15 YEARS OF AGRICULTURAL LITERACY RESEARCH: HAS THE PROFESSION ONLY FOCUSED ON A PARTICAL PICTURE OF WHAT IT MEANS TO BE LITERATE?

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Abstract

The purpose of this historical and philosophical study was to critique the agricultural education profession's predominate way of assessing agricultural literacy and to offer an alternative that focuses on surfacing food and fiber system (FFS) literacy understanding. Over the past 15 years most agricultural education researchers have focused on ascertaining only one aspect of Frick et al.'s definition of agricultural literacy, knowledge, while not tackling the more difficult task of determining what people understand about the FFS. In this paper, we argue constructivism and conceptual change theory offer a theoretical framework to undergird interpretative research methods, which are well-suited to unearthing cognitive structures that represent what people understand about the FFS. The framework and its attendant methods may help the profession meet its goal of fostering a population that is conversationally literate about the food and fiber system.

In Democracy and Education, Dewey (1916) suggested that democratic society relies on the participation of its members to readjust institutions to meet the values of the majority. Unfortunately, most citizens are incapable of intelligently participating in democratic discourse that critically evaluates the science and technology used in food and fiber systems (FFS). This is evident in current debates over biotechnology, water rights, animal ethics issues, pesticide usage, organic production methods, sustainable agriculture definitions, etc. If citizens are to engage in discourse about the FFS, U.S. public schools must teach these concepts so citizens can discuss these issues on a basic level (American Association for the Advancement of Science [AAAS], 1989).

A logical place to teach food and fiber system concepts is in science education. AAAS's Project 2061 (1989) identified agriculture as one of the eight basic technology areas for study by our nation's students. The association argued, "the boundaries between traditional subjects should be softened and more emphasis placed on the connections among science, technology, and society" (p. 5). Some practitioners have sought guides for the implementation of agricultural examples into science curricula. In 1993, AAAS released *Benchmarks for Science Literacy* that, among other things, defined content necessary for K-12 children to understand the scientific and technological underpinnings of the FFS. *Benchmarks* (AAAS, 1993) also sought explicitly to help learners critically evaluate the FFS by developing concepts necessary to understand and weigh the system's effects on society and the environment.

This call for FFS literacy is not new to agricultural education. In 1988, the National Research Council (NRC) coined the term agricultural literacy and suggested that all of our nation's K-12 students receive systematic instruction so as to be agriculturally literate. In an attempt to define agricultural literacy and its attendant educational concepts, Frick, Kahler, and Miller (1991) conducted a Delphi study of U.S. agricultural leaders. The study's definition suggested that a literate person would possess "understanding and knowledge of the food and fiber system" (p.5) thereby allowing him/her to synthesize, analyze, and communicate basic information about agriculture. It is noteworthy that agriculture leaders ranked an *understanding* of agriculture as the most important behavior held by a literate person.

As Frick et al's definition became accepted by most in the profession, research studies were conducted of elementary and high school student, educator, pre-service teacher, and urban and rural adult populations (Frick, et al, 1991; Birkenholz, Frick, Gardner, & Machtmes, 1994; Humphry, Stewart, & Linhardt, 1994; Wright, Stewart, & Birkenholz, 1994; Frick, Birkenholz, & Machtmes, 1995; Harris & Birkenholz, 1996). These survey-based studies focused on assessing FFS perceptions, knowledge, and practices in light of this new definition of agricultural literacy. At about this time, Leising and Zilbert (1994) began work on standards for agricultural literacy in California. After modification of these standards, Leising and Igo (1998) published *A Guide to Food and Fiber Systems Literacy*, which included a Food and Fiber System Literacy Framework (FFSLF). This guide has become the basis of much recent scholarship in the field. In 2001, Leising, Pense, and Igo (2001) conducted a multi-state survey of elementary student agricultural literacy based on the FFSLF. In 2003, Pense, Leising, and Portillo (2003) sought the effects of an agricultural literacy treatment on elementary school children by using a survey to assess knowledge of FFSLF concepts. As agriculture literacy developed, most within our profession assessed FFS literacy with surveys.

Assessing FFS literacy, however, entails more than simply ascertaining bits and pieces of agricultural knowledge, it requires making apparent what people understand. The aforementioned studies proceeded as if knowledge (as assessed through multiple choice and true false survey items) equate to literacy. It can be argued, however, that this line of research may bring our profession closer to ascertaining only the most basic aspect of Frick et al's (1991) FFS literacy definition, "knowledge," while ignoring the more important goal, "understanding." Assessing knowledge and comprehension, the lower levels of Bloom's taxonomy was a good place to start on our profession's road to increasing FFS literacy. After 15 years of research, however, it is time to critically evaluate how the profession has measured FFS understanding.

To "understand" is a personal affair, one entailing a struggle to grasp meaning (Dewey, 1916), and one not readily measured through impersonal survey methods. Gardner (1991) has suggested that traditional surveys can "provide clues to student understanding, [but] it is generally necessary to look more deeply if one desires firm evidence that understandings of significance have been obtained. For these purposes, . . . open-ended clinical interviews or careful observations, provide the best way of establishing the degree of understanding that students have obtained" (p. 145). Evaluating idiosyncratic understanding requires interpreting a person's ideas about the relationships between things, not simply facts known. If literacy is to be evaluated and understood by researchers, then discourse of individuals must be ferreted out through conversation (Rosebury, Warren, & Conant, 1992). In 1999, the National Council on Agricultural Education's published *Reinventing Agricultural Education for the Year 2020* (NCAE, 1999) report which expanded the definition of agricultural literacy by adding conversational literacy about agriculture as a goal for all students.

As the definition of FFS literacy evolves, so must the agricultural education profession re-conceptualize what literacy entails because basic knowledge (historically what the profession has measured) without demonstration of understanding through discourse, reasoning, and problem solving will not allow a person to be FFS literate. To determine the level of understanding a person possesses requires research methods foreign to most in agricultural education, the very same methods the profession has begun to explore at our national research meetings during pre-conference sessions and through its choice of invited speakers (Lincoln, 1999). As recently as the 2003 National Agricultural Education Research Conference, Larry Miller (2003) made an impassioned plea for researchers to explore the use of alternative epistemologies and bring in new methods to answer questions of importance to the profession. Of the three epistemological paradigms (interpretative, positivism, and radical/critical), the agricultural literacy research agenda could be most productively enhanced by the use of the interpretative paradigm. Because agricultural literacy, as defined by Frick et al., includes not only knowledge, but also understanding, and, if conversational literacy is a shared goal, then research methods from the interpretative paradigm maybe the most appropriate for answering questions about these topics.

Purpose/Objectives

The purpose of this study was to critique the profession's predominate way of assessing FFS literacy knowledge and to offer an alternative that focuses on surfacing FFS literacy understanding. The objectives were (1) to provide a theoretical framework and rationale for interpretative methods and (2) to present a framework and model for this type of research.

Method

Historical research methods that focused on primary texts were used to review the progression of agricultural literacy research. Studies from other disciplines were reviewed and a philosophical argument was crafted that supported the use of interpretative methods. Because we were exposed to interpretative research paradigms in graduate school, we may be prone to favor methodologies that incorporate naturalistic approaches to ascertain literacy.

Findings

A Theoretical Framework for Interpretive Research in Agricultural Literacy

For the first half of the 20^{th} Century, the behaviorist school of psychology ruled supreme. This line of thought suggested that people learned in systematic steps that could be reduced to incremental learning. This theoretical model is the basis for much of agricultural education's positivist research orientation (Miller, 2003). The metaphor of the learning machine was often used to conceptualize behaviorist ideas. Later in the century, researchers in computer science, linguistics and cognitive psychology proffered a new conception of learning. This conception involved new notions about how individuals structure perceptions taken from their environmental interaction. These theories were termed constructivism and conceptual change.

Constructivism and conceptual change theory have become two dominant theories in the field of education and offer a potential for ascertaining agricultural literacy levels. Constructivists (Bruner, Goodnow & Austin, 1956**;** Bruner 1986) have viewed learning as an active process were learners construct new ideas or concepts based on past knowledge. This theory relies heavily on Piaget's (1950) work that emphasized the inherited processing complexes of the brain. Piaget suggested that the brain could be thought of as a container of perceptions that are organized into different structures. These structures are modified as a person faces new and different sensory inputs. The brain seeks what Piaget called "equilibrium." He proffered that equilibrium is reached when functions (biologically determined processors) are influenced by the sensory inputs and a balance is achieved. As more input comes in, discontinuity in the previously developed knowledge structures occur forcing change. This change must be accommodated to form new structures within the brain. These structures, Piaget asserted, have sub-units called schemas (Moll, 1990; Bereiter, 1994). Schemas can be thought of as structures of interactions that are constantly changing. As these changes occur, a person learns by reconstructing his/her cognitive maps or schemas.

Related to constructivist theory is the notion of conceptual change. Conceptual change theory was first advanced by Kuhn (1962) in his seminal work *The Structure of Scientific Revolutions*. He argued against the notion of a systematic development of a scientific body of knowledge and suggested that scientific knowledge development actually followed a less linear and less regimented process. That is, scientists follow theories, paradigms as Kuhn called them, for as long as they are fruitful. If they no longer make sense or if the theory becomes too cumbersome, they are dropped in favor of a new paradigm with a greater promise for solving the puzzles of scientific inquiry. These ideas were adopted by Posner, Strike, and Gertzog (1982) and incorporated into their theory of conceptual change in science learning. They suggested that students abandoned their previously held conceptions only when they saw that their idea was no longer fruitful, became too cumbersome, and when the new idea offered the possibility of being more fruitful for answering their questions. Basically, the conceptual change model holds that people must be challenged to learn. Through challenges to previous ideas, the learners reconstruct their internal explanation for the world. Science educators (Smith, 1990; Driver, Guesne, and Tiberghien, 1985) sought to promote learning by trying to help students construct, or at times, reconstruct their cognitive structure through conceptual change.

The FFS is a complex assemblage of interrelated networks, which requires those who come into contact with it to form cognitive structures about the system. To determine what people understand about this system, and then to design educational materials and programs to help people make well-reasoned decisions about it, requires ferreting out idiosyncratic understandings. Representing such understandings can best be accomplished by the use of interpretative methods that allow for a detailed examination of the cognitive structures.

This quest for understanding calls for research methods most often used in cognitive anthropology and linguistics (which have been used by science education researchers). Cognitive anthropology generally focuses on the intellectual and rational aspects of culture, particularly through studies of language use. Cognitive anthropologists have suggested that humans, as social beings, use language as the primary shaper of meaning (Fine, 1990). These anthropologists believe unearthing mental constructs and schemata of individuals requires analysis of speech because "talk exemplifies a conceptual unit" (Frake, 1980, p. 57) whereby we organize our thoughts and ideas. Cazden (1994), a noted linguist, has argued "speech unites the cognitive and social" (p. 1). The particular area of linguistics that shows promise for unearthing understanding is psycholinguistics, a branch of psychology that studies the basis of linguistic competence.

Methods used by cognitive anthropologists and linguists, based on the analysis of oral discourse, have not been well integrated into agricultural literacy research. As mentioned earlier, this is problematic, because agricultural educators have argued that literacy requires possessing both *understanding* and knowledge of the FFS and have stated a goal of conversational literacy of U.S. school children. The prevailing research methods in agricultural education, however, do not allow for detailed evaluation of idiosyncratic thought or conversation. Considering this limitation, we next explore a framework and method to surface FFS understandings.

Framework and Model for Ascertaining Understandings of FFS

In this section a framework and methods for ascertaining FFS understandings are outlined that draw on the work of other outside our discipline. To ferret out idiosyncratic understandings, science education researchers have defined expert conceptions and then probed student conceptions by interview techniques (Driver, Guesne, & Tiberghien, 1985; Posner, Strike, & Gertzog, 1982). They then compared "novice or lay" student conceptions with those of experts, because formal learning is often thought of as acquiring expert knowledge and understandings.

Link Study to Science and Agricultural Education National Benchmarks

To ground interviews in previous scholarship, we advocate using science education (AAAS, 1993) and agricultural education (Leising & Igo, 1998) curriculum framework documents that define grade level specific educational benchmarks (objectives) for agricultural literacy. We suggest analyzing these documents and developing a synthesis of overlapping areas, because agricultural education can reach a larger audience if others outside the discipline teach FFS concepts. To provide a concrete example, a model synthesis of educational standards from the *Benchmarks* (AAAS, 1993) document and the FFSL Framework (Leising & Igo, 1996) regarding the use of fertilizers in crops is provided. Once a synthesis is developed, an expert narrative for a benchmark needs to be articulated. Next, researchers need to clearly define FFS content and language necessary to convey an understanding of the expert narratives for a specific grade level. Table 1 shows a key concept, benchmark, and language needed for discourse about fertilizer use.

Table 1.

Key Concept, Benchmark, and Language for Fertilizer Use

Key Concept	Benchmark	Language
What is the role of science and technology in the agri-food system?	Explain why fertilizers are used to grow crops.	nutrients, soil, water, roots, production, fertilizer, yield

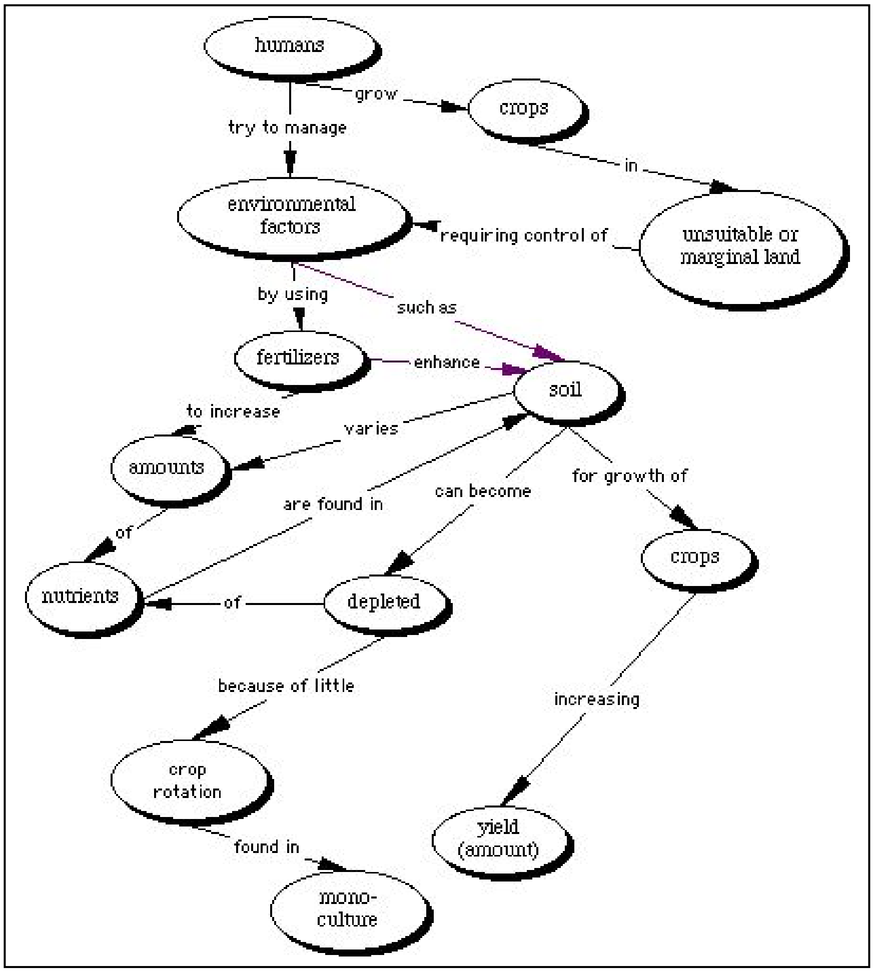
For illustrative purposes, an expert conception for the benchmark is provided below.

> *To explain why fertilizers are used to grow crops, one first needs to understand plant growth requirements and soil fertility and composition.*
>
> *Humans increasingly grow crops on marginal land in areas where temperature is conducive to plant growth. This enables them to obtain crops throughout the year, not simply when they are seasonally available in local geographic regions. Growing crops in these regions requires humans to manage environmental factors such as soil fertility.*
>
> *Humans use technologies to deliver fertilizers to increase plant growth. Fertilizers—organic or inorganic in origin—are applied to soil or in water for delivery to plants. Roots primarily take up nutrients. The use of inorganic fertilizers has, for the most part in conventional farming, replaced organics and is of increasing importance as more marginal land is used for crop production. By growing the same plants on land for consecutive seasons, the soil becomes depleted of nutrients from lack of crop rotation. As a result of monoculture, soil fertility decreases and producers require additional fertilizers to sustain crop yields.*

Developing Concept Maps

Along with the expert narratives, we suggest developing expert concept maps for benchmarks (Figure 1 illustrates a expert concept map for the Fertilizer Use narrative above). Concept maps visually represent the structure of information, how concepts within a domain are interrelated. These interrelationships are the hallmark of understanding the unity of knowledge and are uniquely made apparent through concept maps. Concept maps are based on Ausubel's (1963) theory of meaningful learning which stresses that learning new knowledge is dependent on what is already known. The use of concept maps reduces expert conceptions to fundamental meanings and allows for easier comparisons of informant's (interview subjects) conceptions with the experts. In addition, informants' concepts maps can be compared with one another to identify trends and patterns among those in a study.

Figure 1. Expert Concept Map for Fertilizer Use



Developing a Coding Scheme

Next a coding scheme is developed that provides a basis for interpreting data. Because we suggest evaluating literacy levels based on predetermined benchmarks, developing a coding scheme that compares the expert conception with the study's informants (subjects) seems most appropriate. In the past we have successfully used Hogan and Fisherkeller's (1996) bimodal coding scheme to represent highly complex understandings of FFS benchmarks. This coding scheme allowed us to judge the sophistication informants' subconcepts along two dimensions: quality (compatibility) and depth (elaboration) by comparison with experts. We provide the bimodal coding scheme below in Table 2.

Table 2.

Bimodal Coding Scheme to Compare Informants' Subconcepts with Expert Conceptions

Code	Description
CE (Compatible Elaborate)	Statement concurs with the expert proposition and has sufficient detail to show the thinking behind the concepts articulated.

CS (Compatible Sketchy)	Statement concurs with expert proposition, but lacks essential details. Pieces of facts are articulated but are not synthesized into a coherent whole.
CI (Compatible/Incompatible)	Sketchy statements are made that concur with the proposition, but are not elaborated upon. At other times, statements contradict proposition.
IS (Incompatible Sketchy)	Statements disagree with the proposition, but provide few details, and are not recurring. Responses appear to be guesses.
IE (Incompatible Elaborate)	Statements disagree with proposition, and students provide details or coherent, personal logic supporting them. Same or similar statements/explanations recur throughout the conversation.
N (Nonexistent)	Students respond "I don't know," or do not mention the topic when asked a question calling for its use.
ø (No Evidence)	A topic is not directly addressed by a question, and students do not mention it within the context of response to any question.

Interview Design

The design for clinical interviews procedures is very important. Interviews should be conducted at least twice with the same informants. The first interview is used to gather data about the benchmarks and the second is used to confirm initial interpretations of the informants thinking. Interviews are most effective if limited in terms of the organization of academic knowledge and the language needed for discourse. Questions related to important subconcepts foundational to the benchmark need to be written down as references. In this type of interview it is important not to ask questions that lead an informant to a specific subconcepts directly; but rather, to start the interview with a broad question that allows the informant to think on a metacognitive level. In the past, we (Trexler & Heinze, 2001) have asked informants to retrace the steps a familiar food went through from consumption back to production or asked them to organize the parts of a hamburger in anyway that made sense to them. In the case of fertilizers, we might ask students to think about what a person growing lettuce might provide plants. Once the initial question is posed, it is best to leave the interview area and allow the informant to think about and write down or draw pictures that represent his/her thinking. Metacognitive questions allow for entry points into the interviewees thoughts. From there, interviewers can ask informants about benchmark subconcepts relative to their ideas, rather than following scripted questions that might make the process seem like an inquisition.

Because interviews yield some much detailed data about informants' understandings, it is not reasonable to interview large numbers of people. Exploratory studies by many linguists are often conducted with as few as three subjects. In the case of using cognitive anthropological techniques to determine cognitive structures, science education researchers have found that between seven and eleven purposively selected informants is a reasonable number. Certainly in the case of exploring student FFS understandings with predefined benchmarks, important selection criteria would include informants who are at or above the grade level specified by a given benchmark and who have the ability to express themselves orally. To collect data, it is best to record interviews by either video or audio tapping.

Analysis of Data

Analysis of qualitative data is an ardous process, but the data gleaned can be enlightening. Analysis procedures for interview data suggested in this paper involve three phases. First, raw data from interviews should be interpreted and analyzed by developing concept maps based on student interview tapes and transcripts. These maps can serve as summary portrayals of student thinking for benchmarks and can be verified for accuracy by comparing them repeatedly with the primary data source (interview tapes) and with the secondary data sources (field notes and products developed by informants). During a second meeting, drafts of the researcher-developed maps are shown to interviewees for their confirmation or modification; this member check helps assure trustworthiness and credibility of interpretations (Lincoln & Guba, 1986).

The second phase of the data analysis focuses on coding of interviews based on the concept maps. The sophistication of thinking about a given benchmark as represented in the concept map can be judged along two dimensions (Table 2): quality (compatibility) and depth (elaboration of response) by comparison with expert maps. To ensure confirmability—a parallel to the conventional criterion of objectivity—it is advisable for at least two researchers to independently code data. The final phase of analysis seeks confirming and disconfirming evidence of patterns among individuals. This can be accomplished by analyzing benchmarks across individuals and looking for commonalities, or unique cases of interest.

Presentation of Data

When presenting data obtained from these qualitative techniques, we try to model our presentation after radio or television reporters, because these professionals interpret actual events for others. We generally provide a brief overview of the topic, present a concise picture of the data, provide our interpretation of the data, and then provide raw data that is emblematic of informants, or data that is otherwise interesting or noteworthy. To model this type of data presentation, we offer a glimpse into nine (9) fifth grade students' understandings of fertilizer use. Table 3 lists subconcepts from the expert concept map (Figure 1) deemed necessary for understanding the benchmark related to fertilizer use in crops.

Table 3.

Student Understanding of Fertilizer Use

Subconcepts	Jay	Jill	Tom	Jim	Mona	Sara	Tim	Ema	Liz
Fertilizers									
(a) require minerals	•	-	-	-	-	-	-	-	•
(b) + minerals increase	•	-	-	-	-	-	-	-	•
(c) monoculture deplete	-	-	-	-	-	-	-	-	-
Coding	CS	N	N	N	N	N	N	N	CS

•- indicates subconcept understanding Codings: ø--No evidence; N--Nonexistent; IE--Incompatible Elaborate; IS--Incompatible Sketchy; CI--Compatible/Incompatible; CS--Compatible Sketchy; CE--Compatible Elaborate.

Reporting of findings might be written in this manner:

> This fifth grade benchmark dealt with reasons why fertilizers are used to grow crops. Codings of responses were based on the compatibility and extensiveness of student discourse when compared with expert conceptions and are provided in Table 3. Only Jay and Liz mentioned fertilizers during their interview. They also both knew that fertilizers provided "stuff" that plants needed; they were coded Compatible-Sketchy. Jay said that farmers gave plants food through "little white pellets and sticks." When asked how he knew this, he said that his mother and he had used them in their garden. Liz's fertilizer knowledge was based on her family experience as well. Fertilizers came up in a round about way. Liz talked about what cows needed to be protected from as part of another line of questioning and said cows needed to be protected from fertilizers. She said fertilizers were used on lawns, helped plants grow and got rid of weeds.
>
> Liz- They (cows) eat grass. Maybe they wouldn't let their cows to be poisoned from fertilizers, so the cows would get sick and die.
>
> Interviewer- You just talked about fertilizer, can you tell me what that is?
>
> L- Ah, it's something you put on your grass, um, sometimes it's so the weeds don't grow up, like the dandelions.
>
> *-Due to space limitations, interview data is condensed.*
>
> I- Would you ever use fertilizers on lettuce?
>
> L- I don't know.
>
> The other elementary students were coded Nonexistent in relation to fertilizer understandings as they did not mention them when asked about things that farmers might provide to plants to help them grow.

By providing selected informant conversations (raw data), researchers show the basis for their interpretations. This allows readers to judge the trustworthiness and plausibility of the findings.

Procedures to Draw Conclusions and State Implications

Conclusions and implications of most interpretative studies are not generalizable. In the qualitative paradigm, there is a parallel to generalizability called transferability. Transferability refers the reader's ability to take salient points from the research and use them in his/her setting. In the type of study outlined throughout this paper, presentation of conclusions and implications differ little from those typically made in other forms of agricultural education research. The substance of conclusions and implications, however, tend to provide more holistic and meaningful insights into questions of concern to educators, like what it means to be agriculturally literate.

Conclusion and Implications

Over the past 15 years most agricultural education researchers have focused on ascertaining only one aspect of Frick et al.'s definition of agricultural literacy, knowledge, while not tackling the more difficult task of determining what people understand about the FFS. In this paper, we have argued constructivism and conceptual change theory offer a theoretical framework that undergird interpretative research methods that can unearth what people understand about the FFS. The framework and its attendant methods have implications for helping the profession meet its goal of fostering a population that is conversationally literate about the FFS.

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