Published May 20, 2013

Urban Elementary Students' Conceptions of Learning Goals for Agricultural Science and Technology

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ABSTRACT Nationally, both science and agricultural education professional organizations have identified agriculture as a fundamental technology to be studied by students, with the goal of achieving an understanding of the agri-food system necessary for democratic participation. Benchmarks representing the content that K–12 children need to understand about the scientific and technological underpinnings of the agri-food system have been developed by agricultural and science educators. However, the benchmarks were developed without empirically based evidence on what existing agri-food system knowledge students held. This study examines students' understandings about science and technology concepts underpinning benchmarks for agricultural literacy. Urban upper elementary student concepts of the origins of food, the selection of plants and animals used for production, how people living in harsh environments obtain crops, and the prevention of food spoilage were probed. Using Piaget's theory of schema development, students' understanding of agricultural technology were compared to grade-specific benchmarks for agricultural literacy and examined for relationship to students' backgrounds and experiences. In comparison to the benchmark goals for the age group, informants' schema for the role that science and technology plays in the agri-food industry was nearly nonexistent. This study suggests that existing agricultural literacy benchmarks, as designed, may not be age and/or developmentally appropriate. Additional suggestions indicate that underlying sub-concepts needed for learner understanding may only be loosely connected to any meaningful experience of urban elementary students.

Due to increasing population and limited resources, many of today's major challenges are tied to the science and technology of agri-food systems. America's agriculture has moved past a narrow focus on production and is now a complex interconnected system (National Research Council [NRC], 2002). Yet few lay people understand where the U.S. food supply originates, how food is produced, or how purchasing decisions shape the structure of the agri-food system. Moreover, while quickly making fundamental human endeavors more complex, science has also rapidly increased the quantity of knowledge available to citizens for making decisions on important issues (NRC, 2003).

Society's need for a greater understanding of agriculture becomes paramount as the need for and pressure on existing agri-food systems grow, and agricultural education is being called on to fulfill this need (Sylva et al., 2010; Scott et al., 2011). Current agricultural practices have both positive and negative impacts on the environment and human health. To understand these trade-offs requires public knowledge about agricultural technologies and about individual and institutional roles in shaping the agri-food system.

However, there is concern that the call for agricultural education may go unheralded because of the lack of understanding across educational levels, from K–12 students to teachers (Trexler and Heinze, 2001; Hess and Trexler; 2011a; Trexler and Roeder, 2003). The increasingly complex and rapidly changing U.S. agri-food system presents challenges for preparing future generations of citizens and agriculturalists. The diverse range of students, most with no agricultural background, along with the rapid advancements within the agri-food system may create uncertainty or pose concerns for the future stability and sustainability of the system. The dearth of K–12 agricultural education impacts the ability of citizens to make informed decisions as well as the supply of individuals who are knowledgeable and adequately prepared to enter the food, agriculture, and natural resource sciences (APLU, 2010).

Calls for agri-food system literacy come primarily from two disciplines: science and agriculture education. In science education, the American Association for the Advancement of Science's (AAAS, 1989) Project 2061 identified agriculture as a fundamental technology to be studied by students. Following the 2061 report, AAAS (1993, 2007) published *Benchmarks for Science Literacy*, which defined the content that K–12 children need to understand to obtain a grasp of the scientific and technological underpinnings of the agri-food system. Similarly, agricultural education researchers published *A Guide to Food and Fiber Systems Literacy* (Leising, 1998) and defined what K–12 children should know about agri-food systems. Both documents promote the integration of multiple disciplines and a softening of barriers across

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Nat. Sci. Educ. 42:49–56 (2013)
doi:10.4195/nse.2013.0001
Available freely online through the author-supported open access option.
https://www.agronomy.org/publications/nse

Abbreviations: CI, compatible incompatible; CS, compatible sketchy; IS, incompatible sketchy; N, nonexistent.

domains to help students learn requisite knowledge and gain understandings needed for democratic participation within the agri-food system. However, both were developed based primarily on current practice in agriculture and did not take into account empirically based understandings of children's prior knowledge about the agri-food system as well as current learning theory.

Researchers in the field of cognition have found preexisting student knowledge to be of paramount import to the learning process. Seminal cognitive psychologists Piaget (1950) and Ausubel et al. (1978) theorized that learning could be thought of as the integration of new perceptions and ideas into existing conceptual frameworks called *schemata*. Schemata represent the mental patterns of interconnected information held by individuals about a topic. Moll (1990) and Bereiter (1994) suggested that learning occurs when schemata are constructed, deconstructed, and reconstructed to form new schemata. In this tradition, constructivists view learning as a continually active process that occurs through interpretation of experience (or information) against the backdrop of past experience and existing knowledge within the mind. The integration of new knowledge and understanding challenges existing knowledge structures and leads to new ideas being integrated into preexisting schemata through accommodation or assimilation (Piaget, 1973).

From a constructivist perspective, educators promoting learning seek to create disequilibrium in a learner's existing schemata to force construction of new, more sophisticated understandings. In formal education contexts, learning can be thought of as the alignment of a learner's schema to a specific goal conception. Current research in science and agricultural education often focuses on the ways in which such sophisticated understandings of goal conceptions can be built (e.g., experiential, field based, and inquiry approaches) (Parr and Trexler, 2011; Mjelde et al., 2011). For this to happen efficiently, however, educators must gain insight into what learners already understand to help develop new or modified conceptions more closely aligned to the goal conception.

The following points summarize the need for this study. First, basic knowledge of agricultural technology is required for citizens to make informed choices about the agri-food system (consumer literacy ultimately determines the type of system society creates). Second, grade-level agri-food system benchmarks in both science and agricultural education were developed based on best guesses rather than systemic research based on student conceptions across age levels; and finally, little is known about what people understand related to the aforementioned benchmarks for agri-food system literacy. Thus, there is a need to understand the basic mental models (schemata) students possess about the agri-food system so that future instructional interventions can be designed for maximum efficacy.

This study uses constructivist theoretical perspectives and concomitant research methods to delve deeply into what elementary students understand about foundational knowledge of agricultural science and technology, analyzed in comparison with science and agriculture education benchmarks (goal conceptions). It then provides discussion of areas of needed re-alignment and possible pedagogical approaches.

PURPOSE AND OBJECTIVES

This study sought to determine elementary students' understandings of agri-food system concepts. The study's objectives were:

1. To determine informants' backgrounds and agricultural experiences.
2. To compare informant understandings of agriculture to expert conceptions of grade-specific benchmarks and benchmark sub-concepts for agriculture literacy from science and agricultural frameworks.
3. To ascertain if themes or commonalties exist among informants with regard to their backgrounds, experiences, and understandings of the agri-food system.

MATERIALS AND METHODS

Population

Eighteen informants were included in the study. Individual students were selected based on gender, ethnicity, location, and type of residence to complement previous studies and reflect demographics of this study's local urban schools. This was accomplished by working with the Boys and Girls Club of Long Beach, CA. The program's director recruited 10- and 11-year-old volunteers from the club's summer program. Compensation of $300 was provided to the Boys and Girls Club for the benefit of all members. No participant received any direct compensation.

Data Collection

Semi-structured interviews were used to elicit informant agri-food system understandings and identify states of cognitive development (Novack and Gowin, 1984; Posner and Gertzog, 1982). The interview is widely accepted as a research tool to externalize conceptual knowledge (Jonassen et al., 1993). This type of research protocol has been used extensively in science education (Sherin et al., 2012) as a means to determine a learner's internal mental schema for explaining phenomena.

General interview questions, focused on each benchmark, were prepared before the interview and were reviewed by a panel of experts, but these questions only served as a guide because the interviewer adapted questions based on the responses from each individual. In other words, the interview was flexible and was based on how each interviewee responded to the initial questions about each benchmark. Each interview lasted roughly 45 minutes. During each interview, approximately 5 minutes were spent determining demographic background, while the remainder probed for agri-food system understandings. Interviews were audio and video-recorded, and the digital recordings were transcribed. The transcriptions served as the primary data source. Field notes, colleague consultations, and independent review processes were used as secondary data to triangulate and confirm findings.

Interview Questions and Protocol

The interview protocol (Hess, 2010) was developed based on Trexler's (1999) synthesis of AAAS's (1993, 2007) *Project 2061: Benchmarks for Science Literacy* and *A Guide to Food and Fiber Systems Literacy* framework (Leising, 1998). Faculty from both science and agricultural education reviewed the goal conceptions for Relevant K–5 grade-level benchmarks guided questioning and were the basis

Table 1. Coding scheme for comparing student propositions to expert propositions.

Code	Description
Compatible elaborate (CE)	Statement concurs with the expert's proposition and has sufficient detail to show the thinking behind the concepts articulated.
Compatible sketchy (CS)	Statement concurs with expert proposition, but essential details are missing; bits and pieces of facts are articulated but are not synthesized into a coherent whole.
Compatible incompatible (CI)	Sketchy statements are made that concur with the proposition but are not elaborated on; at other times, statements contradict proposition.
Incompatible sketchy (IS)	Statements disagree with the proposition but provide few details and are not reoccurring; responses appear to be simply guesses.
Incompatible elaborate (IE)	Statements disagree with proposition and informants provide details or coherent, personal logic supporting them; same or similar statements/explanations recur throughout the conversation.
Nonexistent (N)	Informant responds "I don't know" or does not mention the topic when asked a question calling for its use.
No evidence (ø)	A topic was not directly addressed by a question and the informant did not mention it within the context of a response to any question.

for analysis. Initial questions were prompted by an easily recognized food item (a cheeseburger) to focus discussion and provide an entry point into benchmark discourse.

Analysis of Data

Analysis of data involved four phases. In Phase 1, expert propositions regarding the agri-food system and related sub-concepts were developed and then reviewed by experts. These expert propositions were based on Trexler's (1999) benchmark synthesis and were used as concept goals for comparative analysis.

In Phase 2, interview responses were translated into concept maps of the participants' propositions and used to write representations of informant propositions. Drafts were compared to recordings to refine propositions and confirm interpretations. Peer review processes were used to validate the accuracy of propositional statements.

Phase 3 focused on coding informant responses. Sophistication of informant thinking about a given goal's conception was judged for each benchmark in comparison to expert proposition along two dimensions: quality (compatibility) and depth (elaboration of response). Informant understandings were assigned codes based on this bi-modal coding scheme (Yin, 2009). Table 1 presents the bi-modal coding scheme used to determine informant compatibility with the expert propositions.

Informant responses were also coded numerically based on a comparison of responses to underlying benchmark sub-concepts. To ensure coding accuracy, another researcher coded the sub-concepts independently. Minimum levels for intercoder reliability were set at a correlation coefficient of 0.90, and the actual correlation coefficients were above 0.93.

The final phase of analysis sought confirming and disconfirming evidence of patterns among individuals (Huberman and Miles, 1994). First, benchmarks were analyzed across individuals. Second, portraits of informant thinking were analyzed to ascertain how sub-concept understandings influenced understanding of another benchmark and, ultimately, the goal conception. The last step used the constant comparative method to analyze patterns developed across and between participants' responses to flesh out specific commonalities (Glaser and Strauss, 1999).

RESULTS

Research Objective 1: Informants' Backgrounds and Experiences

Background

Race, gender, age, and grade-level demographics were collected. Ten informants were girls and 8 were boys. Of the 10 female informants, 9 were African American and 1 was Hispanic. Seven male informants were African American, and 1 male informant was Caucasian. Ages ranged from 9 to 11 years. At the time of the interviews, informants were enrolled in public schools with traditional academic-year schedules. Nine informants were entering the 6th grade, eight informants were entering the 5th grade, and the last informant was entering the 4th grade. All informants had urban backgrounds and were raised in major metropolitan areas.

Agricultural Experiences

During interviews, informants described where parts of a cheeseburger originated and if they had been to a place similar to what they described. When interviews turned to participants' experience, school-based field trips or a relative's garden were mentioned most frequently. Of the group, eight informants had gone on a field trip to a farm, and seven had experience in a garden. Three informants discussed a visit to their grandparents' family farm. One noted a visit to an aunt's "dirt farm," where the aunt kept a horse. One informant discussed a school-site presentation by a Mobile Dairy Education Unit. Three informants had no exposure to agriculture, and no informant grew plants or raised animals.

Research Objective 2: Comparison of Informant Understandings to Expert Conceptions and Grade-Specific Benchmarks

The four agricultural benchmarks included in this concept were (1) the origins of food, (2) selection for production, (3) addressing environmental conditions, and (4) preventing spoilage. Initial questions for informants were prompted by a cheeseburger to elicit conversation and probe for understanding. These benchmarks were selected because they represent elementary level-knowledge foundational to understanding science and technology in the agri-food system.

Table 2. Informant coding for Benchmark 1 and Benchmark 1 sub-concepts.

	Informant		
Describe the origin of food	**Victor**	**Parker**	**Other 16**
Geography			
Biology (genetic or ecological)	+†	+	
Cultural group origin		+	
Codings‡	CS(1)	CS(2)	N(0)

† A plus indicates that the sub-concept was addressed. Informants with the same codings are combined.
‡ The number in parentheses equals the total number of sub-concepts addressed by the informant.

Benchmark 1: The Origins of Food

Following answers to initial questions about a cheeseburger, informants were engaged in conversation about the crops used to make the sandwich and other prepared foods. During discussion, informants were asked where crops and prepared food items originated. Informant responses were analyzed for benchmark language and were compared to the expert's benchmark goal conception. Table 2 presents coding for Benchmark 1.

In terms of the three sub-concepts, (1) geographic, (2) biologic, and (3) cultural group origin, no informant used language that described the origin of food in geographic terms. Two out of 18 informants, Victor and Parker, used biology-related language when describing the origin of some foods and plants. One informant, Parker, used language describing the cultural group origin of some food items.

Relative to the holistic bimodal coding, Victor and Parker described the biologic origin of food in a *compatible sketchy* (CS) manner when compared to the expert conception. The CS-coded informants provided statements that concurred with portions of the expert's conception, but essential details were missing or not addressed. Most informants (89%) were coded *nonexistent* (N) in comparison to the expert because they either did not mention the benchmark in discussion or stated "I don't know" when asked benchmark-related questions.

Benchmark 2: Selection for Production

During discussion, informants were asked why farmers decided to produce their chosen animal and plant crops. Informant responses were analyzed for benchmark language and were compared to the expert's benchmark goal conception. Table 3 presents informant codings for Benchmark 2.

In terms of sub-concepts (1) plant characteristics, (2) breed characteristics, (3) economics, and (4) environmental concerns or growing conditions, two informants, Parker and Art, used economic-related language when describing decisions farmers made in their selection of crops to produce. One informant, Virginia, used language aligned with differences in plant varieties when describing why farmers decided to produce a particular crop. Another informant, Lilly, used animal breed characteristics as a rationale for farmers deciding to produce a particular crop. No informant used language related to environmental conditions or concerns when asked why or how farmers determined what they would produce.

Table 3. Informant coding for Benchmark 2 and Benchmark 2 sub-concepts.

Discuss reasons why farmers select plant and animal crops for production	Informant			
	Parker and Art	**Virginia**	**Lilly**	**Other 14**
Economics	+†			
Plant characteristics		+		
Animal breeds			+	
Environmental				
Codings‡	CS(1)	CS(1)	IS(1)	N(0)

† A plus indicates that the sub-concept was addressed. Informants with the same codings are combined.
‡ The number in parentheses equals the total number of sub-concepts addressed by the informant.

With respect to the holistic bimodal coding, three informants, Virginia, Parker, and Art, described the origin of food in a CS manner when compared to the expert conception. Art, an example of a CS-coded informant, mentioned making money as a reason why farmers select the crops they produce but did not address other sub-concepts. A portion of Art's transcript is provided to help illustrate a CS-type of response:

INTERVIEWER (I): If you were a farmer, what animals would you raise and what plants would you grow?
ART (A): Animals? I would raise cows, sheep, and horses. Plants? I would grow carrots, lettuce, and tomatoes.
I: Why did you pick those to grow?
A: Because those are plants I see all the time.
I: OK. Why do you think farmers select the animals and plants that they grow?
A: So they can make money when they sell them to the factories.
I: OK. Is there any other reason why farmers may decide to select the plants or animals that they grow?
A: Maybe because the sheep have fur so the factory can make pillows and stuff.

Only Lilly was coded *incompatible sketchy* (IS) because she appeared to make up breed characteristics that supported her guess in making a statement in determining which cows to use for milk production. A portion of Lilly's transcript is provided as an example of an IS-coded informant:

INTERVIEWER (I): You said you have seen cows. Have you seen different cows?
LILLY (L): Yeah.
I: What was different about them?
L: Well, I saw one cow. One of them had brown spots instead of black, but you know how cows are all white and have little black spots. Some of them have brown spots.
I: So is there is difference?
L: Yeah. You know how some have a kind of pink look, I think that's where they get that kind of milk. And they get, I think they get chocolate milk from the one that has brown spots.
I: OK. So which one would you pick for your farm?
L: I would pick the one that got brown spots because the one that has black spots just gives out regular white milk, but the one with brown spots gives out chocolate milk. So I would pick the brown and the black spots 'cause I don't really like the pink milk.
I: So cows have different colors and the different colors indicate different milk flavors, and you would pick cows that have the flavor of milk you like for your farm?
L: Yeah.
I: Why do you think farmers chose the plants and animals they raise on their farm?
L: The same, I guess, they like the taste of the colors.

Table 4. Growth requirement list by number and percentage of informants discussing.

Crop growth requirement	Percentage of informants discussing requirement
Water	72
Soil	67
Light	56
Temperature	50
Air	22
Protection	17
Nutrients	6

Most informants (78%) were coded N in comparison to the expert conception because they either did not mention it in discussion or stated "I don't know" when asked.

Benchmark 3: Addressing Environmental Conditions

To ground informants' discussions of how crops were obtained when adverse growing conditions were present, informants were asked to describe what plant and animal crops need to grow. Table 4 lists growth requirements mentioned by percentage of informants.

Informants mentioned seven items. Water, soil, and light were growth requirements discussed by more than half of the informants. Temperature (heat) was discussed by half the informants. Air, protection, and nutrients were discussed by less than one-quarter of informants.

After discussing what crops need to grow, informants were asked if plants, like lettuce or tomatoes, could grow in environments extremely different from where they lived (i.e., cold mountains, hot deserts, island beaches, etc.). Additional questions focused informants' discussion on describing what people living in adverse conditions do to get food. Informant responses were analyzed for benchmark sub-concept language and were compared to the expert's benchmark goal conception. Sub-concepts for Benchmark 3 were as follows: (1) obtain elsewhere, (2) adjust cultural practices, and (3) adjust growing conditions. Table 5 presents informant coding for Benchmark 3.

Analysis of sub-concept-related language revealed that eight informants used language aligned with making changes to cultural practices (i.e., watering schedule, change planting date, etc.) when describing what people living in adverse environmental conditions do to obtain food. One informant, Lilly, suggested that people can grow tomatoes in the mountains by cutting down sun-blocking trees to adjust growing conditions if tomatoes are too cold. No informant used language that suggested that people living in adverse conditions obtain their food elsewhere.

The holistic bimodal coding assigned was based on comparison of each informant's conception to the expert conception for the benchmark. Eight informants were coded IS when compared to the expert conception. Although IS-coded informants used language partially aligned with aspects of the benchmark sub-concept, statements ran counter to the expert's explanation, lacked detail, or appeared to be guesses. When asked questions related to how people living in harsh environments obtained food, Lilly was not sure. When prodded, she made guesses about adjusting to the conditions in an attempt to resolve the conflict. However, at no time did Lilly discuss the ways and means food could be obtained in a different location as found in the expert's conception. Lilly's transcript provides an example of an informant coded IS:

Table 5. Informant coding for Benchmark 3 and Benchmark 3 sub-concepts.

Describe what people living under adverse conditions do to obtain food	Informant		
	Lilly	7 Others	10 Others
Obtain elsewhere			
Adjust growing conditions	+†		
Adjust cultural practices	+	+	
Codings‡	IS(2)	IS(1)	N(0)

† A plus indicates that the sub-concept was addressed. Informants with the same codings are combined.
‡ The number in parentheses equals the total number of sub-concepts addressed by the informant.

Interviewer (I): What do people living in the mountains do to have tomatoes?
Lilly (L): They need like a really long water hose and cut down trees so plants can get sun.
I: OK. And where is it hot?
L: It is hot in the deserts. In the summer, it's hot here, too.
I: How do people living in the desert get lettuce?
L: I think, uhhh, I don't know.
I: Can you grow lettuce in the desert?
L: I think, yeah 'cause there'd be like a lot of sun, but you may not have any water. Unless you grow it near a house. If a person tried to grow tomatoes in the middle of the desert it would be hard because you have sun but you won't have no water.
I: What if you had water in the desert, would you be able to grow the tomatoes?
L: Yeah, I guess so.

The difference between Lilly and other informants coded IS was that she briefly used language aligned with an additional sub-concept. A majority of informants (56%) were coded N in comparison to the expert proposition because they either did not mention the sub-concept in their discussion or stated "I don't know" when asked.

Benchmark 4: Spoilage Prevention

In addition to discussing where crops originated, how crops are selected for production, and how crops are obtained in areas where growing crops is difficult, informants were also asked to discuss ways people keep crops from spoiling. Informant responses were analyzed for benchmark sub-concept language and were compared to the expert's benchmark goal conception. There were 10 sub-concepts for Benchmark 4: (1) additives, (2) air removal, (3) cooling, (4) drying, (5) fermentation, (6) handling, (7) heating, (8) pest control, (9) salting, and (10) sanitation. Table 6 presents informant codings for Benchmark 4.

Review of informants' transcripts for sub-concept showed that 13 informants used language that addressed the sub-concept of cooling to prevent food spoilage. Eleven informants made references aligned with air removal while discussing ways to prevent food spoilage. Heating food to prevent spoilage was mentioned by eight informants, while two informants used language that addressed the use of sanitation practices to prevent food spoilage. No informant used language that addressed additives, drying, fermentation, handling, pest control, or salting.

The holistic bimodal coding assigned was based on comparison of informants' conceptions to the expert's goal

Table 6. Informant coding for Benchmark 4 and Benchmark 4 sub-concepts.

Describe spoilage prevention methods†	Informant: Sandi, Trisha, Suzanne, Parker, and Lilly	Art and LeMarr	Virginia, Victor, Montie, and Paul	Delaine and Nancy	Alicia, Lynn, and Logan	Denise and Greg
Cooling	+‡	+	+	+		
Air removal (packaging)	+	+	+			
Heating (cooking)	+				+	
Sanitation practices		+				
Codings§	CS(3)	CS(3)	CI(2)	IS(1)	IS(1)	IS(0)

† Of the 10 sub-concepts, ony those addressed by informants are presented.
‡ A plus indicates that the sub-concept was addressed. Informants with the same codings are combined.
§ The number in parentheses equals the total number of sub-concepts addressed by the informant.

conception for the benchmark. Seven informants were coded CS because their statements concurred with portions of the expert goal conception, but they failed to fully articulate a complete picture and left out key information. Four informants were coded *compatible incompatible* (CI) because the portions of their responses aligning with the goal conception lacked detail and support. Additionally, CI-coded informants' sketchy statements also included contradictions.

Seven informants were coded IS when compared to the expert conception. Although IS-coded informants used language partially aligned with aspects of the benchmark sub-concept, statements made frequently lacked detail and appeared to consist primarily of guesses. Logan's transcript provides an example of an informant coded IS:

Interviewer (I): OK, and so this food here, you'll think that it'll be good to eat in a week?
Logan (L): Maybe it will be good to eat tomorrow. You put it in a microwave and you warm it up and take it out and eat it.
I: What will the microwave do?
L: It will make the bread hot, it will be hot so it won't be bad to eat.
I: OK, will it be good to eat in a week?
L: Maybe it can, if you microwave it, I'm not sure.
I: Would you eat it in a week?
L: No.
I: No, how come?
L: Because it might get spoiled.
I: Spoiled? What is spoiled?
L: I'm not sure but it is food that gets spoiled.
I: So what happens when food gets spoiled?
L: It will look like all spoiled and it will have been in there so long and it's like all nasty brown and stuff.
I: And what can we do to keep it from getting spoiled?
L: Eat it.
I: Is there anything else we can do?
L: Other than microwave before [it spoils], no.

Research Objective 3: Themes or Commonalties with Regard to Backgrounds, Experiences, and Understandings of the Agri-food System

Research Objective 3 was met by analyzing data across and between the informant group and the benchmarks. An examination of the relationship between student background and response indicated no patterns with regard to race, age, and agriculturally related experiences and understanding of benchmarks. However, an analysis reveals some consistency in benchmark-related patterns.

Benchmark 1: Discuss the Origins of Food

A comprehensive review revealed a common pattern in understandings across the informant group. First, no informant conveyed an understanding that food and crops originated in many different parts of the world. While Parker identified different processed food items as having cultural group origins, no other informant described an origin. Additionally, all but two informants, Victor and Parker, were unable to describe some type of biological origin. In general, informants demonstrated little prior knowledge of food origins.

Benchmark 2: Discuss Reasons Why Farmers Select Certain Plant and Animal Crops for Production

The informants' benchmark-related discourse revealed two commonalities within Benchmark 2. First, understandings of the *environmental* conditions sub-concept for production was not expressed by any informant and second, most were unable to express an understanding of the benchmark concepts related to trait *selection* or *breeding*.

Benchmark 3: Address Environmental Conditions

Informants' descriptions of what people do to obtain crops in conditions not suited for crop growth were analyzed for patterns and commonalities, and four commonalities were revealed: (1) no informant described ways in which food could be obtained from areas with better growing environs, (2) all but one informant failed to address the sub-concept *adjust growing conditions* to obtain food; (3) just over half the informants failed to address any sub-concept for the benchmark, and (4) no informant provided a description compatible with the expert's conception for the benchmark area. However, just under half the informants did provide some understanding (IS) of *changing cultural practices* to meet growing needs. These four commonalities revealed a pattern that showed that *addressing environmental conditions* had areas in which student prior knowledge could serve as a foundation, but nonetheless that the benchmark was understood only partly.

Benchmark 4: Describe Spoilage Prevention Methods

Informants' descriptions of spoilage prevention were analyzed for patterns and commonalities, and three commonalities were revealed: (1) 6 of the 10 sub-concepts for the benchmark area were not addressed by the informants; (2) except for two informants, the sub-concept *sanitation* was not addressed by the group; and (3) most informants' understandings were incompatible when compared to the expert's conception for the benchmark area. Commonalities revealed in informants' descriptions of preventing spoilage showed a greater pattern of understanding than other benchmarks, particularly in the area of food storage, yet still very limited in comparison to the desired level expressed by agricultural literacy benchmarks.

DISCUSSION

This study determined informants' backgrounds and agricultural experiences and compared their understandings of agriculture to existing grade-level–appropriate benchmarks for agriculture literacy. The informant group was urban, and had little agricultural background or experience. In comparison to the goal conceptions for this age group, informants displayed a limited understanding, restricted in most part to a few underlying sub-concepts found in the four technology benchmarks reviewed.

On a more detailed level, this study showed that informants held no discernable understanding that crops came from different parts of the world, had biologic origins, and are often derived from different cultural groups. Informants were also unaware that plants and animals are selected for production because of a desired trait. While a large portion of the informants expressed understanding water, soil, and light are requirements for plant growth, few other requirements for plant (or animal) growth were mentioned. The lack of a schema for what plants and animal needed to live and grow may have contributed to a lack of understanding about how people living in harsh environments obtained food. Although some informant's logical reasoning was laudable, (e.g., plant earlier if it's cold, water more if you're in a hot desert, cut trees down for more sunlight if you are in the mountains, etc.), many did not know or suggested a change in agricultural practice that would not work. In addition to not fully understanding underlying concepts related to plant and animal growth, informants' schema did not make a connection to obtaining food from locations with more suitable climates nor the science and technology that supports such efforts. Finally, informants' understandings of the technologies used to prevent spoilage were based on basic processes seen routinely in their daily life: (1) cooking food, (2) microwaving leftovers, (3) storing leftovers in the refrigerator, and (4) purchasing cold or hot food items that need to be kept cold or hot. Informants' food spoilage schema did not include common spoilage prevention methods employed today, such as additives, drying, fermentation, handling, pest control, or salting.

While current agricultural literacy benchmarks were developed systematically, they were developed without an investigation into what learners of different ages understand about science and technology used in the agri-food system. The informants in this study did not appear to have acquired the scientific or experiential knowledge that would allow them to align their schema with literacy benchmark goals. While there are many possible reasons why this particular group did not have schema aligned with desired goal conceptions (ranging from lack of science instruction to not having a background in agriculture), two school related deductions are presented for consideration. First, the benchmarks, as designed, may not be age and/or developmentally appropriate. The underlying concepts needed to support the goal conception may not have been presented in school or at home. The second consideration is that the underlying sub-concepts needed for understanding the goal conception have been presented, but were presented from too many loosely connected disciplines disconnected from meaningful experiences of the learner. However, regardless of the reason, educators should be aware that urban elementary students may not have the underlying schema necessary to build to the existent benchmark conceptions.

Although benchmarks may need to be refined or redesigned to reflect student schema, recent research in science education also points to the success of using student funds of knowledge and background experiences to connect them to scientific concepts (Barton and Tan, 2009). When the gap is large, as exhibited in this study, efforts that bridge between existing schema and goal schema by tapping into student experience may be especially important. In addition, exposure, and then purposeful connection within classrooms, to the types every day experiences recommended by NRC (2002), such as school gardens and field trips to farms, are essential to building long lasting understanding of agricultural science and technology concepts. The more rigorous the investigation involving students, the more they may internalize the process and understanding of the science of the agri-food systems (Barton et al., 2005). For example, bringing up student experiences with beef jerky or pickles might activate prior knowledge regarding preservation benchmarks, and allow teachers to build on that schema through instruction and investigation. Making beef jerky or pickles in class would further develop student concepts in accordance with relevant learning theory (Piaget, 1973). However, inquiry into current issues of food preservation and thier relationships to health concerns may provide the most salient experience and greater ability to participate in shaping the future agri-food system.

RECOMMENDATIONS

Three recommendations are offered based on the findings of this study. First, further study is needed in all agriculturally based benchmark areas. Only a few studies exist on the detailed understandings children hold about technology in the agri-food system (Trexler, 2000; Hess and Trexler, 2011b; Meischen and Trexler, 2003; Trexler and Roeder, 2003; Barton et al., 2005; Tsurusaki and Anderson, 2010). This study extends existing knowledge in revealing that students did not have a deep understanding of science and technology sub-concepts. Future studies focused on unearthing children's conceptions related to animal and plant production can help determine which underlying concepts may help or hinder advancement toward broader understanding of technology in the agri-food system.

Second, the lack of knowledge and understanding in children of this age, especially in comparison goal conceptions, suggests that technology benchmarks developed for agricultural literacy efforts should be reviewed for possible re-design.

Finally, because all learning is based on schema that were constructed through past experiences, elementary teachers need training to draw on student funds of knowlege about everyday food-based experiences from home and to integrate agri-food system learning activities (e.g., school gardens, experiences that involve food presevation, etc.), as well as facilitating the types of inquiry experiences that help elementary students build new schema for agri-food system science and technology understanding.

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