Rural Elementary Students' Understandings of Agricultural Science and Education Benchmarks Related to Food Spoilage

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Abstract

The change in American lifestyle from eating home-prepared meals to fast-food dining has contributed to a lack of understanding concerning food safety by many people. Science and agricultural educators have called for educational programs that teach both adults and youth about food safety principles. Educational benchmarks in both science and agricultural education call for elementary students to understand the causes of food spoilage and methods of prevention. Students' understandings of these benchmarks were determined by using interviews and concept mapping activities. The researchers determined that few students understood the causes of spoilage or were able to discuss the role of bacteria or germs in the spoilage of meat. Students with an understanding of microorganisms accurately explained methods for preventing spoilage, while their classmates without such understandings could not. Agricultural and science educators who provide scaffolding for students regarding subconcepts (i.e. microorganisms) may find student understanding of more complex concepts (i.e. spoilage prevention) enhanced. Leaders in government and the meat industry would benefit by supporting increased youth education about meat product food safety due to food borne illness and the subsequent economic cost.

Introduction

American lifestyles have changed along with the demographics, and many of these changes have influenced food safety and food preparation practices in the home (Williamson, Gravani, & Lawless, 1992). The National Research Council (1988) noted that urbanization, lifestyle changes, global competition, public expectations, and new technology are some changes affecting agriculture and food safety. Studies in food and meat science have shown a lack of understanding about food safety issues among American adults (Maciorowski, Ricke, & Birkhold, 2000; Meer & Misner, 2000). These studies call for increased education about food safety not only for adults, but for children as well. Williamson, Gravani, and Lawless (1992) suggested the next generation of consumers be targeted for expanded food safety educational programs because they have grown up in a society of fast-food and convenience and have not learned basic principles of food safety.

Both science and agricultural educators agree that food safety is an important concept (American Association for the Advancement of Science, 1993; National Research Council, 1988). The American Association for the Advancement of Science (AAAS, 1993) and the Food and Fiber Systems Literacy project (FFSL, Leising, 1998) have developed benchmarks that introduce agricultural education into elementary classrooms.

Elementary student agriculture literacy levels with regard to food safety are not well understood. Little research exists that has assessed elementary students' understandings of agricultural concepts, specifically those related to meat. Agricultural elementary education benchmarks have not been fully explored to determine whether they are accurate and attainable goals for education. Before educators can develop curriculum to meet the needs of students, they need to have an accurate portrait of what students understand.

This study's theoretical framework is based on Piaget's research in developmental psychology, which is a basis of constructivism. Piaget suggested that ideas of children are based on preconceived thoughts about how or why things are in a certain state. Only when these knowledge structures, or schemas, are challenged by a new observation or finding does a child's understanding of new information begin to occur (Piaget, 1975/1985). Changes in schema occur through a process called "conceptual change" (Posner, Strike, Hewson, & Gertzog, 1982).

Constructivists have suggested that the initial role of a researcher or teacher should be to assess students' prior knowledge in order to link new concepts to previous knowledge structures or to cause some dissatisfaction with current schema, resulting in the beginning of the conceptual change process (Driver & Oldham, 1986). By understanding where learners' ideas originate, teachers can help them understand scientific knowledge by relating it to familiar contexts that are fruitful for learning.

If constructivist learning theory is to be employed in agricultural education, then uncovering students' prior knowledge structures through a process of discourse analysis would be the first step in development of curriculum. Agricultural education researchers have begun to investigate learner schema (Trexler, 2000; Trexler & Heinze, 2001); this study adds to this body of knowledge.

Purpose/Objectives

The purpose of this qualitative study was to determine rural fifth grade students' understandings of science and agricultural education benchmarks. This study specifically sought

students' understandings of food spoilage with relation to meat (beef) products. The objectives of this study were: 1) to determine students' backgrounds and experience regarding meat, 2) to compare students' understandings of science and agricultural education benchmarks with expert understandings, and 3) to determine if relationships existed between students' backgrounds and experiences and their understanding of the benchmarks.

Methods

Agricultural education researchers often rely on surveys or multiple-choice tests to determine what people understand. There is, however, some question as to whether these types of quantitative measurements truly are indicative of what people understand. Lincoln (1998) has stated that because "knowledge cannot be separated wholly from the context in which it was generated" (p. 17), alternative methods of research are needed. If each person has his or her own unique understanding, then qualitative research and in-depth inquiry are essential. The use of the qualitative paradigm in agricultural education, however, is sometimes suspect. In this study, particular attention was paid to assuring trustworthiness of findings and conclusions (akin to validity in the quantitative paradigm) by explaining how credibility, transferability, dependability, and confirmability were assured.

Population

Sample size in qualitative research often is small compared with the quantitative paradigm (Guba & Lincoln, 1989; Woods & Trexler, 2001), but the reduced numbers are required to deeply examine the phenomenon at hand. In this study, seven students were selected for interviews from a rural Midwestern consolidated school. Four respondents were girls; three were boys. Fifth grade students were selected because it was believed they possessed a vocabulary large enough to converse clearly about the benchmarks, and fell within the grade-level range of the benchmarks. Students attending the school were bused from several small towns separated by less than 15 miles of farm land. A larger city is located approximately 35 miles from the school building.

The researchers purposefully chose more females than males, because it was believed that females would have more experience with cooking and grocery shopping and, as adults, will likely be the primary cooks and shoppers of households. In reporting of data, pseudonyms replaced real names of students.

Data Collection

Clinical interviewing allowed the researchers to ascertain in-depth understanding and be conversational rather than scripted. The goal was to determine the nature and extent of each individual's knowledge through identification of relevant conceptions held and the perceived relationships among those conceptions (Posner & Gertzog, 1982).

Students were individually interviewed twice. The first interview lasted approximately 60 minutes. A hamburger from a nationally known fast food chain was used to initiate conversation (Anderson & Demetrius, 1993; Trexler & Heinze, 2001). Students were asked to draw and explain a concept map of their understanding regarding causes of food spoilage and methods of prevention. They were presented a short lesson on concept mapping at the start of the interview to assure their understanding of how a map was constructed. The interviews were audio taped and transcribed. After the first interview, the transcripts were coded and the students' concept map was expanded by adding information provided during the interview. A

second interview served as a member check and established credibility of the research findings (Guba & Lincoln, 1989; Taylor & Bogdan, 1998). During the member check, students reviewed the concept map and were given the opportunity to change it.

Interview Questions

Interview questions were based on science and agricultural education benchmarks developed by Trexler (1999) from a synthesis of the Benchmarks for Science Literacy (AAAS, 1993) and the Food and Fiber System Literacy Framework (Leising, 1998). Selected benchmarks reflected an understanding of meat concepts and were designed for students from kindergarten through fifth grade. Table 1 shows the benchmarks and the language necessary for demonstrating understanding of these concepts.

Table 1.
Concepts, Benchmarks, and Language

Concept	Benchmark	Language
What is the role of science and technology in the food and fiber system?	1. Describe how foods may spoil before use. (K-5 FFSL[a] & 3-5 AAAS[b])	1. spoil, germs
	1. Describe the advantages of and methods to slowing down food spoilage. (K-5 FFSL & 3-5 AAAS)	2. heating, salting, smoking, drying, cooling, storage, heat, consumer, sanitation

Note. Benchmarks were derived from [a]Food and Fiber Systems Literacy Framework (Leising, 1998) and [b]American Association for the Advancement of Science 2061 Benchmarks (1993).

Analysis

Analysis began with identification of students' backgrounds and experiences, which were reported descriptively. Next, goal conceptions and an expert concept map were developed by the researchers and reviewed and verified by experts in science education, agricultural education and animal science as well as a consumer education director from the beef industry. To analyze student understanding of the benchmarks, Hogan and Fisherkeller's (1996) bidimensional coding system was used to assess participants' compatibility with experts and elaboration on each benchmark. The transcribed interviews served as the data source. Because most students did not have the vocabulary deemed necessary by experts, codings were given based on understanding rather than language use alone.

The students' concept maps were used as a secondary data source. To ensure confirmability of the findings, excerpts of interview transcripts that supported codings were included (Guba & Lincoln, 1989). In addition, another researcher also independently coded the data, obtaining 86% agreement with the primary researcher. Table 2 describes the coding scheme used to identify the extent of elaboration and compatibility with expert conceptions.

Table 2
Coding scheme for comparing student responses to expert conceptions.

Code	Definition

Compatible Elaborate	Statements concur with the expert proposition, have sufficient detail to show the thinking behind them, and/or recur throughout the transcript in the same form.
Compatible Sketchy	Statements concur with expert proposition, but essential details are missing. Often represents a correct guess among choices provided, but reflect no ability to explain why choice was made.
Compatible/ Incompatible	Make sketchy statements that concur with proposition but which are not elaborated, and also make sketchy statements that disagree. Contradictory statements often are found in two parts of the transcript in response to different questions or tasks on the same topic.
Incompatible Sketchy	Statements disagree with proposition, but very few details or logic given and do not recur throughout transcript. Often seem to be responses given just to say something, a guess.
Incompatible Elaborate	Statements disagree with proposition, and students provide details or coherent, personal logic backing them. Same or similar statements/explanations recur throughout transcript.
Nonexistent	Used when students respond "I don't know" or do not mention the topic when asked a question calling for its use.
No Evidence	Used when a topic was not directly addressed by a question and students did not mention it within the context of response to any question.

Finally, to determine the relationships between students' backgrounds and experiences and compatibility and depth of responses, patterns were inductively and intuitively identified (Taylor & Bogdan, 1998).

Findings

By asking students questions regarding their experiences with meat and spoilage, the researchers were able to obtain results for objective one. All students were Caucasian. Three students lived on farms, while the other four lived in a small Midwestern town. Two students' families raised steers, and one student raised lambs for 4-H projects. One student had an uncle who raised cattle. None of the other three students had direct experience with livestock. Most students' parents worked in a nearby city, although one student's father was a part-time farmer. When asked what their parents did for a living, many of the students replied with the company name and not the actual occupation. Table 3 lists the students with their backgrounds and experiences.

Table 3
Student background and experience

Name	Gender	Home location	Parent(s) occupation	Livestock experience

Greg	Male	Farm	Father: Food production company Mother: In city (unknown)	Family raises steers
David	Male	In town	Father: Label company Mother: Cook	None
Heidi	Female	In town	Father: Train driver Mother: College student	None
Jim	Male	In town	Father: Miner Mother: Department store salesperson	Uncle raises cattle
Jessica	Female	Farm	Father: Firefighter/ carpenter/ farmer Mother: Nursing home employee	Family raises steers
Lynn	Female	In town	Father: Filter company Mother: Stays at home	None
Melissa	Female	Farm	Father: Department of Transportation Mother: College student	Shows lambs in 4-H

Objective two was reached by researchers directly questioning students about their understandings of a science and agriculture concept concerning the role of science and technology in the agri-food system. Students were asked to discuss the following benchmarks: (a) how foods may spoil before use and (b) the methods of slowing down food spoilage.

Findings A: Causes of Food Spoilage

Table 4 illustrates codings students were assigned based on an interpretation of their interview and concept map development. A mark (black dot) indicates a student mentioned the term when describing the benchmark or had an understanding of the subconcept. A superscript to the coding gives further clarification regarding the depth of understanding of each student.

Table 4
Student understanding of how food spoils.

Benchmark	Melissa	Jim	Lynn	David	Heidi	Greg	Jessica
1. Describe food spoilage.							
a. spoil/rot/go bad	•	•	•	•	•	•	•
b. germs/ bacteria		•		•			
Coding	CI	CS^2	CI	CS^2	CI	CS^1	CI

Ø=No evidence; N=Nonexistent; IE=Incompatible Elaborate; IS=Incompatible Sketchy; CI=Compatible/Incompatible; CS=Compatible Sketchy; CE=Compatible Elaborate
Superscript indicates depth of understanding of subconcepts to show differences in student understandings of the benchmark. The superscript was determined based on how many subconcepts the student identified.

Melissa, Lynn, Heidi, and Jessica had "Compatible/Incompatible" understandings, while Jim, David, and Greg possessed "Compatible Sketchy" understandings of how food spoils. Those with "Compatible/Incompatible" codings had an alternative conception of how food spoils compared with that of experts.

Jim, David, Jessica, and Melissa all believed that either air or humidity caused meat spoilage. Jessica stated that moisture in the air and warmth of meat from setting out caused spoilage, while Melissa also mentioned warm temperature and "humidity" as causing the meat to rot. Both Lynn and Greg had no schema for why meat must be kept cold and replied repeatedly "I don't know" when asked directly about reasons for temperature control. Heidi was unique in her understanding of what caused meat to spoil. Although she knew that meat must be kept in the refrigerator or deep freeze, she had developed an alternative framework for why. The following is her explanation:

Interviewer – If [your parents] don't cook [meat] right away, where do they put it?
Heidi – We have a deep freeze in our garage.
I – Why do you have to put it in the deep freeze?
H – Because if it stays out too long, it will get rotten. But if you want to cook it [within] like a couple nights, or the night before, or in the morning before dinner, you put it in some warm water to thaw it out so it's not as tough to cook. It doesn't take so long.
I – Why does it go rotten if it's not put in the freezer?
H – Because bugs and stuff can get to it. Because flies like the stinky smell of stuff, and they'll come into your house and fly around on it. And eat it.
I – What kinds of bugs?
H – Like right now, we have a bunch of box elder bugs around our house. Because I don't know why it is, but they like my mom's big rock and our trees and stuff. But they keep flying in our house, and we got ladybugs, too. And so they need something to eat, and so they come in for warmth. And then they smell the rotten meat, and they come in and eat it up and stuff.
I – And that's what causes it to rot?
H – Yeah.
I – So how does keeping [meat] in the freezer keep bugs out?
H – Because they're too small, I don't think they can lift [the lid] up or anything.

Later in the interview, Heather added that meat must be kept cold either in the freezer or refrigerator, but her reasoning was still to prevent the bugs from getting to the meat. The cold, to her, kept the meat from smelling so that the bugs were not attracted to it.

Only Jim and David knew that germs or bacteria could be found on meat and that these germs/bacteria could cause health risks, which is why they were given "Compatible/Sketchy" codings. Jim understood spoilage was caused by air molecules and heat, with germs also playing a part. David believed that bacteria came from heat and that when bacteria mix with oxygen in the air, spoilage occurs. Jim was able to elaborate about the origin of germs on meat, as evidenced by his narrative:

I – Why do the germs live on meat?
J – Because they might of got in there while it was shipping or something. Because maybe the truck was carrying something that had it before, and [the germs] got off of it, and then they were on the truck bed of the truck, so when the truck came, they got into the meat.
I – Is there anything they could have done to the truck to keep from getting the germs there? Or can they kill the germs?

J – You could put a special spray. You could spray over it, and it wouldn't contaminate the meat, and it would just kill the germs off.
I – So, there's things you can clean with. Are there any other ways that we could get germs on meat?
J – Maybe a cow was born with it. Like a disease it had when it was born.
I – Any other ways?
J – Maybe if the butcher had a bunch of cows, and one cow was contaminated with a disease, and he used that knife on that cow and then used it on another cow and didn't know about.
I – Can he do anything then to keep that from happening?
J – He might be able to wash his knife every time before and put it with some soap.
I – Why do you think germs live on meat?
J – That's tricky. Maybe because it's just easy to get on 'em. It's like easy to get on us, but we have white blood cells that fight'em off if we get like a cut and [the germs] get in. But if a piece of meat, it's already dead, it isn't useful because it has no white blood cells against to fight it. So the germs, it's like a piece of cake. If you put sugar out on a table with a bunch of ants, they come to the sugar. The germs will come to the meat because it smells good and also it's easier to get than trying to get into a human, like trying to get all the way into our mouth or a cut.

Jim had a fairly clear understanding of the origin of bacteria and how they could potentially contaminate meat products. Jim's reference to white blood cells was very interesting. He obviously had heard about bacteria and how they affect the human body and the mechanisms that humans use to fend off bacteria. He then transferred this knowledge to meat products; beef in this case, which demonstrated that he had a high level of understanding about disease defense compared with his peers.

Findings B: Prevention of Food Spoilage

The second aspect of the benchmark asked students to describe methods of preventing or slowing down food spoilage. Table 5 indicates students' levels of understanding.

Table 5
Student understandings of preventing food spoilage.

Benchmark	Melissa	Jim	Lynn	David	Heidi	Greg	Jessica
1. Describe methods of preventing food spoilage.							

a. heating	•	•		•	•	•	•
b. salting		•		•			
c. smoking				•			
d. drying		•		•			
e. storage -cooling -freezing	• • •	• • •	• •	• • •	• • •	• • •	• •
f. consumer		•		•		•	•
g. cleanliness		•					
Coding	CS^4	CS^8	CS^2	CS^8	CS^4	CS^5	CS^4

Ø=No evidence; N=Nonexistent; IE=Incompatible Elaborate; IS=Incompatible Sketchy; CI=Compatible/Incompatible; CS=Compatible Sketchy; CE=Compatible Elaborate
Superscript indicates depth of understanding of subconcepts to show differences in student understandings of the benchmark. The superscript was determined by the number of sub-concepts identified by the student.

All seven students were coded "Compatible Sketchy" because they had a partial understanding of the benchmark but were unable to elaborate on their explanations. Lynn, Melissa, Heather, and Jessica all noted that meat had to be cooked, but they thought it was cooked solely to enhance taste. They did not relate heat to preventing spoilage or reducing illness caused by consumption of undercooked or contaminated meat. Greg noted that a consumer could possibly become sick if hamburger meat was not cooked until it was brown throughout; however, he did not know why. Jim and David both explained how heat could destroy microorganisms that might be on the meat, and they also added that there were other methods of slowing down food spoilage. David's explanation of these methods was quite elaborate, as is found below:

I – When you go shopping with your Mom or Dad and they buy the meat, what do they do with it when they get it home?
D – Put it in the freezer.
I – Why do they put it in the freezer?
D – To keep it from getting bacteria and diseases.
I – What happens if they don't put it in the freezer?
D – It spoils and gets bacteria and diseases.
I – Is there any other way we can keep meat from getting this bacteria or diseases?
D – You could smoke it, dry it, put a bunch of salt on it.
I – What do each of those do? What does smoking do?
D – It makes it kinda tough, like beef jerky. And drying, I think that's kinda like beef jerky, too. And putting a bunch of salt on it is what the pioneers did, um, that just kinda keeps it fresh so it doesn't spoil as fast.
I – Why does that keep it from spoiling as fast, do you think?
D – Because it's kinda like a coat to keep the bacteria and disease off.
I – And why does smoking and drying keep the bacteria off of it?
D – It's kinda cooking it. And cooking fries all the disease and stuff. And it kinda gets rid of the disease 'cause it's already cooked, and it ain't raw anymore.

David seemed to understand that by altering the environment required by bacteria, people can slow down spoilage of meat. Jim also understood the environmental requirement concept, but not as elaborately as David. Greg had some understanding of environmental change of meat, but only as it related to cooking temperatures.

Only Greg, Jim, and David had any understanding of how the consumer could eliminate most food borne illnesses by cooking meat to an adequate temperature. Both David and Jim elaborated on the use of heat to destroy microorganisms as well as other methods such as drying, salting, and smoking. Although Greg knew that meat had to be cooked to prevent illness, he did not know why. The four females, however, only mentioned that meat must be cooked to achieve a desired taste.

Conclusions/Implications

It seems that student background and experiences did not affect understanding of meat product spoilage. David and Jim had the most well developed schema regarding food spoilage, but there were no apparent connections between their individual experiences that led to this deeper understanding. Heidi was the least concerned about eating meat that was not fully cooked. She frequently hunted with her father and ate the game they killed, which may have affected her concerns over food safety.

Conclusions A: Causes of Food Spoilage

Overall, students lacked complete, and most lacked any, understanding about the causes of food spoilage. This is an area where this school's health and science curriculum may not have addressed the benchmarks found in national science and agricultural education. Five students were unaware that bacteria and other microorganisms cause food spoilage. This lack of knowledge might stem from a deficiency of appropriate vocabulary to allow for explanation of their ideas (Anderson, 1992; Gallas, 1995). Several students mentioned "humidity" and "air" as causes of food spoilage. These terms might have been substitutes for "bacteria" or "germs" because of insufficient vocabulary. At the time of the interviews, the students' science unit was focused on weather. The words they used to describe spoilage were weather related and may have been an attempt to describe a phenomenon using scientific terminology without complete understanding of the term (Gallas, 1995). This study supports the work of Williamson, Gravani, and Lawless (1992) who similarly found that consumers do not have a clear understanding of food borne disease concepts.

Implications A: Causes of Food Spoilage

School science programs could use food, particularly meat, to teach students about bacteria, its environmental requirements, and how bacteria affect human food products. Through curriculum focused on environmental conditions necessary for bacterial growth, science educators could teach about food safety by discussing temperature control and sanitation. This discussion should include a look at consumers' responsibility for food safety. Although it was not directly addressed, the students seemed to limit the consumers' responsibility to cooking and cooling, with no mention (except for Jim) of cleanliness or sanitation.

Those in the food industry may see this lack of understanding as an opportunity to help students learn how to properly handle food. Cases of food-borne illness associated with mishandling of food products cast a negative image on the agri-food industry. Food-borne

illnesses also translate to billions of dollars per year in expenses for the health care industry and for government agencies (Meer & Misner, 2000; Yang, Angulo, & Altekruse, 2000). Most people obtain food safety information from television and magazines rather than from formal educational settings (Maciorowski et al., 2000; Meer & Misner, 2000). Considering this, a collaborative educational effort between private and public organizations would help students understand proper food handling and cooking techniques that reduce disease, decrease expenses related to food-borne illness, and enhance the image of the agri-food industry. The role of agriculture education in this effort could be helping elementary educators conduct short-course "cooking schools" for elementary students through programs such as Project P.A.L.S.

Conclusions B: Prevention of Food Spoilage

All students knew that meat had to be stored cold and cooked before eating, but only two mentioned use of other food preservation methods. The students (Jim and David) who had the most elaborate understanding of methods for preventing food spoilage also had the most elaborate understanding of the causes of spoilage. Students who lacked an understanding of the nature and growth of bacteria were unable to link how methods of prevention such as drying, salting, or smoking altered meat to make it undesirable for bacterial growth. It seems that without an understanding of what causes spoilage (microorganisms), these students were unable to understand the reasoning underlying techniques used to prevent spoilage. This observation is supported by Trexler (2000), who found that students needed to fully grasp subconcepts before more complex concepts could be understood.

Implications B: Prevention of Food Spoilage

To effectively scaffold learner acquisition of complex concepts, curriculum developers may benefit from assessing student subconcept understandings. In this study, students needed to understand that bacteria caused food spoilage before they could explain how various methods slowed meat spoilage . The AAAS (1993) benchmarks call for a discussion of food preservation and sanitation in early grades but delay exploration of spoilage as a result of microorganisms until sixth grade. This study suggests that an understanding of microorganisms is a subconcept that helps build a foundation for understanding methods of food preservation and should therefore be included at a basic level in earlier grades.

When designing food safety and spoilage curriculum, researchers play a role in determining students' conceptual frameworks concerning the nature and growth requirements of bacteria so curriculum can be designed that promotes conceptual change. Additional studies, with a similar research protocol, would lead to a more complete understanding of students' prior knowledge, which is essential when using a curriculum development model that is based on constructivist theory (Driver & Oldham, 1986). Although the results of this study are not generalizable in the quantitative sense, they are transferable in the qualitative paradigm if the contexts of the comparison are similar (Guba & Lincoln, 1989). By taking into consideration the students' existing knowledge structures, curriculum can be developed that effectively addresses students' schema development and their conceptual understanding of agricultural and scientific concepts.

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Rural Elementary Students' Understandings of Agricultural Science and Education Benchmarks Related to Food Spoilage

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The researchers produced a well written manuscript, one that effectively illustrated the "mechanics" of their qualitative research design. Vetting Piaget's posits about cognitive development, i.e., as "a basis of constructivism," and noting the significance of schemas, scaffolding, and the process of "'conceptual change'" as underpinnings for the study's theoretical frame, was well done. Notably, the investigators employed not one but two sources of curriculum-based "benchmarks" to generate their interview questions. Also, revisiting components of the study's theory-base in the context of related conclusions/implications further strengthened the researchers' work. Questions about selected procedures follow:

1) Regarding "confirmability," it was noted that "another researcher also independently coded the data, obtaining 86% agreement with the primary researcher." What is the "standard" for agreement? Did 86% exceed the acceptable "threshold"? Are there protocols regarding use and/or modification of data for which there is not consensus?

2) Two students demonstrated "understandings" for all but one of eight subconcepts for "preventing food spoilage" and were coded as "compatible sketchy." Presumably, the category "compatible elaborate" is for those who exemplify the highest competency. Does this designation require that one demonstrate understanding for *every* subconcept, or is the determination balanced with one's "depth" of understanding about various subconcepts?

3) Fifth graders were selected as interviewees because it was believed that their vocabulary was sufficient. However, after data transcription, it was determined that they did not possess the requisite vocabulary skills, and thus codings were based "on understandings rather than language use alone." What does this mean in terms of the researchers' behaviors? That is, how does one interpret a person's "understanding" about a concept if that person has a "limited" vocabulary about the body of knowledge in question?

Questions/observations about selected findings and implications follow:

1) What should be concluded regarding the difference of understandings about food spoilage by gender? That is, was it an artifact of the socialization process or some other phenomenon?

2) What should be concluded about selected AAAS benchmarks that may have overlooked important developmental aspects of the learning necessary for accurate concept formation, cognitive scaffolding, conceptual change, and future transfer in the context of food spoilage?

3) The researchers proffered an "inductive" model for curriculum development, one steeped in

constructivism. Yet, their template for measuring understandings relied on a bulwark of behaviorist theory—prescribed learning benchmarks. Intentional or not, this appears consistent with our era, one that calls for the delivery of instruction from a constructivist perspective while demanding that outcomes be assessed using the tools of behaviorism.