: None
Instrument 1					
Exposure	-.08	-.07	.001	.05	.07
Sig. (2-tailed)	.07	.13	.99	.26	.12
Factual Literacy	.02	.01	-.05	.02	.01
Sig. (2-tailed)	.74	.76	.31	.63	.75
Applicable proficiency	.05	.04	.05	-.07	-.08
Sig. (2-tailed)	.22	.32	.25	.12	.08
Instrument 2					
Exposure	-.03	-.06	-.001	.02	.07
Sig. (2-tailed)	.49	.16	.99	.61	.11
Factual Literacy	.02	.07	-.05	.02	-.07
Sig. (2-tailed)	.71	.09	.31	.66	.12
Applicable proficiency	.01	-.03	.06	-.04	.005
Sig. (2-tailed)	.79	.47	.21	.35	.92

Note. Proficiency stages were determined by using the sums of all five items from each learning stage.

$N = 515$.

*$p < .05$.

significance but did verify that there are some positive relationships between a "great deal" and "a lot" of exposure to agriculture and achieving at the factual literacy or proficiency level on JMALI. Table 21 also contains similar information received in the primary results that as students perceive they have fewer agricultural experiences, and limited agricultural exposure, they also show positive correlations with scoring at the exposure level on JMALI.

The only relationships of significance from Table 22 are related to a participant's activity in either agricultural courses or clubs and its association with the proficiency

Table 22

Spearman's Rho Correlation Coefficient to Show Relationships Between Participant's Participation in Agricultural Courses and Clubs and Their Survey Proficiency Stages

Participant proficiency stage	Agricultural course	Agricultural club(s)
Instrument 1		
Exposure	-.06	-.02
Sig. (2-tailed)	.16	.70
Factual Literacy	.05	-.03
Sig. (2-tailed)	.26	.53
Applicable proficiency	-.001	.05
Sig. (2-tailed)	.98	.29
Instrument 2		
Exposure	-.11*	-.11*
Sig. (2-tailed)	.01	.01
Factual Literacy	.03	.08
Sig. (2-tailed)	.46	.08
Applicable proficiency	.09	.02
Sig. (2-tailed)	.05	.66

$N = 515$

*$p < .05$.

stages. There is a negative relationship between students who participate in an agricultural course and achievement on JMALI Instrument 2 at the exposure level, $r_s(513) = -.11$, $p = .01$. The statistic is identical for students participating in agricultural clubs and exposure level achievement on the same instrument, $r_s(513) = -.11$, $p = .01$, comparatively, the other relationships for factual literacy and proficiency are positive in these associations. This may indicate that when, combined with the correlations investigated in Research Question 3, could further confirm the reasoning that students participating in agricultural courses or clubs, both perceive they know more about agriculture and are more likely to perform at either the literacy or proficiency level.

Indeed, lacking in strong statistical significance, these results show positive correlations between achievement at the literacy and proficiency level for these students. As a side note, it was shown in Question 3 that students who participated in agricultural clubs, rather than agricultural courses, had a higher perception of their level of agricultural literacy. There is some indication from Table 22 that there may be a weak, positive relationship between participating in agricultural courses and attaining applicable proficiency levels, $r_s(513) = .09$, $p = .052$. Further research could potentially lead to more clarification on whether agricultural courses do lead to higher proficiency scores over agricultural club participation.

Summary of Results

The purpose of this research was to develop and validate the JMALI using the NALO outcomes. Four research questions addressed in this chapter have been interpreted, analyzed, and reported for clarification of statistical analysis. Research Question 1 showed the assessment development process using a modified Delphi model with panels of agricultural and teaching specialists. They defined the proficiency stages and skills, using the PISA model as a guide. Following the development of 49 items, the experts determined that 45 items met the criteria of the NALO demands. The items were classified from easiest to the most difficult in each of the proficiency stages. The experts determined 45 items could be used as a summative assessment for post-12th grade students between the ages of 18-23 years old, at Utah State University. Demographic information collected during the survey revealed most students were white (94%), had completed ≤ 2 years of college, were from suburban areas (63%), and were mostly from either Utah or Idaho (87%; see Table 2).

Four statistical processes were used to validate and determine the internal consistency of JMALI (Research Question 2). The descriptive measures (*max* = 34, *min* = 4, *M* = 21.34, *SD* = 5.44, *N* = 515), along with the proficiency scale (see Figure 10) were used to determine participant proficiency stages. The proficiency stage results defined the parameters for EFA. The EFA results determined which of the 45 items were aligned with the correct proficiency stage, based on the proficiency scale. The EFA identified that 21 items were aligned correctly, recognized sixteen items for item analysis, and allowed three items to be discarded. Despite EFA results, eight items were determined acceptable for consideration based on pre-determined parameters and the judgment of the researcher. An item analysis revealed that 14 of the 16 items could be acceptable with minor changes. Post-EFA and item analysis, two JMALI instruments were developed each with 15 items.

Those 15-item assessments were analyzed for model fit (Figure 11) and internal consistency using CFA and reliability techniques. For both instruments, the CFA found adjusted GFI (*GFI* = .95 and .96), RMSEA (.03 and .03), CFI (.93 and .94), and NFI (.93 and .92) results indicated the model fits adequately. Regression analysis, considerations of covariance, and residual estimates all added to the credibility of the model. Cronbach's alpha was administered as a scale of reliability. The alpha numbers were low due to multiple factors (*Instrument 1α* = .37-.58 and *Instrument 2α* = .29-.48). However, a Pearson's product-moment correlation measuring the relationship between the proficiency stages and each of the five NALO themes showed that individual items were related to other items within similar proficiency stages.

The discriminant analysis clarified the results from the CFA. By using the proficiency scale, the DA classified each learning stage against the known population placed in each of those stages. A cross-validation provided estimations of error probabilities. The validation results for JMALI Instrument 1 were exceptionally high (Exposure = 97.37%; Factual literacy = 98.86%; Applicable proficiency = 100%) in their classification accuracy, and well-within the range of $p < .05$. The results for JMALI Instrument 2 were not as good, with the Exposure proficiency stage showing an error rate of $p = .08$. Notwithstanding, the Exposure stage was justifiably above the minimum requirement (Exposure = 91.84%; Factual literacy = 97.24%; Applicable proficiency = 100%), with the other stages scoring remarkably high. The DA concluded that both instruments were aligned, validated, and reliable for all proficiency stages across each of the five NALO themes.

Research Question 3 sought to determine if there was a relationship between survey participant's instruction in agricultural courses and/or clubs and their perceived level of agricultural literacy. The results showed that the null hypothesis, H_{01}, should be rejected. Strong, positive, and significant correlations were found between students having participated in either an agricultural course or club and with perceiving they had an "excellent level of agricultural literacy," $r_s(513) = .35$, $p = .000$. Students also reported that if they perceived they had a "great deal" of exposure to agriculture they also felt they had an "excellent" level of agricultural literacy, $r_s(513) = .70$, $p = .000$. Clearly, students identified the amount and type of personal experiences with their own perceptions of agricultural literacy.

Research Question 4 sought to determine if there was a relationship between participant's perceived level of agricultural literacy and their JMALI proficiency scores. Results showed the strongest correlation between students who stated they had a "good" level of agricultural literacy but were negatively associated with scoring at the exposure stage, $r_s(513) = -.14$, $p = .002$. Comparatively, it aligned with the significance of students with a "poor" understanding of agricultural literacy and achievement at the proficiency level, $r_s(513) = -.11$, $p = .01$. In contrast, results defined strong positive associations of students with a "good" understanding and placement in the proficiency stage, $r_s(513) = .13$, $p = .005$, and students with a "poor" understanding and placement in the exposure stage, $r_s(513) = .12$, $p = .009$. For these reasons, the null hypothesis was rejected. There is a statistical relationship between what students perceive they understand about agricultural literacy and their JMALI proficiency scores. The higher their perceived level of literacy, the higher their score.

CHAPTER V

DISCUSSION

This study sought to develop and validate an agricultural literacy assessment using the NALO standards for adults who have completed the 12th grade or equivalent. In this chapter, I will discuss the research questions, implications of a valid assessment, limitations, and recommendations.

Assessment is the process of gathering data about an instructor's (or program's) teaching and a student's learning (Hanna & Dettmer, 2004). When the data are collected, student performance can be evaluated. Evaluation draws on individual judgment to determine the outcome based on the data. It is in the "decision-making process where we design ways to improve the recognized weaknesses, gaps, or deficiencies" ("Formative and Summative Assessment," n.d., para. 1)

Key Findings

Research Question 1

An assessment must correspond to the learning outcomes, and the first research question sought to determine if the JMALIs measure grade-level (9-12) benchmarks and agricultural literacy goals. These learning outcomes can only be assessed by developing an appropriate form of evaluation. JMALIs are designed to be a short (15-item), summative evaluations for use by broad audiences, educators, and agricultural stakeholders. The research concludes both JMALI instruments are properly aligned to meet NALO demands (see Appendix F). Indeed, the JMALIs excel at offering a standardized snapshot of agricultural literacy using the NALO benchmarks. They were designed by panels of experts who examined skill sets at the 12^{th} grade level, created content that matched the skill sets, and linked those skill sets to cumulative NALO demands. The assessment design model is supported by past literature (Longhurst et al., 2019; OECD: PISA, 2016; Pense et al., 2005) and offers transparency for the critical selection of experts (Goodman, 1987; Messick, 1993; Okoli & Pawlowski, 2004; Sireci, 1998; Winkler & Poses, 2004), which allows for content and construct validity. The development experts demonstrated collective wisdom to access and create high quality and valid evaluation content.

Nevertheless, the scope of the JMALIs is not to offer detailed insight regarding student or adult knowledge of the changes in human nutritional needs over time, to predict the types of essential agricultural careers needed in the future, or to list major agricultural events and inventions and show how they have shaped global societies. While these are in fact, components of the 12^{th}-grade NALO benchmarks, they are far too detailed and specific to be accommodated in a baseline assessment. A shorter assessment can only measure a limited range of those outcomes. Rather, educators should focus on "teaching to the NALOs" and using the JMALI instruments as a way of gauging student progress over time. For stakeholders, the instruments can offer a starting-point measurement for a wide variety of audiences, the strength of the alignment to the cumulative NALOs offers users the ability to gain a sense of where knowledge is and where it is not. Meaning, there is enough content connection between the JMALI items and all K-12 NALO benchmarks to indicate either potential information gaps or proficient understanding.

This study also concludes that due to the design of the NALOs, JMALIs serve as a formative assessment for 9-11th graders. JMALI's proficiency stage model allows for showing student progress over time. Educators and stakeholders using younger audiences will benefit as the JMALI outcomes lead to improved instructional adjustment decisions. Formative assessment leads to decisions that are predicated on the best available information. The "in classroom" adjustments can be made in real-time due to the simplicity and ease of use administering and scoring the JMALIs.

Research Question 2

The consideration of the JMALIs as summative assessments for post-12th grade and adult audiences leads to the results determined in the second question. The greatest limitation of some standardized testing is that students receive a pass or fail score. Although, the research question directly points to calculating if JMALIs were a valid and reliable measure of agricultural literacy, it is equally important to address—how will we measure the level of agricultural literacy? The National Research Council (2009) suggested using progressive measures of assessment. This could be either formative in nature or by incorporating a proficiency scale model for summative evaluation. The JMALIs adapt the PISA model (OECD: PISA, 2016), specifically the proficiency scale (see Figure 10), as the foundation for the conceptual framework. From there, the theoretical model reflects three proficiency stages, influenced by the five NALO themes (see Figure 11). The validity and reliability efforts determine if the survey items crafted by the panels of experts meet the parameters of the proficiency stages by using the participant’s scores on the proficiency scale.

Results showed JMALI Instrument 1 and Instrument 2 (both 15-item assessments) were valid and reliable. This leads to the key conclusion that the use of JMALIs can determine an individual’s agricultural literacy proficiency level. Its use of the NALOs incorporates progressive benchmarks, builds upon student experiences, and allows students to transfer information between complementary concepts. The latter two points were critically important to FFSL framework, the seminal agricultural literacy assessment (Pense et al., 2005). However, by incorporating the NALO standards, it offers a level of standardization and updated techniques not seen in previous research (Brandt, 2016; Jones, 2013). Furthermore, Roberts (2006), Joplin (1981), and Collings, Greeno, and Resnick (2001) all concurred learning was ongoing, without a beginning, and seemingly endless, where all learners exist somewhere on the scale. JMALI’s proficiency stages capture all participants at some point on the knowledge scale, either at the exposure, factual literacy, or applicable proficiency level.

Gaining an understanding of what can be known about an individual’s knowledge at each of the proficiency stages is as valuable as knowing they can be obtained. In remembering that agriculture is a concept, which incorporates numerous and overlapping components, it is easy to see that drawing a hard line between knowing “something” and knowing “nothing” is impossible to accomplish. Participants at the exposure level, however, are classified as those who can recognize basic agricultural terms, recall singular facts (particularly those involving personal experiences), and recognize simple cause and effect relationships. For example, in JMALI Instrument 1, an exposure-level question asks participants to select examples of organic nutrients from a list of selections. Students use relatively lower-order learning skills such as recall to answer this terminology and fact-based question. As has been previously discussed, this question directly and indirectly addresses NALO demands, but is addressed to students to determine an exposure-type level of understanding.

Participants at the factual literacy level have what are called fluency skills by Bransford et al. (1999), and Curtis and Kruidenier (2005). They have direct knowledge of the information and some repetitive practice to articulate the information. The complexity of their skill is directly associated with how much practice they have received (Chall & Read, 1967). It can be noted that agricultural literacy "practice" often comes from real-life experience, activity in clubs, work opportunities, even exposure to rural communities and socio-cultural influences. Literacy-level proficiency questions draw on moderately complex facts and ideas. Participants must construct explanations, make simple predictions, and identify the relevancy of facts in context. A literacy-level question in one instrument asks students to determine if "all types of scientific discoveries and applications of technology are acceptable for consumers if they also increase food production." Students must deduce what types of scientific and technological innovation applies to food production and connect it to knowledge about whether those techniques are controversial. Ideally, if using either JMALI as a formative assessment, stakeholders would want to see participants either at or approaching a literacy-stage by the beginning of 12th grade. The literacy-level serves as a determination that students have an adequate level of information to build upon for concept mastery.

In a perfect world, all students would show applicable proficiency in agricultural literacy by the end of the 12th grade. By proficiency, this assessment indicates students would have "learned enough" in K-12 education to be ready to do well at the next level of learning. In this case, the learning would be applied through adult experiences, higher or technical education, career choice, or personal scholarship. Participants at proficiency level can recognize, articulate, and evaluate what they have learned. They use abstract ideas to explain complex phenomenon and demonstrate competency in unfamiliar information. Essentially, they can take what they have learned and synthesize information for "real-world" application. A proficiency stage question in JMALI asks students about identifying practices that benefit from precision agriculture. Beyond knowing a bit about each of those practices and how precision agriculture is conducted, students must scrutinize if those practices could benefit from applications associated with precision innovation and technology. The question is decidedly complex, requiring higher-order thinking skills such as interpretation and evaluation. The proficiency-level questions leave room for stakeholders to also apply qualitative techniques to probe for further understanding. While qualitative follow-up could be used with any participant group, it may be particularly helpful in determining a level of summative mastery in the NALOs.

Previous literature from Powell and Agnew (2011) states that American adults have no direct link to agriculture. If fluencies related to agricultural literacy are acquired through formal and nonformal agricultural experiences, one can conclude that obtaining agricultural education, via the NALOs and through national education standards (i.e., science, social studies, and healthy lifestyles), is as important as ever. If K-12 students aren't given other 'real-world' experiences to learn about agricultural concepts, their attitudes and behaviors will be determined by socio-cultural influences (Pew Research Center, 2015"). Birkenholz et al. (1994) showed that knowledge gaps in agricultural literacy are correlated with negative stereotypes and processes of agriculture. The negative stereotypes are formulated from a lack of or mis-information but grounded in the observations of everyday life. In order to change the stereotype, "we must change the reality that people observe" (Eagly, 2015, para. 7). Facilitating change comes through agricultural literacy interventions. Unfortunately, past literacy efforts have not been able to determine what interventions (e.g., resources, materials, workshops) are most effective (Doerfert, 2003). Determining effective learning outcomes, longitudinal program goals, and in-service achievement all rely upon having standardized assessment measures that can show improvement (or not) of those interventions. Moreover, Doefert concludes that the true implications of agricultural literacy can only be seen as we study populations over an extended period of time. Up until now, a current and reliable tool was not available. Looking ahead, the development of the NALOs provided the educational goals, but the validation of both JMALIs can show stakeholders *how* to achieve the goals and *who* has achieved the goals.

Research Question 3

The research concluded significant, positive relationships between higher amounts agricultural instruction (i.e., either through club involvement or agricultural coursework) and higher perceived levels of agricultural literacy. Research Question 3 also revealed that students who felt they had "a great deal" of exposure to agriculture (e.g., beyond clubs and coursework, but not excluding it) also stated they had either an "excellent" or "good" level of agricultural literacy. Compellingly, these results corroborate that the "things" a person does, most likely through coursework or clubs, and to a lesser extent hobbies, events, or work, will directly influence the perceived level of agricultural literacy obtained by the end of 12th grade. Describing these relationships as self-efficacy, rather than confidence or positive association is important. Self-efficacy levels in this capacity are best described by Bandura (1997) who stated, "Confidence is a nondescript term that refers to strength of belief but does not necessarily specify what the certainty is about…perceived self-efficacy refers to belief in one's agentive capabilities, the one can produce given levels of attainment" (p. 382). Bandura's description allows for the perspective that students felt secure enough in knowledge and experience to *know* they understood and (could) communicate the value of agriculture in everyday life (Spielmaker & Leising, 2013). The metacognitive abilities expressed by the participants have short- and long-term implications further explored in the next section.

Research Question 4

On the surface, the research concluded from Question 3 strengthens previous literature calling for continued efforts in agricultural education and recruitment to agricultural clubs to improve agricultural literacy (National Research Council, 2009). Additively, however, the final question concludes a positive correlation between students with perceptions of high self-efficacy in agricultural literacy and literacy achievement, by performing at a literacy or proficiency stage on JMALI Instrument 1. Consequentially, linking the results of Question 3 and Question 4, provides an educational framework using agricultural courses and clubs to increase the level of exposure, which leads to greater self-efficacy and performance actualization.

Efficacy-Performance relationships are inherently complex, but this educational framework is supported by theorists and literature. Multon, Brown, and Lent (1991) cited in their meta-analysis that older students do have a “more well-defined perception of their academic strengths and weaknesses, and have a better basis for making accurate self-efficacy appraisals” (p. 35). Those perceptions were even more apparent among college students in the low-to-normal achievement range, which fits the pattern seen by the results of this study. Bandura’s (1977) persistence theory states that self-efficacy is related to how long the behaviors have been sustained, or in this case, how long the level of exposure has been maintained. Other constructivist learning theories from Dewey and Kolb also state the significance of increasing exposure or experiences to encourage students to make connections and develop higher-level thinking when students link the “things they do” to “understanding” to “application.” D. A. Kolb (1984) further suggests that previous experience also contributes to an individual’s learning practices, such as reflecting, analyzing, thinking, deciding, and balancing—learning that can continue to increase in complexity.

For stakeholders, these results should serve as a strong confirmation that active learning, or experiential-based learning is not only desirable for teaching agricultural content, but overwhelmingly critical. Agricultural educators should more actively pursue enrolling students in content-area clubs, including environmentally-focused clubs to improve the number of out-of-classroom experiences. Club organizers should enhance active learning with student service learning opportunities and content-specific instruction followed by activities that allow participants to reflect on the experience. Reflective observation is how club participants will formulate, conceptualize, and test new information (A. Y. Kolb & Kolb, 2005).

For some agricultural educators, the message of advocating for active learning seems like old news, but Jones (2013) and Colbath and Morrish (2010) indicate a continued lack of agricultural literacy. This begs the question, are educators using active learning strategies to increase the level of hands-on experience and exposure? Even within this post-12th grade population, only 34% (n = 175, N = 515) of the students performed at the applicable proficiency level on JMALI Instrument 1 and 18% (n = 91, N = 515) at the same level on JMALI Instrument 2. Perhaps it is time to re-examine program and organizational content, strengthening focus on NALO benchmarks. This allows programs and organizations to have very specific outcome goals, for example having students at the 10th grade level meeting or exceeding all factual literacy benchmarks. Stakeholders should use the NALOs to determine guest speakers, field trips, community-service opportunities, and other experiences that can be reinforced by course instruction, or student-led projects. When jointly incorporated with the formative assessment capabilities of the JMALI instruments, stakeholders can track if their efforts are limiting or expanding students' agricultural literacy.

By account of these results, there is also room for improvement in nonformal or community-based education. Millennial and Gen Z young adults who lack self-efficacy in agricultural content will base their decisions on socio-cultural factors, rather than seeking to solidify information from research-based sources (Funk & Kennedy, 2016). With that kind of information, there are two ways to consider the outcomes. On one hand, the socio-cultural factors could lead to misinformation, bad decisions, and misdirected public policy. On the other, using socio-cultural factors to motivate participation can be a significant program advantage. The latter suggests that there is *great* potential for nonformal experiences to help improve the level of exposure, outside of the classroom, using andragogy-learning styles, in a setting that is inherently experiential in nature. Again, the NALOs should be recognized as a standardized benchmark that should be used to compliment content from formal education. Outcome projections and achievements based in standardized benchmarks, with a common tool for formal and nonformal education, unify ongoing literature.

Limitations

All research has limitations. Every assessment is flawed. Perhaps the greatest limitation is within JMALI itself. The NALO benchmarks are concurrent, overlapping, both broad and deep, and range in skill set and construct from K-12th grade. The two JMALI instruments are designed to be summative for the end of 12th grade. It is nigh impossible to comprehensively evaluate all NALO content in a 15-item evaluation. The exclusion of more questions must be countered with considerations related to audience, stakeholders, school and district rules for evaluation, implementation methods, and individual participant factors. Additionally, the development process for creating additional content must be metered against the time, salary, and commitment restraints of each member of the expert panels. Writing assessment questions is a significant undertaking; it must be managed in a way that is ultimately productive, but without resulting in specialists who are overworked and undercompensated. Ideally, the researcher would have liked to double the amount of content. Also, it would have been preferred to send items for review by outside experts, strictly to evaluate them for standards of good assessment. Nevertheless, the model used and the work conducted by the specialists.

As a review of statistical limitations mentioned in Chapter I, restrictions of the study also exist in the use of factor analysis to determine the validity of the questions. Factor analysis is ideal for measuring latent variables, or items that cannot be directly measured. The factors that appear can only come from the answers to the questions asked of the study participants. The questions were directly associated with the NALOs. These factors were naturally correlated, not independent. Therefore, multicollinearity was a risk. Measures of covariances among the latent variables were analyzed, but the confirmatory factor analysis (CFA) results should be treated with caution.

Related to limitations of the survey population, the lack of diversity must be addressed. Samples of convenience are exactly that: conveniently collected. Utah State University is representative of higher education populations within the Intermountain Region of the U.S. It does, however, overrepresent white, suburban, and relatively middle-class students. As such, one can suggest that the JMALIs are valid and reliable among those represented within this population. Certainly, the population does not represent an urban multi-ethnic sample. It is also disappointing that the inclusion of gender and Latinx populations were not identified in the demographic collection measures. It was intended within the proposal to include these measures, but somehow it was overlooked in the final review. Including this information is not critical to the research questions addressed, but it could have given insight, particularly to Question 3 and Question 4, and could have provided baseline information for future research. Lastly, the survey relied upon self-reported information that is subject to misinterpretation, fatigue, and the general apathy found among college students who are "just doing it for extra credit."

The JMALI survey was conducted while fall 2018 courses were in session. The survey was open for a period of three weeks, so threats to internal validity should be considered. It is possible that students could have received information related to agriculture in a related or unrelated course. It is not likely they gained a significant amount of information, maturation, or knowledge, but the consideration should not be zero.

Implications for Research

Agricultural literacy is the ability of a person to understand and communicate the source and value of agriculture as it affects quality of life (Spielmaker et al., 2014). The ability for adult populations to have a scientific and contextual understanding of agriculture has a profound effect upon modern society through the attitudes, perceptions and choices made by American consumers (U.S. Department of Agriculture, Economic Research Service, 2017). Agricultural literacy, then, is the link allowing adults to recognize and interpret information relevant to their own health, climate change, environmental impacts, public policy, and economic outcomes. Consequently, it is *profoundly* unfortunate that despite federal, state, and local formal and nonformal education programs the overall number of agriculturally literate adults remains low or very low (Kovar & Ball, 2013; Mercier, 2015).

The inferior literacy levels generated past efforts to improve the amount and type of education and programs for students and adults. Agricultural literacy assessment was a component of those cited program improvements. Assessment efforts, however, were confounded by inconsistencies between standards, criteria, even the definition of agricultural literacy (Brandt, 2016). Since 1998, the FFSL instrument has played an integral role in providing a backbone for agricultural literacy assessment (Leising et al., 1998). It was used in key assessments conducted by Colbath and Moorish (2010) Leising et al. (2000), Leising and Pense (2001), and Meischen and Trexler (2003). There were numerous other studies that used the FFSL as a framework, but modified for unique populations (Birkenholz et al., 1994; Hess & Trexler, 2011; Mabie, 1996; Meischen & Trexler, 2003; Terry et al., 1992; Trexler, 2000). Over time, stakeholders and researchers recognized the need for a uniform instrument that had consistent standards, could unify results, allow educators to work toward larger program goals, and be used across both formal and nonformal platforms of education. Brandt detailed those needs by affirming it was necessary to use the NALOs as a uniform method of assessment.

At its core, the JMALIs are a compilation of all past agricultural literacy efforts. The model was developed by first examining the deficiencies of previous assessments, focusing on using standardized benchmarks, and seeking to provide unified evaluation across education platforms. JMALIs measure NALO demands on a proficiency scale to provide baselines for programs without prior data, account for student and adult populations, and determine both summative and formative evidence.

What's more, it enables a path forward for directly completing two of the three objectives of the W2006 Multistate Research Project, the top priorities for the National Center for Agricultural Literacy (NCAL), namely: (1) Assessing agricultural knowledge of diverse segments of the population; and (2) Evaluating agricultural literacy programs to measure the program impacts (National Center for Agricultural Literacy, 2017). The third objective relates to the assessment of perceptions and motivations concerning agriculture of diverse segments of the population, which comes as an indirect but associated outcome of using the JMALI assessments. NCAL believes that a multistate effort of evaluation and assessment should be done over the next five years—to set the stage for a two-decade effort to determine longitudinal impacts (National Center for Agricultural Literacy, 2017). For stakeholders looking to join the effort, JMALIs and their companion study, LMALIs (K-5 assessments) from Longhurst et al. (2019) offer straightforward, easy-to-use platforms that can provide validated data to inform research. A directed endeavor to conduct agricultural literacy research, on a unified platform, is long overdue.

As researchers gain more understanding of what adults "know" about agriculture, they can direct the focus of future research on indicating indirect consequences of illiteracy. Public perceptions, attitudes, apathy, and the formation of misconceptions offer a specialized view of how adults make decisions. “By 2025, Millennials will comprise 75% of the workforce…they are repainting the canvas of social policy…it matters what those who are impacted think about current affairs and how they participate in the process” (Cramer et al., 2018, p. 8). It cannot be overstated that the time for conducting research that aligns with understanding their priorities and opinions, is here. Understanding what young adults think, how they think, and how agricultural products, processes, and policy make them feel has the potential to directly and indirectly shape how we produce, process, and provide food, clothing, and shelter for the next century.

The parameters of future research for JMALI also encompass the examination of existing NALOs. As data on a variety of future populations is conducted, the information should be analyzed to determine if patterns or deficiencies are detected in the benchmarks. The process of determining agricultural literacy benchmarks is iterative and JMALI instruments should be used to scrutinize the NALO themes and grade-level content.

Last, results of this study indicate the area of literacy most lacking is in the area of connections between agriculture and STEM. In the companion study (LMALI; Longhurst et al., 2019) and through this research, it is clear that at multiple grade levels students struggle to connect modern technology and innovation with agricultural production and process. Consistently, the scores were so low it was difficult to detect, beyond “farmers use a tractor,” if students understood that agriculturists regularly use GPS, cell phones, computers, drones, and precision technology to “get work done.” These observations lend credibility to Priority 1 of the National Research Agenda’s suggested research in the area of Public and Policy Maker Understandings of Agriculture and Natural Resources, which asks stakeholders and researchers to better understand how STEM is (or is not) integrated into agriculture (National Center for Agricultural Literacy, 2017). JMALI could be used in mixed methods research to more accurately determine where STEM knowledge is acquired (if at all). These gaps often form and become permanently incorporated into misconceptions and leave students with exposure-type proficiency levels as young adults. The measurement of baseline knowledge in STEM, will correlate directly with research to determine consumer attitudes and perceptions. Those with limited agricultural knowledge in STEM-associated areas are most at risk for the inability to distinguish pseudo-science and neglecting probability bias (perceived risk versus actual risk). Research-based and data-driven educational efforts in this area have significant potential to shape decision-making and crucial policies related to science and society.

Implications for Practice

The JMALI instruments each contain 15 items. Though developed as a summative tool, they can be used for formative evaluation. There are immediate implications for practitioners regarding how evaluation should be administered, scored, and analyzed.

How to Administer JMALI Instruments

Stakeholders may choose to use either Instrument 1 or Instrument 2, but it is not advised that questions are mixed between the two. The validated scoring measures are *only* appropriate when each instrument is conducted with its specific 15 items. Any deviation or changes to the survey will invalidate any proficiency scoring gauges.

The JMALI instruments are best administered to young adult populations via online survey format. The study survey was conducted via Qualtrics, but other free programs (e.g., Survey Monkey) will work well. It is strongly recommended that some demographic information be included prior to or during data collection. The demographic survey questions used by the study are included in Appendix B. These questions may be most appropriate for replication research but may serve as a guideline for in-practice evaluations. Practitioners should advise participants that the assessment will take approximately 10-15 minutes, dependent upon additional demographic information collected. The time estimation is maximized, and most participants will finish in far less time. It should be noted that demographic data, collected longitudinally over five years is one of the best ways to view trends. To make predictions based on longitudinal collection, data collected from year to year needs to be organized in a way that facilitates comparison. A reminder that formulating a plan for evaluation, *before* conducting surveys, is the only way to ensure retrieval of meaningful information.

Scoring and Analyzing Proficiency Stages

Scoring the proficiency stages is the most critical part of data analysis. Most online survey tools will provide the practitioner with a total score for each participant. The total scores should be obtained. Other descriptive measures are beneficial for determining baseline information, such as the mean, median, mode, standard deviation for the total correct responses for the whole population. Even more beneficial for practitioners is the identification of each individual proficiency stage, based upon the total number of correct responses. Proficiency stages are determined by using the proficiency scale (see Figure 10). Practitioners can identify participant stages for both instruments by listing those with a score ≥ 12 as proficient, those with a score ≥ 8 as factually literate, and those with a score ≤ 7 as exposure level. Practitioners can then use the average number of participants in each proficiency stage for evaluation goals.

Beyond using the total score to determine proficiency level, practitioners can also examine outcomes based on proficiency in each of the five NALO themes. The themes are representative of areas of agricultural literacy and can be good indicators of where participants excel or are poorly instructed. For example, participant scores at a literacy or proficiency level in all thematic areas, except for Theme 4 (STEM), may possibly indicate that there are knowledge gaps related only to STEM connections. Or, a single student scores at exposure levels, except for themes related to geography (Theme 5) may indicate personal experiences related to living in a rural location or extensive travel. When these anomalies are detected, practitioners are encouraged to use qualitative measures to determine the individual sources of inconsistency. Longitudinal data collection, using JMALIs with student populations, from 9th through the 12th grade may show the most significant results in relation to NALO themes. If NALO benchmarks are used for program achievement goals, and students do not show consistent growth in all five themes, JMALI scores become indicators of curriculum and instruction problems.

Lastly, the use of partial scoring techniques should not be overlooked. Practitioners should examine the correct or incorrect item selections, particularly on multiple choice questions, to that information to dictate future instructional choices. Partial scoring is insightful for comparing a “pure guess” answer to something more substantial where a student only lacks a part of the information related to the whole. It is possible some literacy-level students are nearly proficient, if they could solidify some key pieces of information. Partial scoring also has significant implication for formative instruction. Educators and stakeholders should consider why students missed specific question items to direct future instructional goals and determine how to address misconceptions. The formative evaluation happens in "real-time," which lends the advantage of redirecting effort in the moment it is most needed. Additionally, using JMALIs formatively, in combination with qualitative interviews, could be the most directive way to determine how participants perceived or misperceived the correct answer. It also exposes aspects unrelated, but associated with educational development, such as personal bias, attitudes, and perceived socio-cultural norms.

Considerations for Educators

"Data-driven evaluation" is a trigger word for educators, who struggle to develop valid and reliable instrumentation that leads to accurate evaluation of a program. Often, results of classroom surveys or evaluations are unreliable or fail to provide consistent parameters. The key to determining actual effect is first, establishing the desired outcomes and then using a reliable instrument to calculate the results. If educators use JMALIs to frequently calculate summative or formative measures of agricultural literacy, without *first* establishing the desired outcomes, they will never move the needle towards improvement. It is only through the process of planning *and* doing that practitioners begin to understand when to "maintain the course" and when to make changes.

It is recommended that educators coordinate agricultural literacy efforts by forming a leadership team. Team efforts allow educators to expand both population numbers (*N*) and the interpretation of results. Leadership teams should also use "SMART" goals, or goals that are: (1) specific, (2) measurable, (3) achievable, (4) research-based, and (5) time sensitive (Doran, 1981). Using the NALO benchmarks as outcomes and JMALI instruments as research-based forms of assessment allows education teams to tackle all five components for goal setting and achievement. Furthermore, coordinating efforts for outcomes and evaluation leads to avenues for educators to share curriculum and pedagogy strategies. It cannot be overlooked that the teacher's level of agricultural literacy will contribute to the level of abilities achieved by students. It may be beneficial to use JMALI assessments to determine proficiency stages among educators, to identify weaknesses in understanding. The identification can help determine potential professional development opportunities to increase or improve expertise.

Last, based on study results, educators must use and increase the use of experiential learning. The strong, positive associations shown here, and in numerous other studies, prove again and again that experiential learning increases agricultural literacy. One way to improve the quality of experience is to consider the student's proficiency stage. By measuring student progress with JMALIs, students could be placed in groupings based on their knowledge and skill needs. These practices are frequently used for other forms of literacy acquisition because of their effectiveness. When students are grouped by ability, the learning environment becomes more collaborative and dependent upon teamwork. Teachers can tailor specific activities, encourage more proficient students to share the experiences that have improved their literacy levels, and use curriculum designed for that learning stage. The informative nature of the JMALI assessments offers an efficient way to group students for more intensive instruction and to quickly advance their progression.

Considerations for Program Evaluation

Although there are numerous different types of stakeholders invested in agricultural literacy, most have a common question. Did this [insert: funding, workshop, in-service, activity kit, presentation, field day, seminar, institute, promotional flyer] increase levels of agricultural literacy over time? Nearly all want to know it because it is a direct reflection on the efficacy of their program, agency, non-profit group, or teaching ability. In evaluation research, immediate action is based on the recommendation of the results. Stakeholders have practical purposes and must clearly determine whether a program is successful and valuable enough to be continued.

JMALI instruments best serve as indicators for assessing program outcomes. Care should be taken not to associate agricultural literacy proficiency with organizational effectiveness (e.g., management, organizational effort, or marketing a message). Rather, proficiency scores relate to efficacy in measuring changes in knowledge, behaviors, and learned skills of assessment participants. Proficiency scores, as a quantitative measure, only offer a limited degree of what participants may know. Before determining program outcomes, determine exactly how the score will be used as a program measure. Preferably, proficiency scores would be used for program evaluation in conjunction with participation numbers, evaluation forms, community or regional information, or post-assessment participant interviews. Combining collective data alleviates a few of the limitations of basing programs on a single assessment. Non-school-centered adult participants are not highly motivated to exert a full measure of effort. They are rarely compensated and probably lack the insight to see the significance or impacts of their effort. Therefore, it is important to present the administration of these instruments in circumstances that provoke thoughtful responses. Assessments should be administered in a fashion that creates an environment where participants clearly understand the importance of their effort. It is recommended that these instruments are used with a written, logical plan of action, with strategies in place for last minute or emergency modifications.

Conclusions

Agricultural literacy needs to be more than “farmers use a tractor and milk comes from a cow.” Efforts to improve literacy should include instruction about the depth of agriculture’s complexities. The impact of those efforts should also be determined with a level of complexity. The quality of analysis used to establish literacy levels will also be correlated to the quality of literacy improvement. It has been 20 years since researchers last attempted to build a framework of standardized benchmarks with a validated and reliable assessment for measuring literacy rates. Moving forward, the JMALIs have demonstrated potential to unify agricultural research for educators and stakeholders. The instruments developed through this study should be used to conduct further research related to agricultural literacy, program evaluation, participant attitudes and behaviors, and curriculum improvement. Researchers and stakeholders should use JMALI instruments to acquire short-and-long-term data serving to influence both programs and future policy. Ultimately, the voice controlling the progression of modern agricultural practice will be determined by majority rule. The process of ensuring the majority is agriculturally literate will be established by knowing what is working and what is not. Agricultural literacy will *not* improve until programs, decisions, and goals are made using standardized, data-driven assessment.

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APPENDICES

Appendix A

National Agricultural Literacy Outcomes

Theme 1: Agriculture and the Environment

Agriculture has transformed and had to work with natural ecosystems to fulfill societal needs. Agro-ecosystems are now recognized as a major part of global ecosystems. To understand the processes and components, and the dependence and interactions of organisms and environment in natural systems, is to understand the dynamics of agricultural systems. Agriculture and natural resource management is a science-based human activity subject to divergence of opinions and public policies influencing the development and application of science and technology for the public good. Inputs and outputs of modern agriculture and food industries involve many technologies based on both public and private research and development. Theme 1 examines the relationship between agriculture and the environment.

Grade Level Benchmarks	**Agriculture and the Environment Outcomes** * Science-related content ** Social studies-related content
Early Elementary (Kindergarten – Grade 2) T1.K-2	a. Describe how farmers/ranchers use land to grow crops and support livestock * b. Describe the importance of soil and water in raising crops and livestock * c. Identify natural resources * d. Provide examples of how weather patterns affect plant and animal growth for food *
Upper Elementary (Grades 3-5) T1.3-5	a. Describe similarities and differences between managed and natural systems (e.g., wild forest and tree plantation; natural lake/ocean and fish farm) * b. Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production * c. Identify land and water conservation methods used in farming systems (wind barriers, conservation tillage, laser leveling, GPS planting, etc.) * d. Identify the major ecosystems and agro-ecosystems in their community or region (e.g., hardwood forests, conifers, grasslands, deserts) with agroecosystems (e.g., grazing areas and crop growing regions) ** e. 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) *
Middle School (Grades 6-8)	a. Compare and contrast the advantages and disadvantages involved when converting natural ecosystems to agricultural ecosystems *

T1.6-8	b.	Describe benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests), in agricultural systems which impact water, air, and soil quality *
	c.	Discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation) *
	d.	Discuss (from multiple perspectives) land and water use by various groups (i.e., ranchers, farmers, hunters, miners, recreational users, government, etc.), and how each use carries a specific set of benefits and consequences that affect people and the environment *
	e.	Discuss the comparative environmental pros and cons of populations relying on their local and regional resources versus tapping into a global marketplace *
	f.	Explain and discuss why people migrate and change environments to meet their basic needs **
	g.	Recognize how climate and natural resources determine the types of crops and livestock that can be grown and raised for consumption *
	h.	Recognize the factors of an agricultural system which determine its sustainability *
High School (Grades 9-12) T1.9-12	a.	Describe how wildlife habitats are created and maintained by farmers/ranchers and why these habitats are important (e.g., promoting pollinator habitat, insect refuges, creating buffer zones for nutrient management, etc.) *
	b.	Describe resource and conservation management practices used in agricultural systems (e.g., riparian management, rotational grazing, no till farming, crop and variety selection, wildlife management, timber harvesting techniques) *
	c.	Discuss the scientific basis for regulating the movement of plants and animals worldwide to control for the spread of potentially harmful organisms (e.g., invasive species and disease-causing organisms such as foot and mouth disease and avian and swine flu) as well as the methods of control in place (state, national, and international policies, economic incentives) *
	d.	Discuss the value of agricultural land *
	e.	Evaluate the potential impacts of climate change on agriculture*
	f.	Evaluate the various definitions of “sustainable agriculture,” considering population growth, carbon footprint, environmental systems, land and water resources, and economics *
	g.	Identify non-native or invasive species in your state that impact the sustainability and/or economic value of natural or agricultural ecosystems *
	h.	Understand the natural cycles that govern the flow of nutrients as well as the way various nutrients (organic and inorganic) move through and affect farming and natural systems *

Theme 2: Plants and Animals for Food, Fiber & Energy

Early humans developed agriculture as an alternative to hunting and gathering. This transition not only began to free up labor but resulted in surpluses of various goods, which could, in turn, be traded. Since the domestication and cultivation of plants, and the domestication and raising of animals (agriculture), humans have been experimenting with genetics, types of soils, climate, production practices, and harvesting to meet the needs of a growing population.

Agriculture provides the food supply needed for survival, growth, and health for both humans and animals. The variety of year-round food choices has grown; foods not locally produced are available partly due to the transportation and distribution networks. The major factors in food and feed choices for people and their animals are cost, culture, convenience, and access and/or availability. Theme 2 focuses on the importance and stewardship of natural resources in sustainably delivering high quality food, fiber, and energy while at the same time maintaining a quality environment.

Grade Level Benchmarks	**Agriculture and the Environment Outcomes** * Science-related content ** Social studies-related content *** Health-related content
Early Elementary (Kindergarten – Grade 2) T1.K-2	a. Explain how farmers/ranchers work with the lifecycle of plants and animals (planting/breeding) to harvest a crop * b. Identify animals involved in agricultural production and their uses (i.e., work, meat, dairy, eggs) * c. Identify examples of feed/food products eaten by animals and people *** d. Identify food safety practices to demonstrate at home *** e. Identify the importance of natural resources (e.g., sun, soil, water, minerals) in farming * f. Identify the types of plants and animals found on farms and compare with plants and animals found in wild landscapes *
Upper Elementary (Grades 3-5) T1.3-5	a. Discuss similarities and differences in food, clothing, shelter, and fuel sources among world cultures ** b. Distinguish between renewable and non-renewable resources used in the production of food, feed, fuel, fiber (fabric or clothing) and shelter * c. Explain how the availability of soil nutrients affects plant growth and development * d. Provide examples of specific ways farmers/ranchers meet the needs of animals * e. Understand the concept of stewardship and identify ways farmers/ranchers care for soil, water, plants, and animals *
Middle School (Grades 6-8)	a. Describe the differences in plants and animals used for food, clothing, shelter, and fuel before and after European settlement of the U.S. **

T1.6-8

b. Explain the role of ethics in the production and management of food, fiber (fabric or clothing), and energy sources ***
c. Identify farm practices for plant protection (e.g., using a pesticide, integrated pest management, cultural practices) and the harvest of safe products for consumers *
d. Identify renewable and nonrenewable energy sources *
e. Identify strategies for housing for animal welfare and the safety of animal products (e.g., meat, milk, eggs) *
f. Identify where labeling indicates the origin of food and fiber (fabric or clothing) **

High School
(Grades 9-12)

T1.9-12

a. Compare and contrast the differences between nature's plant and animal lifecycles with agricultural systems (e.g., producers manage the lifecycle of plants and animals to produce a product for consumption) *
b. Compare similarities and differences between organic and inorganic nutrients (i.e., fertilizer) on plant growth and development; determine how their application affects plant and animal life *
c. Discuss reasons for government's involvement in agricultural production, processing, and distribution **
d. Evaluate evidence for differing points of view on topics related to agricultural production, processing, and marketing (e.g., grazing; genetic variation and crop production; use of fertilizers and pesticides; open space; farmland preservation; animal welfare practices; world hunger) *
e. Identify inspection processes associated with food safety regulations **

Theme 3: Food, Health & Lifestyle

Healthful eating means eating a variety of nutritious foods. Food contains six nutrients that people need for good health. The nutrients include carbohydrates, proteins, fats, minerals, vitamins and water. The U.S. Department of Agriculture (USDA) makes general recommendations about what people should eat. The USDA's "My Plate" features a dinner plate divided into four sections: fruits, grains, vegetables, and protein, with dairy pictured as a glass alongside the plate. Vegetables and grains have the largest recommended daily serving size, and proteins and fruits are slightly smaller in serving size, along with dairy.

Farmers and ranchers provide a variety of year-round food choices. Foods not locally produced are available partly due to the transportation and distribution networks.

The major factors in food choices have been cost, culture, convenience, and access and/or availability. Advertisements are another form of information that guide food choices. Recently, Americans have become more interested in how food is produced, its nutritional value, agriculture's impact on the environment, and the contribution agriculture makes to the local economy and landscape. Consumer demand ultimately influences what is produced and how it is processed and marketed.

The U.S. food supply is considered the safest in the world. Still, food safety issues exist in the U.S. and abroad. According to food safety experts, improper storage, handling, and preparation of food—both at home and at food establishments—pose the top food safety problems today. Everyone who handles food in any form should know the basic safe food-handling practices. Safety concerns include microbiological contamination and non-living contaminates such as drug and pesticide residues and bone fragments. Contamination can occur during any step of food processing, storage, or handling of food products. The USDA regulates food processors and also provides consumer guidelines for safe handling, preparation, and storage of foods. Theme 3 explores the relationship between food production, storage, preparation, consumption, and health.

Grade Level Benchmarks	Agriculture and the Environment Outcomes * Science-related content ** Social studies-related content *** Health-related content
Early Elementary (Kindergarten – Grade 2) T1.K-2	a. Identify healthy food options *** b. Recognize that agriculture provides our most basic necessities: food, fiber (fabric or clothing), energy, and shelter ** c. Understand where different types of foods should be stored safely at home **
Upper Elementary (Grades 3-5) T1.3-5	a. Describe the necessary food components of a healthy diet using the current dietary guidelines *** b. Diagram the path of production for a processed product, from farm to table **

c. Distinguish between processed and unprocessed food ***
d. Explain the costs associated with producing and purchasing food **
e. Explain the practices of safe food handling, preparation, and storage ***
f. Identify careers in food, nutrition, and health ***
g. Identify food sources of required food nutrients ***

Middle School
(Grades 6-8)

T1.6-8

a. Demonstrate safe methods for food handling, preparation, and storage in the home ***
b. Evaluate food labels to determine food sources that meet nutritional needs ***
c. Evaluate serving size related to nutritional needs ***
d. Explain how factors, such as culture, convenience, access, and marketing affect food choices locally, regionally, and globally***
e. Explain the benefits and disadvantages of food processing ***
f. Explain the role of ethics in the production and management of food, fiber (fabric or clothing), and energy sources ***
g. Identify agricultural products (foods) that provide valuable nutrients for a balanced diet ***
h. Identify forms and sources of food contamination relative to personal health and safety ***
i. Identify sources of agricultural products that provide food, fuel, clothing, shelter, medical, and other non-food products for their community, state, and/or nation **
j. Identify the careers in food production, processing, and nutrition that are essential for a healthy food supply ***

High School
(Grades 9-12)

T1.9-12

a. Accurately read labels on processed food to determine nutrition content ***
b. Compare the changes in nutritional needs of humans over their lifetimes ***
c. Describe the nutritional value that can be added by processing foods ***
d. Evaluate the cost of food in the U.S. relative to other countries **
e. Explain food labeling terminology related to marketing and how it affects consumer choices (e.g., natural, free-range, certified organic, conventional, cage-free, zero trans-fat, sugar-free, reduced calorie) ***
f. Explain how food production systems are influenced by consumer choices ***
g. Identify how various foods can contribute to a healthy diet ***
h. Provide examples of foodborne contaminants, points of contamination, and the policies/agencies responsible for protecting the consumer ***

Theme 4: Science, Technology, Engineering & Mathematics

According to most historians, the development of agriculture resulted in the beginning of civilization. Agricultural development has relied on evolving scientific understandings, engineering processes, and the application of both to develop innovative technologies to save labor and increase yields. In the early 1900s, 50% of the U.S. population lived in rural areas, and 30% made their living on the farm. Technological advancements of the last century have resulted in a nation where just over 1% (Central Intelligence Agency, 2013) of the population make their living on farms and ranches. It may seem that we no longer need to consider agricultural careers as important or relevant; however, it takes 21 million workers, or about 15% of the U.S. population to support farm and ranch production, processing, and marketing (Goecker et al., 2010). The fact that 1% of the population produces for the other 99% is a real achievement! What has happened to cause this change in 100 years? Science, technology, engineering and mathematical understandings to address labor, and solve production and environmental problems.

The science and technologies applied to agriculture and food, rival the science and technologies applied to medicine. Agriculture is the "other" major health science—applying science, engineering, technology, and mathematics to improve the health of plants and animals, of people, and our environment. The fields of mechanical engineering, microbiology, genetics, and chemistry have their origins intrinsically linked with agriculture and food, and while we have fewer people working on farms, the 21 million workers that support agricultural production include scientists, engineers, and entrepreneurs.

Our quality of life is dependent upon the continued development of appropriate use of science and engineering to provide an abundance of safe, healthy, nutritious food, fibers, and the fuels necessary to sustain the needs of a growing world population. At the same time, we need to sustain the natural resource base of this planet—on which all life depends! While yields and laborsaving technologies remain important, future agricultural scientists and engineers will need to solve additional problems that will lead to a more sustainable agricultural system that feeds a growing population. Theme 4, understanding the science, engineering, technology, and mathematics of agriculture, food, and natural resources is crucial for the future of all humanity.

Grade Level Benchmarks	Agriculture and the Environment Outcomes * Science-related content ** Social studies-related content
Early Elementary (Kindergarten – Grade 2) T1.K-2	a. Explain what tools and materials farmers/ranchers use to reduce heating and cooling in plant and livestock structures * b. Recognize and identify examples of simple tools and machines used in agricultural settings (e.g., levers, screws, pulley, wedge, auger, grinder, gears, etc.) *
Upper Elementary (Grades 3-5) T1.3-5	a. Compare simple tools to complex modern machines used in agricultural systems to improve efficiency and reduce labor * b. 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 * c. 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.) * d. Provide examples of science being applied in farming for food, clothing, and shelter products *
Middle School (Grades 6-8) T1.6-8	a. Compare and contrast historical and current food processing and systems ** b. Describe how biological processes influence and are leveraged in agricultural production and processing (e.g., photosynthesis, fermentation, cell division, heredity/genetics, nitrogen fixation) * c. Describe the process of development from hunting and gathering to farming ** d. Discuss how technology has changed over time to help farmers/ranchers provide more food to more people ** e. Explain how and why agricultural innovation influenced modern economic systems ** f. Explain the harmful and beneficial impacts of various organisms related to agricultural production and processing (e.g., harmful bacteria/beneficial bacteria, harmful/beneficial insects) and the technology developed to influence these organisms * g. Identify science careers related to both producers and consumers of agricultural products * h. Identify specific technologies that have reduced labor in agriculture ** i. Provide examples of science and technology used in agricultural systems (e.g., GPS, artificial insemination, biotechnology, soil

		testing, ethanol production, etc.); explain how they meet our basic needs; and detail their social, economic, and environmental impacts *
High School (Grades 9-12)	a.	Correlate historical events, discoveries in science, and technological innovations in agriculture with day-to-day life in various time period **
T1.9-12	b.	Describe how agricultural practices have contributed to changes in societies and environments over time **
	c.	Discuss population growth and the benefits and concerns related to science and technologies applied in agriculture to increase yields and maintain sustainability *
	d.	Evaluate the benefits and concerns related to the application of technology to agricultural systems (e.g., biotechnology) *
	e.	Identify current and emerging scientific discoveries and technologies and their possible use in agriculture (e.g., biotechnology, bio-chemical, mechanical, etc.) *
	f.	Predict the types of careers and skills agricultural scientists will need in the future to support agricultural production and meet the needs of a growing population *
	g.	Provide examples of how processing adds value to agricultural goods and fosters economic growth both locally and globally**

Theme 5: Culture, Society, Economy & Geography

Agriculture and natural resource systems have played a key role in the development of the U.S. and the sustainability of civilizations throughout the history of the world. Agriculture changed from hunting and gathering to forms of permanent agriculture, which in turn, led the way for expansion of agricultural production and the integration of new technologies. Producing, processing, marketing, and distributing food, fuel, clothing, and shelter have been the work of most of humanity through the ages to ensure survival.

Largely, geographic location (longitude, latitude, elevation, soil type and precipitation) determines what plants and animals will grow and, therefore, determines what humans and animals will generally eat, what materials will be available for building shelters, making clothing, and providing fuel. As a result, distinct diets emerge for people living in different places in the world. Religion and other customs have further guided people's food choices, language, dress, festivals, and artistic expression, which we often refer to as culture.

As productivity of agriculture increased through the application of science and technology, global trade of agricultural products expanded, which led to the development of more industrialized societies. Also, changes in the demand for agricultural workers from production (farming) to science, processing, and related agri-businesses resulted. Today, food, fiber, and fuel are traded globally, and often products travel thousands of miles from where they were produced to where they are consumed.

The global movement of agricultural products continues to be driven by economics, and consumer demand and preferences. Agriculture, food, and natural resource systems continue to play an integral role in the evolution of societies, both in the U.S. and the world.

Grade Level Benchmarks	**Agriculture and the Environment Outcomes** All indicators are Social studies-related content
Early Elementary (Kindergarten – Grade 2) T1.K-2	a. Discuss what a farmer does b. Explain why farming is important to communities c. Identify places and methods of exchange for agricultural products in the local area d. Identify plants and animals grown or raised locally that are used for food, clothing, shelter, and landscapes e. Identify the people and careers involved from production to consumption of agricultural products f. Trace the sources of agricultural products (plant or animal) used daily
Upper Elementary (Grades 3-5) T1.3-5	a. Describe how supply and demand impact the price of agricultural goods b. Discover that there are many jobs in agriculture c. Explain how agricultural events and inventions affect how Americans live today (e.g., Eli Whitney - cotton gin; Cyrus McCormick - reaper; Virtanen - silo; Pasteur - pasteurization; John Deere - moldboard plow) d. Explain the value of agriculture and how it is important in daily life e. Provide examples of agricultural products available, but not produced in their local area and state f. Understand the agricultural history of an individual's specific community and/or state

Middle School (Grades 6-8) T1.6-8	a.	Consider the economic value of agriculture in America
	b.	Distinguish between careers in production (farmers and ranchers) with those that directly involve consumers (business and nutrition)
	c.	Explain how agricultural production and trade led to the development of industrialized societies
	d.	Explain how prices for agricultural goods are determined
	e.	Explain the role of exploration and trade in sustaining early societies
	f.	Highlight the interaction and significance of state historical and current agricultural events on governmental and economic developments (e.g., the building of railroads, the taxation of goods, etc.)
	g.	Identify agricultural products that are exported and imported
	h.	Identify farm ownership in relation to processor ownership (e.g., cooperatives, corporations, vertical integration)
High School (Grades 9-12) T1.9-12	a.	Communicate how the global agricultural economy and population influences the sustainability of communities and societies
	b.	Compare and contrast the advantages and disadvantages of fewer farmers/ranchers
	c.	Compare and contrast the economic challenges facing developed and under-developed countries (poverty, population, and hunger)
	d.	Describe essential agricultural careers related to production, consumption, and regulation
	e.	Discuss how agricultural practices have increased agricultural productivity and have impacted (pro and con) the development of the global economy, population, and sustainability
	f.	Discuss the relationship between geography (climate and land), politics, and global economies in the distribution of food
	g.	Evaluate and discuss the impact of major agricultural events and agricultural inventions that influenced world and U.S. history
	h.	Explain how comparative and absolute advantage in agriculture impacts supply and demand in relation to trade
	i.	Explain the role of government in the production, distribution, and consumption of food
	j.	Provide examples of how changes in cultural preferences influence production, processing, marketing, and trade of agricultural products

Appendix B

JMALI 2019: Demographic Questions

JMALI 2019: Demographic Questions

1. Please identify your ethnicity.

   - ☐ White
   - ☐ Black or African American
   - ☐ American Indian or Alaska Native
   - ☐ Asian
   - ☐ Native Hawaiian or Pacific Islander
   - ☐ Other
   - ☐ I do not wish to identify my ethnicity

2. How many years of college have you completed?

   - ☐ 0-1 years
   - ☐ 2 years
   - ☐ 3 years
   - ☐ 4 years
   - ☐ 4+ years

3. Please identify your intended major. [open-ended, text box included]

4. Please mark all the options that best describe the geography and location of your hometown.

   - ☐ Urban area, many people living in apartments and using public transit for travel.
   - ☐ Urban area with designated open spaces for public use (e.g., parks, zoos, lakefront, walking trails, or gardens).
   - ☐ Suburban area, many people travel by car or public transit (e.g., bus, subway, train) to their home, from more urban areas where they work.
   - ☐ Suburban area, some designated open space areas mixed with businesses and service providers.
   - ☐ Suburban area, relatively few people have a home with a yard or acreage.
   - ☐ Suburban area, many people have a home with a yard or acreage.
   - ☐ Suburban area, many students are bused/travel to school from more rural, open areas.
   - ☐ Rural area, many fields and agricultural businesses (including nurseries or greenhouses) are present.

5. Did you take an agricultural course in middle or high school (i.e., agricultural biology, animal science, greenhouse management)? If so, please list the course.

   - ☐ Yes, [open ended, text box]
   - ☐ No

6. Have you participated in any agricultural-related club(s) or group(s) (e.g., FFA, biology, robotics)? If so, please list the club(s) or group(s).

- ☐ Yes, [open ended, text box]
- ☐ No

7. Have you participated in any environmental-related club(s) or group(s) (e.g., related to recycling, sustainability, or increasing awareness)? If so, please list the club(s) or group(s).

   - ☐ Yes, [open ended, text box]
   - ☐ No

8. On a scale from 0-5, please rate your level of exposure to agriculture.

   How much do you know or understand about agriculture?
   [A great deal, A lot, A moderate amount, A little, None at all]

9. Please indicate which of the following events you have experienced.

   - ☐ Working on a farm/ranch, greenhouse, timber, or other agricultural industry
   - ☐ Traveling to a farm or touring a farm
   - ☐ Farm-related events at school
   - ☐ Attending a state or county fair
   - ☐ Listening to guest speakers who spoke about an agricultural topic (e.g., a farmer or landscaper)
   - ☐ School or home/family gardening
   - ☐ Traveling to a garden or botanical event
   - ☐ Farm to School or Community Food programs
   - ☐ Listening to volunteers or being a volunteer who shares agricultural information
   - ☐ Reading books about agriculture
   - ☐ Involvement in local food programs
   - ☐ Other
   - ☐ None of these choices

10. Rank your perception of your own level of agricultural literacy. An agriculturally literate person understands and can communicate the source and value of agriculture in their everyday life.

My own level of agricultural literacy. [Excellent, Good, Average, Poor, Terrible]

Appendix C

Judd-Murray Agricultural Literacy Instruments

Instrument 1

1. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources.* *1.12.E₁*
   - ☐ The statement is true
   - ☐ The statement is false

2. Determine if the statement is true or false: *There are few incentives for agriculturists to protect the environment and natural resources.* *1.12.L₁*
   - ☐ The statement is true
   - ☐ The statement is false

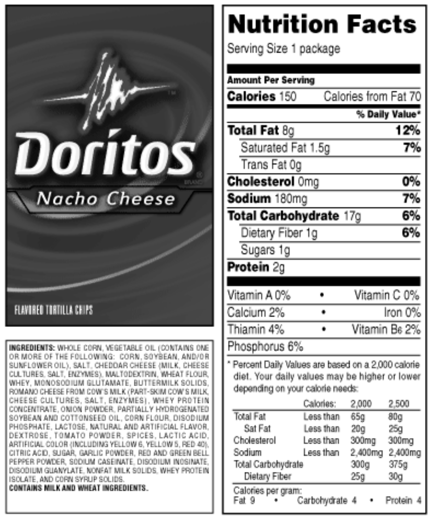
3. **Select all** the potential outcomes of practicing sustainable agriculture. *1.12.P₁*
   - ☐ Reduction of world hunger
   - ☐ Protection of food supply
   - ☐ Wildlife habitat loss
   - ☐ Conservation of natural resources

4. **Select all** the examples of organic nutrients. *2.12.E₁*
   - ☐ Dead/decaying animals
   - ☐ Synthetic nitrogen
   - ☐ Lawn/grass clippings
   - ☐ Manure
   - ☐ Silt

5. **Select all** the factors that affect food choices for people. *2.12.L₁*
   - ☐ Cost
   - ☐ Culture
   - ☐ Convenience
   - ☐ Access and/or availability
   - ☐ Taste

6. **Select all** the following practices that provide the best balance for agricultural production, while maintaining balance with natural resources. *2.12.P₁*
   - ☐ Integrated pest management
   - ☐ Using robots, drones, and global positioning systems
   - ☐ Using radio frequency identification chips
   - ☐ Using advertising strategies

7. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.E₁*



Items	***Description***
150	Grams of protein in two servings
2%	Percent of the daily requirement of Calcium per serving
4	Number of calories per serving
1	Number of servings in this package

8. **Select all** the ways that consumers can prevent food-borne illness. *3.12.L₁*
   - ☐ Washing hands
   - ☐ Cooking meat thoroughly
   - ☐ Keeping most food products at room temperature
   - ☐ Using the same knife for cutting meat and vegetables
   - ☐ Thawing frozen meat on the kitchen counter

9. Determine if the statement is true or false: *The American food supply is among the safest in the world. 3.12.P₁*
   - ☐ The statement is true
   - ☐ The statement is false

10. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science, technology, and engineering. 4.12.E₁*
    - ☐ The statement is true
    - ☐ The statement is false

11. Determine if the statement is true or false: *All types of scientific discoveries and applications of technology are accepted by consumers if they increase food production. 4.12.L₁*
    - ☐ This statement is true
    - ☐ This statement is false

12. **Select all** the technological advancements in agriculture that contribute to the ability to feed a growing population with a smaller number of producers. *4.12.P₁*
   - ☐ Biotechnology
   - ☐ Availability of organic labeling
   - ☐ Genetic engineering
   - ☐ Animal-powered equipment
   - ☐ Refrigeration
   - ☐ Mechanization of equipment and implements
   - ☐ Reduction of conservation practices

13. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food.* *5.12.E₁*
   - ☐ The statement is true
   - ☐ The statement is false

14. **Select all** factors that affect a country's production and distribution of food. *5.12.L₁*
   - ☐ Economics
   - ☐ Geography
   - ☐ Population size

15. A farmer has 50 acres of land to grow a crop, which factors would need to be considered before making a choice about what to plant? **Select all** the correct choices. *5.12.P₁*
   - ☐ Geographic location
   - ☐ Soil composition
   - ☐ Consumer demand
   - ☐ Climate change

Instrument 1: Answer Key

1. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources.* *1.12.E₁*
   - **X** The statement is true
   - ☐ The statement is false

2. Determine if the statement is true or false: *There are few incentives for agriculturists to protect the environment and natural resources.* *1.12.L₁*
   - ☐ The statement is true
   - **X** The statement is false

3. **Select all** the potential outcomes of practicing sustainable agriculture. *1.12.P₁*
   - **X** Reduction of world hunger
   - **X** Protection of food supply
   - ☐ Wildlife habitat loss

X Conservation of natural resources

4. **Select all** the examples of organic nutrients. *2.12.E₁*
   - **X** Dead/decaying animals
   - ☐ Synthetic nitrogen
   - **X** Lawn/grass clippings
   - **X** Manure
   - ☐ Silt

5. **Select all** the factors that affect food choices for people. *2.12.L₁*
   - **X** Cost
   - **X** Culture
   - **X** Convenience
   - **X** Access and/or availability
   - **X** Taste

6. **Select all** the following practices that provide the best balance for agricultural production, while maintaining balance with natural resources. *2.12.P₁*
   - **X** Integrated pest management
   - **X** Using robots, drones, and global positioning systems
   - **X** Using radio frequency identification chips
   - ☐ Using advertising strategies

7. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.E₁*

Items	***Description***
150	Number of calories per serving
2%	Percent of the daily requirement of Calcium per serving

4	Grams of protein in two servings
1	Number of servings in this package

8. **Select all** the ways that consumers can prevent food-borne illness. *3.12.L*$_1$
   - **X** Washing hands
   - **X** Cooking meat thoroughly
   - ☐ Keeping most food products at room temperature
   - ☐ Using the same knife for cutting meat and vegetables
   - ☐ Thawing frozen meat on the kitchen counter

9. Determine if the statement is true or false: *The American food supply is among the safest in the world. 3.12.P*$_1$
   - **X** The statement is true
   - ☐ The statement is false

10. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science, technology, and engineering*. *4.12.E*$_1$
    - **X** The statement is true
    - ☐ The statement is false

11. Determine if the statement is true or false: *All types of scientific discoveries and applications of technology are accepted by consumers if they increase food production. 4.12.L*$_1$
    - ☐ This statement is true
    - **X** This statement is false

12. **Select all** the technological advancements in agriculture that contribute to the ability to feed a growing population with a smaller number of producers. *4.12.P*$_1$
    - **X** Biotechnology
    - ☐ Availability of organic labeling
    - **X** Genetic engineering
    - ☐ Animal-powered equipment
    - **X** Refrigeration
    - **X** Mechanization of equipment and implements
    - ☐ Reduction of conservation practices

13. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food. 5.12.E*$_1$
    - **X** The statement is true
    - ☐ The statement is false

14. **Select all** factors that affect a country's production and distribution of food. *5.12.L*$_1$
    - **X** Economics

X Geography
X Population size

15. A farmer has 50 acres of land to grow a crop, which factors would need to be considered before making a choice about what to plant? **Select all** the correct choices. *$5.12.P_1$*
   - **X** Geographic location
   - **X** Soil composition
   - **X** Consumer demand
   - **X** Climate change

Instrument 2

1. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources.* *$1.12.E_2$*
   - ☐ The statement is true
   - ☐ The statement is false

2. Drag and drop the natural resource into the box with the corresponding sustainability practice. *$1.12.L_2$*
   - ☐ Water
   - ☐ Soil
   - ☐ Water

   Selecting drought-tolerant crop species

   Using a methane digester

   Reduce tillage

3. **Select all** examples of sustainable agricultural practices. *$1.12.P_2$*
   - ☐ Unregulated water use
   - ☐ Intensive grazing along stream banks
   - ☐ Continuous planting of the same crop
   - ☐ Eliminate or reduce soil tillage

4. Determine if the statement is true or false: *The inspection of meat and poultry, for wholesomeness, is mandatory in the U.S. of America.* *$2.12.E_2$*

☐ The statement is true
☐ The statement is false

5. Match the name of the production system with its appropriate description. *2.12.L₂*

Production System	***Description***
Local food system	Consumers share the benefits and risks of food production by purchasing shares of a farm operation.
Community-supported agriculture	The prevailing agricultural production system uses technological innovation for maximum efficiency.
Organic food system	Food produced, processed, and distributed in a limited geographic area, often connects farms and consumers at the point of sale.
Conventional food system	Production promotes biodiversity, food is grown and processed using little or no synthetic fertilizers or pesticides.

6. Farmers must abide by state and federal animal welfare laws. **Select all** the laws that must be observed in the U.S. of America. *2.12.P₂*
   ☐ Providing comfortable living spaces
   ☐ Providing free-range living spaces
   ☐ Providing responsible medical care

7. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.E₂*

Items ***Description***

150	Grams of protein in two servings
2%	Percent of the daily requirement of Calcium per serving
4	Number of calories per serving
1	Number of servings in this package

8. **Select all** the processed foods. *3.12.L*$_2$
   - ☐ Chocolate
   - ☐ Apple
   - ☐ Peanut butter
   - ☐ Artichoke
   - ☐ Yogurt

9. **Select all** the marketing terms that are used to influence consumer choices. *3.12.P*$_2$
   - ☐ Barn-free
   - ☐ Non-vaccinated
   - ☐ Cage-free
   - ☐ Non-GMO

10. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science, technology, and engineering*. *4.12.E*$_2$
    - ☐ The statement is true
    - ☐ The statement is false

11. **Select all** the following technologies that are frequently used in agricultural production systems. *4.12.L*$_2$
    - ☐ Unmanned aerial systems (drones)
    - ☐ Robotics
    - ☐ Global positioning systems
    - ☐ Cloning

12. Which of the following practices is benefitted using precision agriculture? *4.12.P*$_2$
    - ☐ Wildlife levels
    - ☐ Determining topsoil depth
    - ☐ Variable-rate pesticide application
    - ☐ Animal stocking rates

13. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food. 5.12.E*$_2$
    - ☐ The statement is true
    - ☐ The statement is false

14. **Select all** factors that affect a country's production and distribution of food. *5.12.L*$_2$
    - ☐ Economics

☐ Geography
☐ Population size

15. **Select all** the following jobs related to agriculture? *5.12.P₂*
☐ Bio-engineer
☐ Timber grader
☐ Mechanic
☐ Biologist
☐ Nutritionist

Instrument 2: Answer Key

1. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources.* *1.12.E₂*
X The statement is true
☐ The statement is false

2. Drag and drop the natural resource into the box with the corresponding sustainability practice. *1.12.L₂*
Selecting drought-tolerant crop species: Water
Using a methane digester: Air
Reduce tillage: Soil

3. **Select all** examples of sustainable agricultural practices. *1.12.P₂*
☐ Unregulated water use
☐ Intensive grazing along stream banks
☐ Continuous planting of the same crop
X Eliminate or reduce soil tillage

4. Determine if the statement is true or false: *The inspection of meat and poultry, for wholesomeness, is mandatory in the U.S. of America.* *2.12.E₂*
X The statement is true
☐ The statement is false

5. Match the name of the production system with its appropriate description. *2.12.L₂*

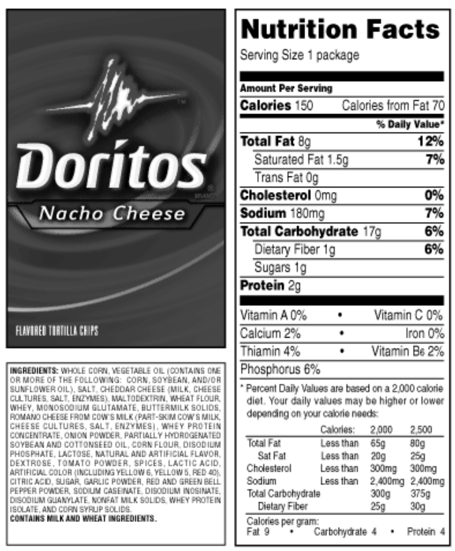
Production System	***Description***
Local food system	Food produced, processed, and distributed in a limited geographic area, often connects farms and consumers at the point of sale.
Community-supported agriculture	Consumers share the benefits and risks of food production by purchasing shares of a farm operation.
Organic food system	Production promotes biodiversity, food is

	grown and processed using little or no synthetic fertilizers or pesticides.
Conventional food system	The prevailing agricultural production system uses technological innovation for maximum efficiency.

6. Farmers must abide by state and federal animal welfare laws. **Select all** the laws that must be observed in the U.S. of America. *2.12.P₂*

X Providing comfortable living spaces
☐ Providing free-range living spaces
X Providing responsible medical care

7. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.E₂*



Items	***Description***
4	Grams of protein in two servings
2%	Percent of the daily requirement of Calcium per serving
150	Number of calories per serving
1	Number of servings in this package

8. **Select all** the processed foods. *3.12.L₂*

X Chocolate
☐ Apple
X Peanut butter
☐ Artichoke
X Yogurt

9. **Select all** the marketing terms that are used to influence consumer choices. *3.12.P₂*

☐ Barn-free
☐ Non-vaccinated
X Cage-free
X Non-GMO

10. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science, technology, and engineering*. *4.12.E$_2$*
    X The statement is true
    ☐ The statement is false

11. **Select all** the following technologies that are frequently used in agricultural production systems. *4.12.L$_2$*
    X Unmanned aerial systems (drones)
    X Robotics
    X Global positioning systems
    X Cloning

12. Which of the following practices is benefitted using precision agriculture? *4.12.P$_2$*
    ☐ Wildlife levels
    X Determining topsoil depth
    X Variable-rate pesticide application
    ☐ Animal stocking rates

13. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food.* *5.12.E$_2$*
    X The statement is true
    ☐ The statement is false

14. **Select all** factors that affect a country's production and distribution of food. *5.12.L$_2$*
    X Economics
    X Geography
    X Population size

15. **Select all** the following jobs related to agriculture? *5.12.P$_2$*
    X Bio-engineer
    X Timber grader
    X Mechanic
    X Biologist
    X Nutritionist

Appendix D

JMALI Student Assessment 2019

JMALI Student Assessment 2019

1. **Select all** examples of sustainable agricultural practices. *1.12.E.2*
    - ☐ Unregulated water use
    - ☐ Intensive grazing along stream banks
    - ☐ Continuous planting of the same crop
    - ☐ Eliminate or reduce soil tillage

2. Determine if the statement is true or false: *There are few incentives for agriculturists to protect the environment and natural resources.* *1.12.E.3*
    - ☐ The statement is true
    - ☐ The statement is false

3. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources.* *1.12.E.4*
    - ☐ The statement is true
    - ☐ The statement is false

4. **Select all** the following management practices used by agriculturalists to promote environmental conservation. *1.12.L.1*
    - ☐ Early harvesting of crops
    - ☐ Riparian management
    - ☐ Rotational grazing
    - ☐ Recirculation systems for fisheries
    - ☐ Wildlife restriction plans

5. Drag and drop the natural resource into the box with the corresponding sustainability practice. *1.12.L.2*
    - ☐ Water
    - ☐ Soil
    - ☐ Air

Selecting drought-tolerant crop species

Using a methane digester

Reduce tillage

6. Applying manure from livestock to soil, where crops will be grown, is an example of using which natural resource cycle. *1.12.L.5*
   - ☐ Carbon cycle
   - ☐ Water cycle
   - ☐ Nitrogen cycle
   - ☐ Hydrogen cycle

7. Select the objectives that should be implemented for a farmer/rancher to practice sustainable agriculture. *1.12.L.6*
   - ☐ Environmental health, economic profitability, social and economic equity
   - ☐ Environmental health, economic profitability, and educational equity
   - ☐ Scientific research, educational equity, and affordable recreation
   - ☐ Scientific research, affordable recreation, and distribution improvement

8. **Select all** the potential outcomes of practicing sustainable agriculture. *1.12.P.1*
   - ☐ Reduction of world hunger
   - ☐ Protection of food supply
   - ☐ Wildlife habitat loss
   - ☐ Conservation of natural resources
   - ☐ Increased use of non-renewable natural resources

9. **Select all** the benefits of animal grazing on rangelands. *1.12.P.3*
   - ☐ Increased animal health
   - ☐ Decreased risk for catastrophic wildfire
   - ☐ Natural fertilizer source
   - ☐ Eliminates potential for stream bank erosion

10. Determine if the statement is true or false: *Agriculture allowed humans a way to have a reliable and consistent food source*. *2.12.E.1*
    - ☐ The statement is true
    - ☐ The statement is false

11. **Select all** the examples of organic nutrients. 2.12.E.2
    - ☐ Dead/decaying animals
    - ☐ Synthetic nitrogen
    - ☐ Lawn/grass clippings
    - ☐ Manure
    - ☐ Silt

12. Determine if the statement is true or false: *The inspection of meat and poultry, for wholesomeness, is mandatory in the U.S. of America.* *2.12.E.5*
    - ☐ The statement is true
    - ☐ The statement is false

13. **Select all** the factors that affect food choices for people. *2.12.L.3*
    - ☐ Cost
    - ☐ Culture
    - ☐ Convenience
    - ☐ Access and/or availability
    - ☐ Taste

14. Farmers must abide by state and federal animal welfare laws. **Select all** the laws that must be observed in the U.S. of America. *2.12.L.4*
    - ☐ Providing appropriate feed rations
    - ☐ Providing comfortable living spaces
    - ☐ Providing free-range living spaces
    - ☐ Providing responsible medical care
    - ☐ Providing year-round access to open pasture

15. Match the food or agricultural product with its primary source. *2.12.L.5*

☐ Chocolate milk	☐ Sugar Beet
☐ Bottle of lotion that contains lanolin	☐ Sheep
☐ Cashmere Sweater	☐ Dairy Cow (Holstein)
☐ T-shirt or jeans	☐ Cotton
☐ Granulated table sugar	☐ Meat Cow (Angus)
☐ Leather belt	☐ Hog
☐ Bacon or pork chops	☐ Goat

16. Determine whether each statement describes the principles of animal welfare or animal rights. Drag and drop each of the statements into the correct box indicating your answer. *2.12.P.1*

Items: ***A principle of animal welfare*** ***A principle of animal rights***

- ☐ Animals should be treated with antibiotics when they are sick, to prevent disease and death.
- ☐ Dairy cows should not be housed in barns and milked for human use.
- ☐ Producers should follow best practices for castration procedures.
- ☐ Producers should not raise pigs for food, they are not meant to be eaten.
- ☐ Chickens should roam free and not be forced to lay eggs.
- ☐ Regular sheep shearing decreases disease and improves comfort for the animals in warm weather.

17. **Select all** the following practices that provide the best balance for agricultural production, while maintaining balance with natural resources. *2.12.P.3*
    - ☐ Integrated pest management
    - ☐ Using robots, drones, and global positioning systems
    - ☐ Using radio frequency identification chips
    - ☐ Using advertising strategies

18. Match the name of the production system with its appropriate description. *2.12.P.4*

Production System	***Description***
Local food system	Consumers share the benefits and risks of food production by purchasing shares of a farm operation.
Community-supported agriculture	The prevailing agricultural production system uses technological innovation for maximum efficiency.
Organic food system	Food produced, processed, and distributed in a limited geographic area, often connects farms and consumers at the point of sale.
Conventional food system	Production promotes biodiversity, food is grown and processed using little or no synthetic fertilizers or pesticides.

19. Determine if the statement is true or false: *Consumer demand ultimately influences what food is produced and how it is processed and marketed.* 3.12.E.1
    - ☐ This statement is true
    - ☐ This statement is false

20. **Select all** the processed foods. *3.12.E.3*
    - ☐ Chocolate
    - ☐ Apple
    - ☐ Peanut butter
    - ☐ Artichoke
    - ☐ Yogurt

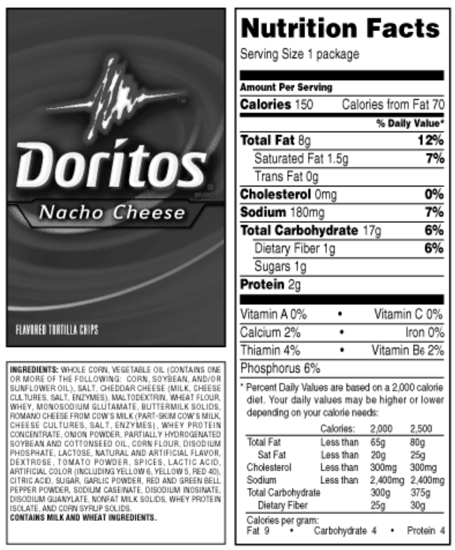
21. Determine if the statement is true or false: *The American food supply is among the safest in the world. 3.12.E.5*
    - ☐ The statement is true
    - ☐ The statement is false

22. **Select all** the marketing terms that are used to influence consumer choices. *3.12.L.1*
    - ☐ Barn-free
    - ☐ Free-range
    - ☐ Certified organic
    - ☐ Non-vaccinated

☐ Cage-free
☐ Non-GMO

23. Select the option that best completes both blank spaces in the statement. Following laws of supply and demand, as consumers buy________ of a select product, farmers produce _________ of the product in demand. *3.12.L.4*
   ☐ More, more
   ☐ More, less
   ☐ Less, less

24. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.L.5*



Items	***Description***
150	Grams of protein in two servings
2%	Percent of the daily requirement of Calcium per serving
4	Number of calories per serving
1	Number of servings in this package

25. **Select all** the ways that consumers can prevent food-borne illness. *3.12.P.5*
   ☐ Washing hands
   ☐ Cooking meat thoroughly
   ☐ Keeping most food products at room temperature
   ☐ Using the same knife for cutting meat and vegetables
   ☐ Thawing frozen meat on the kitchen counter

26. **Select all** the food labels that indicate the style of production used on the farm that produced the item. *3.12.P.3*

☐ 

☐ 

☐ 

☐ 

☐ 

☐ 

☐ 

27. The U.S. Department of Agriculture (USDA) quality assurance programs are designed to analyze which of the following elements? **Select all** that apply. *3.12.P.6*
    - ☐ Consumer appeal
    - ☐ Marketing techniques
    - ☐ Monitoring procedures
    - ☐ Hazard analysis
    - ☐ Food additives
    - ☐ Herbal supplements

28. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science, technology, and engineering*. *4.12.E.1*

☐ The statement is true
☐ The statement is false

29. What do historians believe was the primary factor allowing for the rise of civilizations? *4.12.E.2*
    ☐ Organization of government
    ☐ Cultivation of land
    ☐ Use of the barter system
    ☐ Invention of the mechanical reaper

30. Determine if the statement is true or false: *All types of scientific discoveries and applications of technology are accepted by consumers if they increase food production.* *4.12.E.4*
    ☐ This statement is true
    ☐ This statement is false

31. **Select all** the technological advancements in agriculture that contribute to the ability to feed a growing population with a smaller number of producers. *4.12.L.2*
    ☐ Biotechnology
    ☐ Availability of organic labeling
    ☐ Genetic engineering
    ☐ Animal-powered equipment
    ☐ Refrigeration
    ☐ Mechanization of equipment and implements
    ☐ Reduction of conservation practices

32. **Select all** the following technologies that are frequently used in agricultural production systems. *4.12.L.4*
    ☐ Unmanned aerial systems (drones)
    ☐ Computer systems
    ☐ Robotics
    ☐ Global positioning systems
    ☐ Cloning

33. **Select all** the following potential benefits for agriculturists and consumers due to biotechnology. *4.12.L.5*
    ☐ Increased crop yield
    ☐ Reduction of allergic reactions
    ☐ Decreased production costs
    ☐ Increased antibiotic resistance
    ☐ Improved nutritional value

34. **Select all** the following ways farmers/ranchers will be affected by climate change. *4.12.L.6*
    ☐ Ability to market product

☐ Determining soil type
☐ Animal extinction patterns
☐ Intensification of weather
☐ Increased economic risk

35. Determine whether each product is a *result* of selective breeding or genetic engineering. Drag and drop each agricultural product under the correct identifier. *4.12.P.2*

Item	***Identifiers***	
	Selective Breeding	Genetic Engineering
Herbicide-resistant corn		
Disease-resistant papaya		
Non-browning apples		
Seedless watermelon		
Virus-resistant squash		
Baby carrots		
Grape-sized tomatoes		

36. Which of the following practices is benefitted using precision agriculture? *4.12.P.5*
☐ Wildlife levels
☐ Determining topsoil depth
☐ Variable-rate pesticide application
☐ Animal stocking rates

37. **Select all** the benefits of using technological innovations in modern agriculture. *4.12.P.6*
☐ Decreased use of natural resource inputs
☐ Increased human safety
☐ Improved immigration policies
☐ Decreased farm equipment cost
☐ Improvement in public perception

38. The U.S. of America is a net-importer of which of the following commodities? *5.12.E.1*
☐ Soybeans
☐ Coffee
☐ Wheat
☐ Corn
☐ Cotton

39. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food.* *5.12.E.3*
☐ The statement is true
☐ The statement is false

40. **Select all** the following jobs related to agriculture? *E.12.L.3*
   - ☐ Bio-engineer
   - ☐ Timber grader
   - ☐ Mechanic
   - ☐ Biologist
   - ☐ Nutritionist

41. Select *one* way a local food system would not affect a community. *5.12.L.4*
   - ☐ Local economy will be improved
   - ☐ Only seasonal foods available
   - ☐ Greater variety of foods
   - ☐ Reduction in fossil fuel use
   - ☐ Improved access to producers

42. A farmer has 50 acres of land to grow a crop, which factors would need to be considered before making a choice about what to plant? **Select all** the correct choices. *5.12.L.5*
   - ☐ Geographic location
   - ☐ Soil composition
   - ☐ Consumer demand
   - ☐ Climate change

43. **Select all** the positive impacts of trade agreements on the American food supply. *5.12.P.2*
   - ☐ Lower production costs
   - ☐ Limits the specialization of resources
   - ☐ Greater investment opportunities
   - ☐ Reduction of market fluctuations
   - ☐ Creates a surplus of products

44. **Select all** factors that affect a country's production and distribution of food. *5.12.P.4*
   - ☐ Economics
   - ☐ Geography
   - ☐ Health-care standards
   - ☐ Politics
   - ☐ Population size

45. **Select all** programs included in the legislative U.S. Farm Bill that are not directly related to production agriculture. *5.12.P.5*
   - ☐ Supplemental Nutrition Assistance (Food stamps)
   - ☐ College scholarships for farm owners
   - ☐ School lunch programs
   - ☐ Internet connections in rural communities
   - ☐ Nutritional analysis for world food programs

Appendix E

JMALI Student Assessment 2019: KEY

JMALI Student Assessment 2019: KEY, X indicates a correct response

1. **Select all** examples of sustainable agricultural practices. *1.12.E.2*
   - ☐ Unregulated water use
   - ☐ Intensive grazing along stream banks
   - ☐ Continuous planting of the same crop
   - **X** Eliminate or reduce soil tillage

2. Determine if the statement is true or false: *There are few incentives for agriculturists to protect the environment and natural resources. 1.12.E.3*
   - ☐ The statement is true
   - **X** The statement is false

3. Determine if the statement is true or false: *Sustainable agriculture is the practice of producing food, fiber, and fuel in a way that is profitable to the producer, supports quality of life, and protects natural resources. 1.12.E.4*
   - **X** The statement is true
   - ☐ The statement is false

4. **Select all** the following management practices used by agriculturalists to promote environmental conservation. *1.12.L.1*
   - **X** Early harvesting of crops
   - **X** Riparian management
   - **X** Rotational grazing
   - **X** Recirculation systems for fisheries
   - ☐ Wildlife restriction plans

5. Drag and drop the natural resource into the box with the corresponding sustainability practice. *1.12.L.2*

   Selecting drought-tolerant crop species: Water
   Using a methane digester: Air
   Reduce tillage: Soil

6. Applying manure from livestock to soil, where crops will be grown, is an example of using which natural resource cycle. *1.12.L.5*
   - ☐ Carbon cycle
   - ☐ Water cycle
   - **X** Nitrogen cycle
   - ☐ Hydrogen cycle

7. Select the objectives that should be implemented for a farmer/rancher to practice sustainable agriculture. *1.12.L.6*
   - **X** Environmental health, economic profitability, social and economic equity

☐ Environmental health, economic profitability, and educational equity
☐ Scientific research, educational equity, and affordable recreation
☐ Scientific research, affordable recreation, and distribution improvement

8. **Select all** the potential outcomes of practicing sustainable agriculture. *1.12.P.1*
   X Reduction of world hunger
   X Protection of food supply
   ☐ Wildlife habitat loss
   X Conservation of natural resources
   ☐ Increased use of non-renewable natural resources

9. **Select all** the benefits of animal grazing on rangelands. *1.12.P.3*
   ☐ Increased animal health
   X Decreased risk for catastrophic wildfire
   X Natural fertilizer source
   ☐ Eliminates potential for stream bank erosion
   X Improvement of soil health

10. Determine if the statement is true or false: *Agriculture allowed humans a way to have a reliable and consistent food source*. *2.12.E.1*
    X The statement is true
    ☐ The statement is false

11. **Select all** the examples of organic nutrients. 2.12.E.2
    X Dead/decaying animals
    ☐ Synthetic nitrogen
    X Lawn/grass clippings
    X Manure
    ☐ Silt

12. Determine if the statement is true or false: *The inspection of meat and poultry, for wholesomeness, is mandatory in the U.S. of America.* *2.12.E.5*
    X The statement is true
    ☐ The statement is false

13. **Select all** the factors that affect food choices for people. *2.12.L.3*
    X Cost
    X Culture
    X Convenience
    X Access and/or availability
    X Taste
14. Farmers must abide by state and federal animal welfare laws. **Select all** the laws that must be observed in the U.S. of America. *2.12.L.4*
    X Providing appropriate feed rations

X Providing comfortable living spaces
☐ Providing free-range living spaces
X Providing responsible medical care
☐ Providing year-round access to open pasture

15. Match the food or agricultural product with its primary source. *2.12.L.5*
    Chocolate milk: Dairy Cow (Holstein)
    Bottle of lotion that contains lanolin: Sheep
    Cashmere Sweater: Goat
    T-shirt or jeans: Cotton
    Granulated table sugar: Sugar beet
    Leather belt: Meat Cow (Angus)
    Bacon or pork chops: Hog

16. Determine whether each statement describes the principles of animal welfare or animal rights. Drag and drop each of the statements into the correct box indicating your answer. *2.12.P.1*

    A principle of animal welfare
    Animals should be treated with antibiotics when they are sick, to prevent disease and death.
    Producers should follow best practices for castration procedures.
    Regular sheep shearing decreases disease and improves comfort for the animals in warm weather.

    A principle of animal rights
    Producers should not raise pigs for food, they are not meant to be eaten.
    Chickens should roam free and not be forced to lay eggs.
    Dairy cows should not be housed in barns and milked for human use.

17. **Select all** the following practices that provide the best balance for agricultural production, while maintaining balance with natural resources. *2.12.P.3*
    X Integrated pest management
    X Using robots, drones, and global positioning systems
    X Using radio frequency identification chips
    ☐ Using advertising strategies

18. Match the name of the production system with its appropriate description. *2.12.P.4*

Production System	***Description***
Local food system	Food produced, processed, and distributed in a limited geographic area, often connects farms and consumers at the point of sale.
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Organic food system	Production promotes biodiversity, food is grown and processed using little or no synthetic fertilizers or pesticides.
Conventional food system	The prevailing agricultural production system uses technological innovation for maximum efficiency.

19. Determine if the statement is true or false: *Consumer demand ultimately influences what food is produced and how it is processed and marketed. 3.12.E.1*
    X This statement is true
    ☐ This statement is false

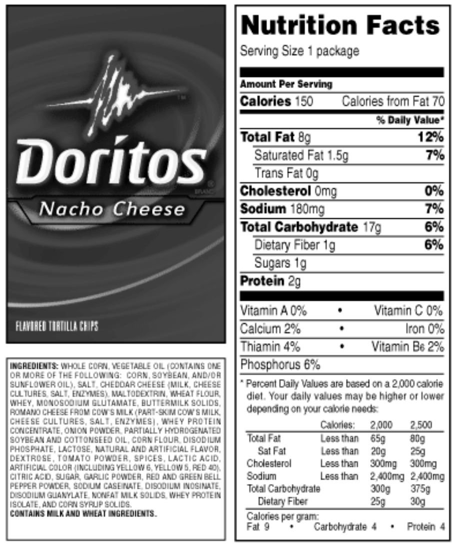
20. **Select all** the processed foods. *3.12.E.3*
    X Chocolate
    ☐ Apple
    X Peanut butter
    ☐ Artichoke
    X Yogurt

21. Determine if the statement is true or false: *The American food supply is among the safest in the world. 3.12.E.5*
    X The statement is true
    ☐ The statement is false

22. **Select all** the marketing terms that are used to influence consumer choices. *3.12.L.1*
    ☐ Barn-free
    X Free-range
    X Certified organic
    ☐ Non-vaccinated
    X Cage-free
    X Non-GMO

23. Select the option that best completes both blank spaces in the statement. Following laws of supply and demand, as consumers buy________ of a select product, farmers produce _________ of the product in demand. *3.12.L.4*
    X More, more
    ☐ More, less
    ☐ Less, less

24. Interpret the information given on this food label. Match the correct answer with correct description. *3.12.L.5*



Items	***Description***
150:	Number of calories per serving
2%:	Percent of the daily requirement of Calcium per serving
4:	Grams of protein in two servings
1:	Number of servings in this package

25. **Select all** the ways that consumers can prevent food-borne illness. *3.12.P.5*
    X Washing hands
    X Cooking meat thoroughly
    ☐ Keeping most food products at room temperature
    ☐ Using the same knife for cutting meat and vegetables
    ☐ Thawing frozen meat on the kitchen counter

26. **Select all** the food labels that indicate the style of production used on the farm that produced the item. *3.12.P.3*

☐ 

X 

☐ 

X 

☐ 

☐ 

☐ 

27. The U.S. Department of Agriculture (USDA) quality assurance programs are designed to analyze which of the following elements? **Select all** that apply. *3.12.P.6*
    - ☐ Consumer appeal
    - ☐ Marketing techniques
    - **X** Monitoring procedures
    - **X** Hazard analysis
    - ☐ Food additives
    - ☐ Herbal supplements

28. Determine if the statement is true or false: *An adequate global food supply is dependent upon the continued development and appropriate use of science,*

technology, and engineering. *4.12.E.1*

X The statement is true
☐ The statement is false

29. What do historians believe was the primary factor allowing for the rise of civilizations? *4.12.E.2*
    ☐ Organization of government
    X Cultivation of land
    ☐ Use of the barter system
    ☐ Invention of the mechanical reaper

30. Determine if the statement is true or false: *All types of scientific discoveries and applications of technology are accepted by consumers if they increase food production. 4.12.E.4*
    ☐ This statement is true
    X This statement is false

31. **Select all** the technological advancements in agriculture that contribute to the ability to feed a growing population with a smaller number of producers. *4.12.L.2*
    X Biotechnology
    ☐ Availability of organic labeling
    X Genetic engineering
    ☐ Animal-powered equipment
    X Refrigeration
    X Mechanization of equipment and implements
    ☐ Reduction of conservation practices

32. **Select all** the following technologies that are frequently used in agricultural production systems. *4.12.L.4*
    X Unmanned aerial systems (drones)
    X Computer systems
    X Robotics
    X Global positioning systems
    X Cloning

33. **Select all** the following potential benefits for agriculturists and consumers due to biotechnology. *4.12.L.5*
    X Increased crop yield
    ☐ Reduction of allergic reactions
    X Decreased production costs
    ☐ Increased antibiotic resistance
    X Improved nutritional value

34. **Select all** the following ways farmers/ranchers will be affected by climate change. *4.12.L.6*

☐ Ability to market product
☐ Determining soil type
☐ Animal extinction patterns
X Intensification of weather
X Increased economic risk

35. Determine whether each product is a *result* of selective breeding or genetic engineering. Drag and drop each agricultural product under the correct identifier. *4.12.P.2*

Selective Breeding
Seedless Watermelon
Baby carrots
Grape-sized tomatoes

Genetic Engineering
Herbicide-resistant corn
Disease-resistant papaya
Non-browning apples
Virus-resistant squash

36. Which of the following practices is benefitted using precision agriculture? *4.12.P.5*
☐ Wildlife levels
☐ Determining topsoil depth
X Variable-rate pesticide application
☐ Animal stocking rates

37. **Select all** the benefits of using technological innovations in modern agriculture. *4.12.P.6*
X Decreased use of natural resource inputs
X Increased human safety
☐ Improved immigration policies
☐ Decreased farm equipment cost
☐ Improvement in public perception

38. The U.S. of America is a net-importer of which of the following commodities? *5.12.E.1*
☐ Soybeans
X Coffee
☐ Wheat
☐ Corn
☐ Cotton

39. Determine if the statement is true or false: *The geographic location of your food source plays a part in determining the price of the food. 5.12.E.3*

X The statement is true
☐ The statement is false

40. **Select all** the following jobs related to agriculture? *E.12.L.3*
    X Bio-engineer
    X Timber grader
    X Mechanic
    X Biologist
    X Nutritionist

41. Select *one* way a local food system would not affect a community. *5.12.L.4*
    ☐ Local economy will be improved
    ☐ Only seasonal foods available
    X Greater variety of foods
    ☐ Reduction in fossil fuel use
    ☐ Improved access to producers

42. A farmer has 50 acres of land to grow a crop, which factors would need to be considered before making a choice about what to plant? **Select all** the correct choices. *5.12.L.5*
    X Geographic location
    X Soil composition
    X Consumer demand
    X Climate change

43. **Select all** the positive impacts of trade agreements on the American food supply. *5.12.P.2*
    X Lower production costs
    ☐ Limits the specialization of resources
    X Greater investment opportunities
    X Reduction of market fluctuations
    ☐ Creates a surplus of products

44. **Select all** factors that affect a country's production and distribution of food. *5.12.P.4*
    X Economics
    X Geography
    X Health-care standards
    X Politics
    X Population size

45. **Select all** programs included in the legislative U.S. Farm Bill that are not directly related to production agriculture. *5.12.P.5*
    X Supplemental Nutrition Assistance (Food stamps)
    ☐ College scholarships for farm owners
    X School lunch programs

X Internet connections in rural communities
☐ Nutritional analysis for world food programs

Appendix F

Example of NALO Construct Analysis for Instrument 1

Item Number	Assessment item content	NALO Demands
$1.12.E_1$	Determine a definition of sustainable agriculture; who/what benefits from sustainable agricultural practices.	To understand the processes and components, and the dependence and interactions of organisms and environment in natural systems; agriculture fulfills societal needs; recognize natural resources used in agricultural practices; discover how natural resources are used and conserved in agriculture; describe how wildlife habitats are maintained by farmers; describe resource and conservation management practices used in agricultural systems; evaluate definitions of sustainable agriculture considering population growth, carbon footprint, systems, resources, and economics.
$1.12.L_1$	Determine if there are incentives for agriculturalists to protect the environment and natural resources.	To understand the processes and components, and the dependence and interactions of organisms and environment in natural systems; discover how natural resources are used and conserved in agriculture; describe benefits and challenges of using conservation practices for natural resources in agricultural systems; recognize the factors of an agricultural system which determine its sustainability; discuss the value of agricultural land; evaluate definitions of sustainable agriculture considering population growth, carbon footprint, systems, resources, and economics; evaluate the potential impacts of climate change on agriculture.
$1.12.P_1$	Determine potential outcomes of practicing sustainable agriculture. Students must identify connections to hunger, food supply, wildlife habitat, and conservation of resources.	To understand the processes and components, and the dependence and interactions of organisms and environment in natural systems; agriculture fulfills societal needs; describe how wildlife habitats are maintained by farmers; describe resource and conservation management practices; evaluate definitions of sustainable agriculture considering population growth, carbon footprint, systems, resources, and economics.
$2.12.E_1$	Identify examples of organic nutrients.	Lifecycles of plants and animals; distinguish between renewable and non-renewable resources; importance of soil nutrients; compare natural cycles in comparison to managed lifecycles within agriculture; how organic and inorganic nutrients affect plant growth and development.

Item Number	Assessment item content	NALO Demands
$2.12.L_1$	Identify the factors (including cost, culture, convenience, access, and taste) that affect population food choice.	The variety of year-round food choice; food distribution networks and transportation systems; major factors in food and feed choices for people and animals are cost, culture, convenience, and access; examine viewpoints on production methods and practices; impacts of transporting food due to location, climate, and geography; consumer demand influences what is produced and how it is processed and marketed; explain how food production systems are influenced by consumer choices.
$2.12.P_1$	Determine agricultural practices that balance production and conservation (e.g., using modern science and technology).	Importance and stewardship of natural resources in delivering agricultural products and maintaining environment; understand the concept of stewardship for soil, water, plants and animals; examine viewpoints on production methods and practices.
$3.12.E_1$	Interpret the information on a food label.	Food contains nutrients that people need for good health; identify healthy food options; evaluate food labels; evaluate serving size.
$3.12.L_1$	Identify ways that consumers can prevent food-borne illness.	Identify food safety practices to demonstrate at home; food safety issues exist due to improper storage, handling, and preparation of food; regulation provides consumer guidelines; identify forms and sources of food contamination relative to personal health and safety; provide examples of points of contamination.
$3.12.P_1$	Recognize the safety of the American food supply.	Identify inspection processes associated with food safety regulations; the US food supply is considered the safest in the world; food safety issues exist due to improper storage, handling, and preparation of food; identify forms and sources of food contamination relative to personal health and safety; provide examples of the policies/agencies responsible for protecting consumers.
$4.12.E_1$	Recognize the significance and contribution of STEM to providing a global food supply.	Quality of life is dependent upon STEM advancements in agriculture; compare how modern machines improved efficiency and reduced labor; describe how technology assisted in increasing agricultural outputs with fewer inputs; provide examples of science being applied in agriculture; discuss how technology has changed over time to help provide more food to more people; discuss population growth and the benefits of STEM in agriculture to maintain sustainability.

Item Number	Assessment item content	NALO Demands
4.12.L_1	Know that not all scientific discoveries and technological applications are accepted by consumers for increasing food production.	Contrast historical and current food processing and systems; explain how and why agricultural innovation influenced modern economic systems; identify current and emerging scientific discoveries and their potential in agriculture.
4.12.P_1	Determine which technological advancements have contributed to feeding a growing population with a smaller number of producers (i.e., biotechnology, refrigeration, mechanization)	Technological advancements have resulted in a limited sector makes their living on farms and ranches; quality of life is dependent upon STEM advancements in agriculture; compare how modern machines improved efficiency and reduced labor; describe how technology assisted in increasing agricultural outputs with fewer inputs; provide examples of science being applied in agriculture; describe how biological processes are leveraged for production; provide examples of STEM used in agricultural systems (e.g., GPS, biotechnology) and detail their social, economic, and environmental impacts; identify current and emerging scientific discoveries and their potential in agriculture.
5.12.E_1	Identify that geographic location of a food source affects food price.	Geographic location determines what plants and animals will grow and therefore, determines what humans and animals will have available for consumption; global movement of agricultural products continues to be driven by economics, consumer demand, and preference; provide examples of local and non-local agricultural products; explain how prices for agricultural goods are determined; discuss the relationship between geography, politics, and global economies in the distribution of food; provide examples of how cultural preferences influence agricultural markets.
5.12.L_1	Identify factors that affect production and distribution of food (i.e., economics, geography, population).	Geographic location determines what plants and animals will grow and therefore, determines what humans and animals will have available for consumption; global movement of agricultural products continues to be driven by economics, consumer demand, and preference; explain the value of agriculture in daily life; explain how prices for agricultural goods are determined; identify agricultural products that are exported and imported; discuss the relationship between geography, politics, and global economies in the distribution of food; explain the role of government in the production, distribution, and consumption of food; provide examples of how cultural preferences influence agricultural markets.

Item Number	Assessment item content	NALO Demands
5.12.P_1	Identify factors that affect a producer’s crop selections (i.e., geography, soil, demand, climate).	Geographic location determines what plants and animals will grow and therefore, determines what humans and animals will have available for consumption; describe how supply and demand impact the price of agricultural goods; explain how prices for agricultural goods are determined; discuss the relationship between geography, politics, and global economies in the distribution of food; provide examples of how cultural preferences influence agricultural markets.

Appendix G

Permission and Guidelines to Reprint Figures

UtahState University
SCHOOL OF APPLIED SCIENCES, TECHNOLOGY & EDUCATION

Debra Spielmaker, PhD
Graduate Program Director
School of Applied Sciences, Technology & Education
National Center for Agricultural Literacy – Team Leader
debra.spielmaker@usu.edu
Phone: 435-213-5562

July 11, 2019

To whom it may concern,

I grant Rose Judd-Murray the permission to use the:

1) 5Fs figure, adapted from a poster I created in 2002
2) 5Fs accompanying concept map, adapted from a poster I created in 2002
3) Conceptual model for National Agricultural Literacy Outcomes (NALO) development, based on the research I conducted to develop the NALOs.

Sincerely,

Debra Spielmaker, PhD
Professor - Graduate Program Director

Figure 1. 5Fs

Figure 2. Single food item…

Figure 3. No written permission needed, just citation

Figure 4. Conceptual model

Figure 5. PISA Technical Report

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Figure 6. Model of experiential learning contexts.

As editor of the Journal of Agricultural Education, I give you permission to use Figure 7. Model of Experiential Learning Contexts. I am sure that you will, however I must ask you to please make sure you provide appropriate citations.

Harry N. Boone, Jr., Ph.D.
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CURRICULUM VITAE

M. ROSE JUDD-MURRAY

EDUCATION

Ph.D., School of Teacher Education and Leadership (TEAL) 2019
Curriculum & Instruction
Utah State University, Logan, Utah, USA

- Concentration: Instructional Leadership
- Emphasized coursework in student services, diversity & technology
- Dissertation: Judd-Murray, R. (2019). *Development and Validation of an Agricultural Literacy Instrument Using the National Agricultural Literacy Outcomes.*

M.S., School of Applied Sciences, Technology & Education (ASTE) 2002
Agricultural Extension
Utah State University, Logan, Utah, USA

- Emphasis on Adult Education
- Thesis: Judd-Murray, M. R. (2002). *An examination of private water use for agricultural production at the Abbey of Our Lady of the Holy Trinity, Huntsville, Utah*. Utah State University, Logan, Utah

B.S., Animal Science 1997
Utah State University, Logan, Utah, USA

CURRENT ROLE

Assistant Professor, School of Applied Sciences, Technology & Education Aug 2019-
Utah State University, Logan, Utah. Tenure-track appointment, faculty appointment in Nonformal & Community-based Education

- Teaching and course development for program appointment
- Research focused on agricultural literacy, gender equality in agricultural programs, professional learning in nonformal education

Graduate Student Researcher, TEAL Oct. 2018-May 2019
Utah State University, Logan, Utah. Research sponsored by the National Center for Agricultural Literacy (NCAL). Principal Investigator, Dr. Max Longhurst. *The Development and Validation*

of the Longhurst-Murray Agricultural Literacy Instrument

- Crafted the research proposal for IRB
- Conducted critical research for literature review and methodology
- Coordinated 2 separate panels of experts for instrumentation development
- Responsible for coordination efforts for visiting experts
- Assisted in the development of agricultural literacy assessment questions
- Facilitated communication and conferencing for research development

Graduate Student Teacher, ASTE Jan. 2015-June 2019

Utah State University, Logan, Utah

Course: Science, Technology, & Modern Society (DSC)

- Designed course to challenge students from non-science majors by developing an understanding of dynamic interactions between science, technology & society
- Focused course methodology on the importance of developing critical thinking skills, including the development of knowing how to find, use, and communicate reliable sources of information
- Required students to formulate concept maps and create infographics to convey scientific and technological information. Committed to building skill-based communication and organizational practices in general education courses
- Provided opportunities for students to explore positions of human responsibility for agriculture as it related to medicine, genetically modified organisms, drones (UAVs), climate change, human health and longevity, and ethical standards
- Developed, designed, and implemented an online version of the course. Utilized technology including Panopto, Canvas, CIDI audio-visual creation tools, Padlet, Camtasia, Adobe Photoshop, and Adobe In-Design
- Generated daily classroom discussions, both face-to-face and online to improve students' ability to process and communicate STEM topics
- Continually sought for ways to improve student engagement in large classroom settings

Project Director, National Agriculture in the Classroom (NAITC) 2013-2015

Utah State University, Logan, Utah

- Assisted in the development of the NAITC Curriculum Matrix
- Aligned all National Agricultural Literacy Outcomes (NALOs) to National Education Standards for science, health, and social studies

- Evaluated existing agricultural literacy curriculum from the U.S. and some selected global locations for inclusion in the National Curriculum Matrix; Aligned all qualified curriculum to NALO standards and National Education Standards
- Maintained the Curriculum Matrix by providing new curriculum, reviewing and in-putting existing curriculum, and highlighting featured resources
- Monitored and provided communication and public relations information for social media and networking sites for the NAITC organization
- Collaborated with other curriculum developers and program director to improve the Curriculum Matrix and strengthen support for users

Educational Specialist, National Gardening Association 2010-2013

Burlington, Vermont

- Writing, development & design of monthly Kids Garden News, an online newsletter
- Developed new curriculum for NGA, as well as for other contract partners such as Ball Canning, International Peace Gardens, and Epsoma Organics
- Conducted review, oversight and correspondence for all social media outlets, including student and educational blogs and video
- Assisted in new product development and product layout for printed catalog
- Directly responsible for the development, design, layout, and instruction of the online instructional course, School Gardening 101 and 102. Conducted through Adobe platforms and financed through the National Teacher Institute, a partnership with Longwood Gardens

Program Coordinator, National Resource Directory & Utah AITC 2007-2010

Utah State University Extension, Logan, Utah

- Responsible for the organization, review of resources, revision of existing resources, and oversight of the USDA-AITC National Resource Directory
- Crafted new curriculum and/or classroom activities to fill existing gaps in educational resources for K-12 teachers
- Conducted face-to-face and online pre-service teacher instruction to improve agricultural literacy among new teachers
- Coordinated pre-service instruction workshops with 6 different Utah universities, integrated instruction with science, health & social studies methods courses
- Monitored and provided social media support for the Utah AITC

and National Resource Directory

- Utilized writing, graphics and design capabilities to create a quarterly teacher newsletter

Project Coordinator, Utah AITC 2001-2005

Utah State University Extension, Logan, Utah

- Responsible for statewide coordination of K-6 agricultural education and agricultural literacy programs
- Generated new K-6 curriculum focusing on experiential learning, core curriculum alignment, and agricultural literacy
- Assisted directly in the development of an online course, ASTE 6400, designed to give K-6 teachers an opportunity to earn university credit, while using agricultural resources in their classroom
- Course instructor for ASTE 6400
- Conducted face-to-face and online pre-service teacher instruction to improve agricultural literacy among new teachers
- Coordinated pre-service instruction workshops with six different Utah universities, integrated instruction with science, health & social studies methods courses
- Utilized writing, graphics and design capabilities [Adobe In-Design, Illustrator & Photoshop] to create a quarterly teacher newsletter for the Utah AITC (The Beeline)
- Engaged in deliberate review of scientific and popular information sources to improve multiple perspectives of agricultural industries

Regional Coordinator, Utah Soil and Water Conservation Service 2000-2001

Utah Department of Agriculture and Food, Salt Lake City, Utah

- Communicated state and federal guidelines for water conservation and erosion control to local community soil and water councils
- Advised community councils in Morgan, Salt Lake, Tooele, and Weber counties in ways to connect, communicate and organize with local businesses, non-profit groups, university Extension, and educational entities
- Consulted individual agricultural farms and businesses in community mediation for improving relationships between agri-businesses and general populations
- Mentored individual farmers in the construction and execution of water quality plans that met federal guidelines for Concentrated Animal Feeding Operations (CAFOs)
- Primary grant writer for 4 county soil and water councils
- Provided timely press releases regarding agriculture, conservation, and agricultural literacy for urban and sub-urban regulatory and advisory committees

- Sought cooperation with environmental non-profit groups to better advocate for urban-agricultural promotion and protection

Staff Assistant and Office Manager, Utah AITC 1998-2000

Utah State University Extension, Logan, Utah

- Prepared materials and resources for instructional workshops
- Assisted with workshop instruction for both pre-service and in-service teachers
- Conducted the National AITC Conference Pre-Tour at Deseret Land & Livestock, Salt Lake City Conference
- Assisted in the preparation and delivery of programs for the National AITC Conference in Salt Lake City, Utah

Animal Health Specialist, USU Extension & Thanksgiving Point 1997-1998

Utah State University Extension, Logan, Utah

- Designed and implemented an animal breeding program to meet the needs of the Farm Country program
- Constructed and implemented an individual health and vaccination plan for all animals and livestock in the Farm Country program (e.g., goats, sheep, cattle, horses, water buffalo, geese, chickens, rabbits, bison, ostrich, mules)
- Worked directly with the state and regional USDA-APHIS coordinators to complete all federal and state regulations. Including on-site health examinations, state and federal documentation, regulatory measurements for health and safety, and necropsy certifications
- Designed the first Farm Country school tours for K-6 educational groups
- Coordinated with Thanksgiving Point marketing team to develop signage that accurately conveyed correct information about farm animals and agricultural practices

Internship, Utah State University 1996

Castroville Animal Clinic, Monterey, California

- Veterinary Technician, Small Animal Experience
- On-site, 3-months under the direction of Dr. Marty Field, DVM

TEACHING

Course Description

Science, Technology & Modern Society, ASTE 3440 (DSC), Utah State University: 80 Undergraduate Students/Semester; 3 Credits

- Course consists primarily of non-science majors completing general education credits

- Content focuses on communicating the significance and relevance of modern science and technology. Students regularly engage in face-to-face group work, online discussions, and hands-on application in the classroom

University Connections, USU 1010, Utah State University: 35 Undergraduate Students/Semester; 2 Credits

- Implemented curriculum designed to assist first-year students in a successful transition to higher education
- Utilized office hours to conduct mentoring and progress sessions with students
- Used class time to assist students in evaluating their goals and listing specific needs
- Enabled students to locate student resources to empower their progress

School Gardening Online Course 101 & 102, National Teacher Institute: 112 Teachers

- Created course content and student resources that showed how to design, develop, and operate a successful school garden. Assisted students in locating regional sources for construction, funding, and communicating with district and local community officials
- Designed and disseminated advertising materials and registration resources to a national audience
- 112 teachers enrolled and 105 completed the 8-week online course
- As course instructor, 97% percent of course participants said they would recommend the course to others

School Gardening On-Site Course 101 & 102, National Teacher Institute: 35 Teachers

- Workshop instructor and program director for face-to-face school garden educational programs
- Assisted each participant in determining specific locations, funding sources, and public relations techniques for implementing a school garden at their school or site
- 35 teachers enrolled and 35 completed the 3-day on-site course
- As course instructor, all course participants said they would recommend the course to others

Teacher Pre-service Programs: 800 Student Teachers Trained Per Year

- In-service content tailored to improve the agricultural literacy of new K-6 teachers
- Focused instruction on how to integrate agriculture into existing core curriculum Approach featured non-biased, science-based content to strengthen understandings and reduce initial hesitation to agricultural content

- Instructional methods included inquiry, experiential learning, and team-based learning in small groups

Credit Courses and Evaluations: Academic Department Credit Courses

Semester	*Department*	*Title*	*Credits*	*No. Students/ Response Rate*	*IDEA Scores*
Fall 2018	ASTE/TEE 3440	Science, Technology & Modern Society	3	72/94%	62
Fall 2018	ASTE/TEE 3440	Science, Technology & Modern Society	3	73/84%	60
Spring 2018	ASTE/TEE 3440	Science, Technology & Modern Society	3	77/86%	63
Spring 2018	ASTE/TEE 3440	Science, Technology & Modern Society	3	82/87%	64
Fall 2017	ASTE/TEE 3440	Science, Technology & Modern Society	3	72/90%	64
Fall 2017	ASTE/TEE 3440	Science, Technology & Modern Society	3	83/88%	62
Spring 2017	ASTE/TEE 3440	Science, Technology & Modern Society	3	72/92%	61
Spring 2017	ASTE/TEE 3440	Science, Technology & Modern Society	3	78/92%	61
Fall 2016	USU 1010	Connections	2	35/80%	5.6/6
Fall 2016	ASTE/TEE 3440	Science, Technology & Modern Society	3	73/74%	63
Fall 2016	ASTE/TEE 3440	Science, Technology & Modern Society	3	67/79%	64
Spring 2016	ASTE/TEE 3440	Science, Technology & Modern Society	3	65/82%	60

Spring 2016	ASTE/TEE 3440	Science, Technology & Modern Society	3	73/88%	63
Fall 2015	ASTE/TEE 3440	Science, Technology & Modern Society	3	67/88%	63
Fall 2015	ASTE/TEE 3440	Science, Technology & Modern Society	3	76/88%	65
Summer 2015	ASTE/TEE 3440	Science, Technology & Modern Society	3	15/67%	59
Spring 2015	ASTE/TEE 3440	Science, Technology & Modern Society	3	67/94%	61
Spring 2015	ASTE/TEE 3440	Science, Technology & Modern Society	3	61/90%	64
2005	ASTE 5560	Food, Land & People for Elementary Teachers	1-3	~100-150	5*
2004	ASTE 6400	Food, Land & People for Elementary Teachers	1-3	~100	4.8*
2003	ASTE 6400	Food, Land & People for Elementary Teachers	1-3	~100	5*
2002	ASTE 6400	Food, Land & People for Elementary Teachers	1-3	~70	4.8*

Rating Scale for ASTE 5560 & 6400, 1-5, 5 being the highest

Teaching Innovations – Ongoing

Year Initiated	***Innovation Description***	***Impact***
2018-2019	Participation in ETE Learning Circle: Experiential/Active Learning Emphasis	Improved communication and collaboration with USU faculty; increased the number of active learning activities conducted in class; incorporated the use of "lecture pauses" to improve course instruction.
2018	Utilized the first active-learning classroom on USU campus; implemented lecture pausing structure to improve student knowledge capture and retention	Increased group communication and the quality of discussion responses.
2017	Research and Implement low-stakes testing in ASTE 3440. Build an assessment framework that focuses on comprehensive learning throughout the semester.	Removed high-stakes testing from curriculum format. Developed comprehensive short quiz framework that focused on main ideas and critical thinking processes. Improved classroom discussion responses, project-based work, and final writing assignments.
2016	Development and design of a online/blended learning course for ASTE 3440; Science, Technology & Modern Society	The ability to offer an online/blended learning section of the depth-science course greatly increased accessibility of high-quality science instruction to USU undergraduate students, especially on regional campuses.
2013	Development of the National Agricultural Literacy Outcomes for use within the NAITC Curriculum Matrix.	Outcomes designed to produce measurable assessment goals to improve agricultural literacy and program evaluation. The Matrix is an online, searchable, and standards-based curriculum map for K-12 teachers.
2013	Increase the application of social networking to share agricultural literacy information.	Increased substantially, the number of visitors, friends, and users of the NAITC Twitter, Facebook, YouTube pages.

2011	Development of the online and on-site courses School Gardening 101 & 102 for the National Teacher Institute	Established 20 new school gardens within the U.S. and 1 International project. Ongoing projects reported that they were more likely to increase student participation in existing school gardening projects after participating in the course.
2010	Implementation of formatted lesson plans which can easily be downloaded from the KidsGardening.org website	Increased website usability by teachers nationwide. Increased the number of lessons downloaded and increased the number of requests for the KidsGardening.org Newsletter that displayed the newest lesson plans.
2008	Add the Featured Resources links to the homepage of the National Resource Directory to direct users to some of the best educator resources within the database.	Multiple state programs indicated an increase in the number of teachers visiting, downloading and/or purchasing resource materials from their website(s).
2008	Assist in the redevelopment of the National Resource Directory to change the administrative menus, search engines, and resource details. Determine and implement an improved review process for resource materials.	Website traffic increased following the re-development of the website.
2007	Create a web-based PowerPoint presentation and web pages for pre-service educational programs statewide.	Presented to and used by 800+ student teachers each year to introduce them to Agriculture in the Classroom resources.
2005	Develop instructional materials and design an online course for in-service K-6 teachers. A web-based course gives teachers more flexibility and an opportunity to try-out what they learn in “real-time.”	Enrolled 100-150 teachers and delivered statewide. The course required accountability from teachers (students) for what they learned and used in the classroom. In addition, the course design allowed for formative assessment to meet the needs of teachers and their students.
2004	Assist in the development of an online store for teachers to purchase Agriculture in the Classroom Resources.	In 2009, 624 orders shipped grossing $24,087.

Peer-Reviewed Curriculum and Instructional Materials

Judd-Murray, R. M. (2012). *Kids Gardening News: After the Harvest*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2012). *Kids Gardening News: Pet Safety and Your Garden*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2012). *GAME: Grow, Ask, Move & Eat*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2012). *School Gardening 102, Making the Most of Your Garden*. Burlington, VT. National Teacher Institute, National Gardening Association, Longwood Gardens.

Judd-Murray, R. M. (2012). *School Gardening 101, An Introduction to School Gardening*. Burlington, VT. National Teacher Institute, National Gardening Association, Longwood Gardens.

Judd-Murray, R. M. (2012). *Working with Volunteers (Instructional Unit and Survey)*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2012). *Kids Gardening News: The Rain Garden*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2012). *Understanding Pollinators (Instructional Unit)*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Gardening With Children*. Parenting Magazine, May 2011 Issue.

Judd-Murray, R. M. (2011). *Kids Gardening News: Growing a Memorial Garden*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Composting in the Classroom Instructional Guide and Kit*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Muhammad Ali Center Gardening Guide (Instructional Unit).* Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Ball Company Garden Activity Guide (Instructional Unit)*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Kids Gardening News: Garden Safety*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Kids Gardening News: Taking It to the Bank.* Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2011). *Kids Gardening News: How Sweet It Is*. Burlington, VT. National Gardening Association.

Judd-Murray, R. M. (2010). *Utah Agriculture in the Classroom Bulletin: Horse and Rider, The Pony Express in Utah*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2010). *Utah Agriculture in the Classroom Bulletin: Grocery Store Problem Solving*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2010). *Utah Agriculture in the Classroom Bulletin: Inside the Egg, Hatching Chickens*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2009). *Utah Agriculture in the Classroom Bulletin: Baa, Ram, Ewe…Sheep Tales*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2009). *Utah Agriculture in the Classroom Bulletin: The Quicker the Better? Food Processing*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2009). *Utah Agriculture in the Classroom Bulletin: The Seed Match & Where Do They Grow*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2008). *Utah Agriculture in the Classroom Bulletin: Just Kidding Around: Using Goats for Fire Prevention*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2005). *Utah Weather* (Instructional unit). Logan, UT: Utah State University.

Judd-Murray, R. M. (2005). *Utah Agriculture in the Classroom Bulletin: The Little Red Hen: From Seed to Harvest*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2004). *Utah Agriculture in the Classroom Bulletin: Malnutrition: A Problem for the Hungry and Fed & Who's Hungry: A Closer Look at Feeding the World*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2004). *Utah Agriculture in the Classroom Bulletin: Food Systems Feed the World*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2004). *Utah Agriculture in the Classroom Bulletin: Getting* *to the Core of Indoor and Outdoor Gardening*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2004). *Utah Agriculture in the Classroom Bulletin: A Worm's World*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2004). *Utah Agriculture in the Classroom Bulletin: King Cotton*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2003). *European Agricultural Map*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2003). *Utah Agriculture in the Classroom Bulletin: Local Food Production*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2003). *Utah Agriculture in the Classroom Bulletin: The Right Fit for Fabric*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2003). *Utah Agriculture in the Classroom Bulletin: Does Your Diet Stack Up*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2003). *Western Water Issues*. Salt Lake City, UT: Utah Society for Environmental Education.

Judd-Murray, R. M. (2002). *Heredity: Your Link to the Past* (Instructional unit). Logan, UT: Utah State University.

Judd-Murray, R. M. (2002). *Utah Agriculture in the Classroom Bulletin: A Bug's Life*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2002). *Utah Agriculture in the Classroom Bulletin: Journaling to Increase Retention*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2001). *Field Guide to Utah Agriculture in the Classroom, Volume II*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2001). *Utah Agriculture in the Classroom Bulletin*. Logan, UT: Utah State University.

Judd-Murray, R. M. (2001). *Social studies and agriculture K-3*. Logan, UT: Utah State University.

SCHOLARLY PRESENTATIONS

Hitting Pause. Using Pauses to Improve Classroom Lecture. (2019, June). North American Colleges and Teachers of Agriculture, National Conference. Twin Falls, Idaho.

Hitting Pause. Using Pauses to Improve Classroom Lecture. (2019, April). Empowering Teaching Excellence (ETE) Spring Conference. Logan, Utah.

Engaging Students Through Issues-based Topics. (2018, August). Empowering Teaching Excellence (ETE) Faculty Teaching Conference. Logan, Utah.

The Development and Validation of the Longhurst-Murray Agricultural Literacy Instrument. (2018, June). National Agriculture in the Classroom Conference. NAITCO Meeting. Portland, Maine.

Engaging Students Through Issues-based Topics. (2018, June). National Agriculture in the Classroom Conference. Portland, Maine.

Engaging Students Through Issues-based Topics. (2017, September). USU College of Agriculture and Applied Sciences, Faculty Retreat/Teaching Academy. Logan, Utah.

Analysis of Pre-Service Workshop Evaluation for the Utah Agriculture in the Classroom Organization. (2017, March). Western Regional Meeting, American Association of Agricultural Education, Ft. Collins, Colorado. Poster Session.

Objective and Subjective Truth in the Classroom. (2017, October). Empowering Teaching Excellence Seminar, Utah State University.

Using Social Media to Engage Students. (2016, October). Canvas Management Podcast, CIDI/AIS, Utah State University.

Introduction of the Curriculum Matrix. (2013, June). National Agriculture in the Classroom Conference, Minneapolis, MN.

School Gardening 101. (2012, July). Longwood Gardens Summer Gardening Courses: On-Campus Learning, Longwood Gardens, Kennett Square, PA.

GAME: Grow, Ask, Move & Eat. (2012, June). National Agriculture in the Classroom Conference, Denver, CO.

The Benefits of School Gardening. (2011, March). Arbico Organics, Solutions for

Home, Garden & Professional Agriculture. South Burlington, VT.

Blogging for Beginners. (2009, June). National Agriculture in the Classroom Conference, St. Louis, MO.

The Search is Over, Using the National Resource Directory. (2009, June). National Agriculture in the Classroom Annual Meeting, St. Louis, MO.

Annual Report, National Resource Directory (2009, February). Western Regional Agriculture in the Classroom Annual Meeting, Las Cruces, NM.

Annual Report, National Resource Directory. (2008, February). Western Regional Agriculture in the Classroom Annual Meeting, Jackson Hole, WY.

Updating the National Resource Directory. (2008, June). National Agriculture in the Classroom Conference, Costa Mesa, CA.

Helping students understand hunger-related issues. (2004, June). California Foundation for Agriculture Annual Meeting, Ventura, CA.

Teaching Effective Online Courses. (2004). National Agriculture in the Classroom Conference, Albuquerque, NM.

The Basics of Heredity. (2003, June). National Agriculture in the Classroom Annual Meeting, Nashville, TN.

Effective Social Studies Integration Strategies. (2002, February). National Food, Land & People Conference, Orlando, FL.

Strategies for a Successful Farm Field Day. (2002, June). National Agriculture in the Classroom Annual Meeting, Washington, D.C..

Benchmarks to an improved program; Beyond status quo. (2001, June). National Agriculture in the Classroom Conference, Chicago, IL.

Scholarly Presentations Table

Presentations and Programs **Total Participants: 29,560**

Year	Program	Duties	Audience	Participants
2019	North American Colleges and Teachers of Agriculture (NACTA) National Conference	Conference Oral Presentation	NACTA Members	50
2018	Empowering Teaching	Faculty	USU Faculty	50

	Excellence (ETE), Spring Conference	Presentation	Members	
2018	National Agriculture in the Classroom Conference (NAITC)	Presenter	NAITCO Leadership	35
2018	National Agriculture in the Classroom (NAITC) Conference	Presenter	National AITC Conference attendees	50
2017	USU College of Agriculture and Applied Science (CAAS) Faculty Retreat	Faculty Presentation	CAAS Faculty Members	100
2017	American Association for Agricultural Education (AAAE) Conference	Poster Presentation	AAAE Western Regional Conference members	150
2017	Empowering Teaching Excellence (ETE), Teaching Factual Information Panel Speaker	Presenter	Utah State University Faculty & Lecturers	80
2016	Utah Cattlewomen Annual Convention	Keynote Speaker	Utah Cattlewomen Association	35
2010	Connections: World Geography and Agriculture	Presenter	Utah State University	90
2004	Foundations of Agriculture	Presenter	Utah State University	15
2004	School Gardening	Presenter	K-6 Davis Teachers	40
2003	Soils	Presenter	K-6 Granite Teachers	40
2002	Heredity: A Link to Your Past	Developer, Presenter	K-6 Teachers, Statewide	500
2002	Soils	Presenter	K-6 Teachers	60
2002	Agriculture and Social Studies Workshops	Developer, Presenter	K-6 Jordan & Davis County SD Teachers	30
2001	Agriculture and Social Studies Workshops	Presenter	K-6 Jordan & Davis County SD Teachers	200
2001-present	Western Regional AITC Meeting	Presenter	CA, NM, AZ, UT, WY	15
2000	National Agriculture in the Classroom Conference	Presenter	All 50 states and U.S. Territories	400
2001-2005	Food, Land & People Facilitator Training	Co-Coordinator & Presenter	Utah	17
1998-2000	Cache County Farm Field Day	Presenter	Utah	2,700
2000-1997	Utah State Fair Agriculture Literacy Exhibit	Presenter	Utah	25,000
			TOTAL	**29,660**

Instruction & Design Proficiencies

- Lucid Chart
- Infographic Design
- Adobe: Connect, In-Design, Photoshop
- Canvas LMS
- Skype, Zoom & WebEx
- Panopto
- Camtasia
- Social Media tools
- Blogger
- Edmodo
- Web 2.0 tools

RESEARCH

Journal

Hitting Pause: Practical Ways to Incorporate Reflective Learning Experiences in Class. Graf, M., Judd-Murray, R., Rutigliano, H. (2019). North American Colleges and Teachers of Agriculture (NACTA) Journal. Vol. 63, Supplement 1.

Journal In-Progress

Measuring Agricultural Literacy: Grade 3-5 Instrument Development and Validation. Longhurst, M., Judd-Murray, R., Coster, D. C., & Spielmaker, D. M. (2019). Manuscript submitted for publication.

Poster Sessions

Analysis of Pre-Service Workshop Evaluation for the Utah Agriculture in the Classroom Organization. (2017, March). Western Regional Meeting, American Association of Agricultural Education, Ft. Collins, Colorado. Poster Session.

Research Interests

Agricultural Literacy, STEM Literacy, Gender & Science Instruction, Gender & STEM, and Professional Development in Nonformal Education

SERVICE

University, State, Regional and National Professional Service

- Faculty panel presentations, USU Connections Course 2019
- Improvement Team Member for Active Learning Classroom 2019
- Member of North American Colleges and Teachers of Agriculture (NACTA) 2019
- Engagement Badge: ETE Conference 2018
- Implementation Badge: ETE Conference 2018
- Contribution Badge: E-Learning Workshop 2018
- Instruction for USU Career Center, USU Connections Course 2018
- Faculty panel presentations, USU Connections Course 2018
- Hiring Committee Member, VP USU Career Center Search 2018
- Earned Empowering Teaching Excellence (ETE) Badge: Engage 2017
- AITC Program, Position Search Committee 2017
- ETE Badge: Online Teaching: CIDI Instructor Training: Implement 2017
- ETE Badge: Improve Teaching Contribute 2017
- ETE Teaching Instruction Advisor 2017

- Member of American Association for
Agricultural Educators (AAAE) 2016-present
- *InstructureCon 2016*: Canvas LMS Annual Conference 2016
- Canvas Systems Teaching & Instruction Podcast Presenter 2016
- Completed the Academy for E-Learning Excellence 2016
- Participating in-kind author, KidsGardening Newsletter 2014-2016
- AITC Program, Position Search Committee 2015
- Member of National Science Teachers Association 2010-present
- Certified Master Gardener, Program Member
and Participant 2005-present
- Community Garden Director and Planning Committee 2008-2010
- Utah Foundation for AITC, Projects Committee Member 2001-2007
- Utah College of Agriculture Alumni Association Board
of Directors 1998-1999
- USU College of Agriculture Alumni Association Member 1997-2010
- 5-A-Day for Better Health Committee Member 1998-2000
- Assisted with the Food & Fiber Systems Literacy Assessment 2001
- Utah State University Presidential Benchmark Tour 2001
- Thanksgiving Point Institute Extension Educator
Search Committee Member 2001
- Thanksgiving Point Institute Agricultural Advisory
Committee Member 1997-2007
- Prepared and mailed Farm Field Day packets for
2000 teachers 1998-2003
- Participated in 16 statewide Farm Field Day events 1998-2003
- USOE Informal Science Education Committee Member 1998
- Exhibited at 44 Extension and educational trade shows 1997-2010
- Presented or piloted tested educational materials in
35 Utah classrooms 1995-2007

AWARDS AND HONORS

- *Graduate Student Teacher of the Year* 2016-2017
Utah State University, College of Agriculture and Applied Sciences
- *Graduate Student Teaching Award of Merit* 2017
North American Colleges and Teachers of Agriculture and USU
College of Agriculture and Applied Sciences
- *Graduate Assistantship* 2015
Utah State University, School of Applied Sciences, Technology & Education
- *Outstanding Teaching Recognition* 2005
University of Utah, College of Education
- *College of Agriculture Student Ambassador* 1997
Utah State University, College of Agriculture
- Recipient of USU College of Agriculture Scholarship 1994

- Recipient of Summit County Women in Business Scholarship 1993

STUDENT EVALUATION COMMENTS

- The content of Rose’s lectures was very compelling, very relevant, and she kept an excellent pace throughout the semester.
- She is the best teacher that made the course inviting and interesting through the materials, lessons, and objects.
- I loved how Rose cares about us as individuals and not just numbers. She learned everyone’s names and you could tell she cared!
- She is such an awesome teacher and she should teach all professors on campus how to teach and not just lecture. I loved that she applied things to everyday life.
- The teaching methods were excellent. Rose is a fantastic professor. She teaches in a way that is welcoming for the quiet individuals to be a part of the discussion and makes students think about a large variety of real world issues and information that is actually helpful to know.
- Really excellent teacher. She really loved what she taught about and loved us as students. I got the impression that she really liked us as students. She was concerned for us, was super open to questions and comments, and knowledgeable about the class.
- She is the best teacher I have ever had. It really felt like she not only cared about the subject, but about us and our academic success in her class. She was also really funny, and did an amazing job teaching.
- Mrs. Judd−Murray was a phenomenal teacher. The class setting was always interesting and she changed it up. The content was always interesting and related to the "real world."
- I found that Professor Judd−Murray really cared about how students were doing and how they learned. I love the hands-on activities she had us do in class and how she put her lectures together. She is the BEST professor I have had here at USU.