Rural elementary students' livestock and meat concepts literacy: Understanding of agricultural and science benchmarks

by

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Signatures have been redacted for privacy

For Mom and Dad

Table of Contents

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Abstract

Agricultural and science educators have deemed agriculture literacy important to people of all ages. Industry leaders have also noted the importance of having a society that is agriculturally literate. Educational benchmarks were developed for school age children that supported this call for a basic level of agriculture literacy. Little research has been conducted, however, that assess what students understand about agriculture. This qualitative study attempted to add to that body of knowledge by unearthing the understandings of rural fifth grade students about meat and livestock benchmarks. Overall the students had a basic understanding of the origin of food and the process from farm to consumer. Their understandings about modern farm size and structure, however, were not compatible with expert propositions. There was also a lack of understanding about the use of cattle by-products and the causes of food spoilage and methods of preventing food spoilage. Agricultural and science educators as well as industry leaders could increase agriculture literacy levels by providing experiences for students with livestock and meat, as most of these students had no direct experience with farm animals. Also, helping students understand subconcepts may increase understanding of more complex concepts. More studies following a similar research protocol would add to the knowledge that educators now have about student understanding. This would lead to better curriculum that challenges students' existing knowledge structures.

Chapter I. Introduction

Agricultural education is continually challenged in its efforts to inform society about agriculture. Urbanization, life-style changes, global competition, public expectations, and the introduction of new technology are but a few of these challenges that agriculture faces (National Research Council, 1988). Moreover, due to the continued loss of connection with the land, today's society is constructing, generation by generation, less and less understanding of the food and fiber system. Regardless of the disconnection to agriculture directly, everyone in society is linked to agriculture by the food they eat, the clothes they wear, and many of the products they use everyday. It becomes agriculture's responsibility to insure that society is well-informed and knowledgeable about agriculturally related topics (Roper Starch Worldwide, 2000). Adult society should not be the only focus, but education of youth as well.

An age group that should be one of the focuses of agricultural education is elementary school children (American Association for the Advancement of Science, 1993; National Research Council, 1988). At this age children develop ideas and opinions that they will carry with them for the rest of their lives. Scientists agree that educating elementary students in agriculturally related areas is important for all subjects. The National Research Council (NRC, 1988), American Association for the Advancement of Science (AAAS, 1993), and the Food and Fiber Systems Literacy project (FFSL, Leising, 1998) are among those that have developed benchmarks and frameworks for introducing agricultural education into elementary classrooms. These benchmarks included production of animals and plants as well as the use of technology in agriculture.

The benchmarks that were developed by the NRC, AAAS, and FFSL included animal related topics, which support the idea of students not only developing basic agriculture literacy but more specifically livestock and meat literacy. Beyond their family pet, non-farm students have few opportunities to interact with animals, especially livestock. Their understanding of how these animals are raised and what is done with the animals is limited by their lack of experience.

Problem Statement

Elementary student agriculture literacy levels are not well understood. Little research exists that has assessed elementary students' understandings of agricultural concepts, specifically those related to livestock and meat. The benchmarks developed for these students related to agriculture have not been fully explored to determine whether they are accurate and attainable goals for education. Therefore, before educators can develop curriculum to meet the needs of students, they need to have an accurate portrayal of student understanding.

Although studies were conducted to determine agriculture literacy levels (Frick, Birkenholz, & Machtmes, 1995), they did not ascertain the depth of student understanding of concepts and instead measured recognition of terms on a survey form. While quantitative research is useful in generalizing among groups of students, it far from reaches the idiosyncratic understandings the students possess. Qualitative research, however, attempts to reach the unique understandings that students possess about concepts by allowing the student to explain and describe their own understanding. Some non-agriculture disciplines have moved to the qualitative approach of research based on learning theory that more effectively measures understanding.

Some researchers in science education have moved to a belief in a learning theory that emphasizes the importance of an individual student's schema structure. Constructivism is the learning theory that many science educators believe to be effective in teaching science concepts. A foundational idea of constructivism is that of schema formation. Schema are a mental organization of knowledge that individuals possess. The development and formation of schema occur through additions to or restructuring of previous knowledge. Constructivists argue, therefore, that before curriculum can be written, educators must know what level of understanding students possess. Following the lead of science educators, agricultural educators have begun employing constructivist learning principles in order to determine students' schema regarding agriculture literacy.

Purpose of the Study

This study's purpose was to determine the level of agriculture literacy among one group of rural Iowa fifth grade students. The concepts of animal production, transportation and preservation of meat products, animal by-products, and food safety were the focus of this study. Through this study of agriculture literacy understandings, educators will be better able to write curriculum for elementary students in agricultural and science education. Because livestock and meat commodity groups continually develop educational materials for use in school classrooms, the findings also have implications for stakeholders in the meat industry by identifying alternative frameworks that youth (future consumers) possess.

To determine student understandings, I have developed four objectives:

Objectives

1. To determine informants' background and experiences.
2. To describe how student understandings of the agri-food system compare to goal conceptions based upon a synthesis of agriculture and science benchmarks.
3. To determine if a relationship exists between student experience and background and agriculture literacy knowledge.
4. To compare these findings of rural children to the findings from a previous study of urban and suburban children.

To meet these objectives, the following general questions guided the research.

1. What types of experiences do students have with livestock and meat?
2. What are students' understandings of the agri-food system with relation to meat and livestock?
3. What types of experiences in students' backgrounds lead to a greater or reduced understanding of meat and livestock?
4. Are there any similarities or differences in understandings between the rural students in this study compared to urban and suburban students from a previous study?

Limitations of the Study

There were three limitations to this study of agriculture literacy. These limitations begin with a discussion of how my methodology prevents transferability of the results to other populations. I then recognize how my biases might effect my interpretations of the data. The last limitation I note is my assumption of accuracy of the benchmarks used in the study and how that might effect the comparison of the students with the experts.

This study's results will not be transferable to different populations of students due to its qualitative nature. The findings will only give insight into the current understanding of students interviewed in one particular context. The results may, however, be used as a comparison to previous studies that used a similar methodology. If looked at through a constructivist lens, similar studies would add to the schema that the field of agricultural education is attempting to build related to literacy. Also, by attempting to give an extensive description of the study's context, I allow others to personally make transferability judgments (Guba & Lincoln, 1989).

Another limitation of the study is that the results are based on my interpretations of my conversations with the students. These interpretations are limited by my ability to accurately portray the understanding of the participants from the verbal data generated in the interview and the concept maps that the students developed. My interpretations are also influenced by my bias towards the livestock industry. I support livestock producers, particularly beef producers, in their endeavors because I, too, am a producer. I want these students to understand the industry in such a way that they will support the farmers and ranchers who, I believe, work hard to bring a safe, healthy, and inexpensive food product to the tables of all people. To combat these biases I employed methods to ensure credibility, dependability, and confirmability of my results.

Another limitation of the research is that I am assuming that the benchmarks previously developed by the AAAS (1993) and the Food and Fiber Systems Literacy Framework (Leising, 1998) are accurate in their assumption of children's understanding in agriculture and science. I am consequently assuming that the benchmarks developed by Trexler (1999) from a synthesis of the previous benchmarks are also accurate and the language that children need in order to communicate these ideas are appropriate as well. I attempted to verify the goal conceptions of the benchmarks and language by having experts in the fields of science, agriculture, and industry review them.

Conclusion

Science and agricultural educators have noted the importance of developing a basic level of agriculture literacy among people of all ages. Little research has been conducted, however, that has determined what people, particularly children, understand about agriculture. This study is attempting to add to the body of knowledge about student understandings of agriculture, particularly meat and livestock concepts. By determining students' prior knowledge, curriculum can then be written that promotes learning in students. Although some limitations exist in this study's protocol, I am employing research methods that attempt to overcome these limitations.

Organization of Thesis

The format of this thesis is a modified format. The thesis begins with a general introduction and then includes an extensive review of the literature. Following the literature review, a methods chapter is included as well. Two journal papers are then found in chapters four and five. An overall conclusions and implications chapter if found last. Appendixes are also included.

Definition of Terms

Agriculture literacy – knowledge and understanding of agriculturally-related scientific and technologically-based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity; includes the ability to engage in social conversation, evaluate the validity of media, identify local, national, and international issues, and pose and evaluate arguments based on scientific evidence related to agriculture, food, fiber, and natural resource systems.

Agri-food system – an interrelated system that produces, processes, distributes, markets, and sells food and fiber products

Concept map – a tool used to represent concept or propositional ideas held by the learner in a hierarchical manner (Novak, 1998)

Schema – knowledge structures in the mind of the learner that form cognitive networks or frameworks; schema are altered or changed through the conceptual change process

Chapter II. Literature Review

The literature review begins with a description of agriculture literacy and a justification for why it is necessary for students to possess basic literacy. Second, I discuss criteria that those in agricultural education have deemed important in developing an agriculturally literate person. Third, I look at those who have typically been the target of agricultural education, who is now the focus, and who should also be included in this quest of an agriculturally literate society. Fourth, I focus on what research has been conducted or has not been conducted in an attempt to know what adults and children understand. Fifth, I discuss the theoretical framework that undergirds this study and provide a discussion of constructivism in both science and agricultural education. Finally, curriculum development based on constructivism is reviewed.

Agriculture Literacy

Literacy involves the mastery of language in both oral and written forms (Gee, 1990). Language, however, is more than simply vocabulary; it also embodies culturally based beliefs, values, and attitudes. As one becomes literate, he or she masters the ability to make judgments based on culturally based norms that reify or reshape the culture and its institutions. Agriculture is a culture unto itself. Most Americans have not grown up within this culture and, as a result, have not acquired basic agriculture literacy.

The term "agriculture literacy" was coined from the National Research Council's 1988 report *Understanding Agriculture: New Directions for Education.* The Council's idea of agriculture literacy was "education *about* agriculture" (p. 1) compared to "education *in* agriculture" (p. 2) which had dominated vocational agriculture education since its inception.

The report contended that an agriculturally literate person should understand many aspects of the food and fiber system, including "its history and current economic, social, and environmental significance" (National Research Council, 1988, p. 1). To further clarify the definition, Frick and Spotanski (1990), Frick, Kahler, and Miller (1991), and Russell, McCracken, and Miller (1990) also included an understanding of the production, processing, and marketing of agriculture products as components necessary for agriculture literacy.

The early definitions of agriculture literacy focused on identifying salient content but did not include an explanation of what literacy was and how agriculture literacy levels could be determined through discourse. The definition of literacy is constantly evolving as changes in society and cultures occur (Trexler, 2000a). The National Council on Agricultural Education's 1999 report *Reinventing Agricultural Education for the Year 2020* began to expand the definition of agriculture literacy by adding conversational literacy about agriculture as a goal. This was a beginning, however, the new definition needs to include discourse and understanding within the culture of agriculture as aspects of literacy.

From the definition of science literacy in National Science Standards (National Research Council, 1996) and Gee's (1990) definition of literacy in relation to discourse, an updated definition of agriculture literacy is offered. This new definition merges both agriculture content and linguists' definition of literacy relative to culture. The following is suggested as an updated definition: agriculture literacy entails knowledge and understanding of agriculturally related scientific and technologically based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. At a minimum, if a person were literate about agriculture, food, fiber, and natural resource systems, he or she would be able to a) engage in social conversation, b) evaluate the validity of media, c) identify local, national, and international issues, and d) pose and evaluate arguments based on scientific evidence about the systems. Because agriculture is a unique culture, an understanding of beliefs and values inherent in agriculture should also be included in a definition of agriculture literacy so people can become engaged in the system.

Understanding Agriculture: New Directions for Education challenged the agricultural education profession to shift its focus (NRC, 1988). The Council contended that agriculture, food safety, and the environment were important topics that needed to be taught to all ages of students, not just those in vocational agriculture programs for secondary schools. The study argued that "beginning in kindergarten and continuing through twelfth grade, all students should receive some systematic instruction about agriculture" (NRC, 1988, p. 2). Producers also agreed that because “students are the consumers of tomorrow” it was important to educate them early (Messenger, 2001, p. 34).

The idea of teaching agriculture in elementary classrooms is not new. Snowden and Shoemake (1973) (as cited in Terry, Herring, & Larke, 1992) noted that Socrates and other philosophers believed that people should learn about plants, animals, and the way humans use them early in life. Shively (1936) also noted that educators in Morgan County, Indiana expressed the need for agricultural objectives at all levels of education. He developed a list of 15 agricultural objectives considered important in elementary education including conservation of natural resources and a well developed agricultural vocabulary. Objectives such as these compare with the ones that have more recently been developed in the Food and Fiber Systems Literacy Guide (Leising, 1998).

The focus, however, has changed since 1936. No longer is the focus only on vocational agriculture, but now also includes the task of bringing everyone to a basic level of agriculture literacy. Frick, Birkenholz, and Machtmes (1995) have argued programs designed to teach agriculture literacy should be directed at all youth and grade levels. To set up effective programs, agricultural educators must know what students understand.

Educators must not only examine understanding from one context, but must look to those in locations with different populations in order to develop a more complete picture of student understanding. In a quantitative study on rural and urban adults, urban citizens lacked the most knowledge of agriculture, however, rural non-farm citizens also lagged behind their on-farm peers (Frick et al., 1995). Increasingly, people are moving away from urban areas, although they may still work in the city. Instead, they are moving to small towns close by that allow their children to grow up in what they hope is a safer, friendlier environment (Theobald, 1988). Even though these children are living and going to school in rural areas (as defined by the U.S. Census Bureau as locations with a population of less than 2,500), they may have no more ties to agriculture than their urban counterparts. In another study reported in Pork Magazine, there were no significant differences in perceptions of the pork industry between people living close to livestock areas and those in more urban environments (Messenger, 2001). This also supports the idea that rural does not have the same meaning as it once did. In other words, "rural" no longer can be directly associated with "farm".

The family farm is no longer the most common type of farm operation, while small hobby farms and acreages continue to increase in number which translates to off farm employment as being the main source of family income (Albrecht & Albrecht, 1996). This change in farm structure has led to a change in rural populations and rural family structure. In 1990, only seven percent of the rural population lived on farms (Albrecht & Albrecht, 1996). The perception that rural children will have greater direct experience with agriculture is challenged by this type of information.

Agriculture literacy is important because it allows people to make informed decisions about policy affecting agriculture, food safety, and the environment. Birkenholz (1990) contended that to have informed citizens regarding agriculture policy, students needed to be educated about agriculture at the pre-secondary level. All citizens are consumers of agricultural products, which means they have a vested interest in agricultural systems and policy. For citizens to make informed decisions about policy, a basic level of agriculture literacy is essential (Leising, 1998). With fewer people directly involved in agriculture, education must come from some place other than on the farm experiences (Birkenholz, 1990; Leising, 1998).

This basic level of agriculture literacy needed by citizens can be taught in the classroom (NRC, 1988). The AAAS also noted the importance of agricultural education in the classroom by including agriculture topics in their Project 2061 Designed World Science Benchmarks (1993). The University of California, Davis and the Milton Hershey School along with other educators also supported the need for agriculture literacy (Leising, 1998). They developed a framework and a set of learner outcomes for agriculturally related topics in order to set the building blocks of agriculture literacy. This framework was later revised and renamed the Food and Fiber Literacy Framework (Leising, 1998).

Agricultural Education

Currently most Americans, and particularly youth, have little understanding about agriculture and its significance in their lives and to the environment (Leising, 1998). This is may have resulted because few organized efforts have fostered agriculture literacy in students of any age. Although some programs exist such as the United States Department of Agriculture's Ag in the Classroom, they have not been frequently used. Terry, Herring, and Larke (1992) conducted a study of 510 fourth grade Texas teachers to determine teachers' understanding and use of agricultural concepts in classrooms. They found that the Ag in the Classroom program was only used by eleven percent of the teachers in the study and the FFA's Food for America project (which is no longer available) was only used by five percent.

Commodity groups such as the National Cattleman's Beef Association, the National Pork Producers and state beef, egg, and pork councils also produce educational and reference materials. These industry designed materials are for classroom teachers and are often commodity specific. For example, kits are available for teachers through state beef councils that teach students about how cattle are environmental stewards of range land. Other kits are available that teach students about meat's journey from gate to plate and about proper food handling practices. Iowa State University also holds a teachers clinic where commodity groups, in conjunction with university faculty, have the opportunity to help teachers learn how to use agricultural examples in their classroom.

A study conducted by Roper Starch Worldwide (2000) and commissioned by the Philip Morris family of companies and the American Farm Bureau Federation indicated that those directly involved with agriculture had miscalculated consumers' concerns about agriculture issues. This study of over 1,000 adult consumers and over 700 American farmers found that adult consumers felt that they had not heard much about the benefits or drawbacks of farming and food processing practices. This was especially true for those practices such as biotechnology, irradiation, use of antibiotics to treat animal diseases, and the use of hormones to increase milk production. The researchers concluded there was a lack of public education on agricultural topics and that the gaps in understanding must be identified. Those in the pork industry also identified a need for public education on agriculture practices (Messenger,2001).

Although there have been studies on adults' understandings and perceptions, few studies have measured the level of agriculture literacy in elementary students. The AAAS (1993) acknowledged that their Designed World benchmarks, which include the agriculture concepts, were based on very little research but rather on recommendations from technology teachers. In his qualitative research on urban and suburban fifth grade elementary school children, Trexler (2000b) found that elementary students have little understanding of the scope of agriculture in today's society and of how new technologies, especially biotechnology, effect agriculture and the environment. Studies with children on their agriculture literacy levels of animal concepts are not abundant.

Most research conducted in agricultural education has been based on survey methodology, which may not give a full picture of what respondents actually understand. Trexler (1999) stated that "survey findings of many agricultural education researchers do not lend themselves to an accurate picture of what people understand about the agri-food system" (p. 40). The use of surveys, multiple choice, or true-false tests discourage complete understanding or "knowing" by students and are often not very effective in determining much more than rote memory recognition (Brooks & Brooks, 1993; Gardner, 1991; Mintzes & Wandersee, 1998b). Researchers in science education have recognized this for years and many over the past two decades have moved toward a constructivist view of learning (Georghiades, 2000). To accommodate this theoretical perspective, these researchers have adopted research methods that more accurately assesses students' conceptions.

Science education researchers have moved significantly ahead of those in agricultural education researchers in this respect. Since the late 1970's, many science education researches have utilized research tools including clinical interviews, concept maps, participant observation, ethnomethodology, and classroom artifacts in qualitative studies that reflect meaning making, understanding, conceptual change, knowledge structure, and quality of students' learning (Mintzes & Wandersee, 1998b). These types of research methods have developed out of a constructivist view of learning. By using qualitative research methods, researchers more completely determine students' schema regarding concepts and then continue to build upon the students' previous knowledge structures.

Theoretical Framework

The theoretical framework of this study is based on Piaget's research on child development psychology, which is considered a basis of constructivism. Piaget posited that children are not born with knowledge, instead they must construct their own form of knowledge over time (Gardner, 1991). Piaget suggested the ideas of children are based on pre-conceived 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 the new information begin to occur (Piaget, 1975/1985).

Piaget contributed to the development of constructivism by addressing how knowledge structures are changed or altered in the mind of the learner. He believed that children actively construct schema about the world as they encounter new things and that these are organized into a network or cognitive structure (Bliss, 1995). Schema can be altered or changed when the child experiences something new that does not fit their existing framework. Piaget described change as a process of assimilation, accommodation, and equilibrium (Piaget, 1975/1985). Assimilation is the addition of information to existing knowledge structures while accommodation is the change of the existing schemes (Bliss, 1995; Dole & Sinatra, 1998). Equilibrium occurs through the process of accommodating new knowledge. Progress has occurred in the form of new understandings when there is no longer conflict between the child's mental constructs and the outside experience (Piaget, 1975/1985). That is to say, the child is able to solve the problem or understand the experience based on the knowledge that he or she already possesses or has accommodated to his or her schema.

Changes in schema occur through a process called conceptual change (Posner, Strike, Hewson, & Gertzog, 1982). Conceptual change, according to Posner et al. (1982), occurs under certain conditions. They state that first there must be some form of dissatisfaction with the existing conceptions in order for the individual to have a reason to change their schema. Second, there must be a new conception that seems intelligible or makes sense to the person. Third, the new conception must appear to be plausible or have the ability to solve the problem. Fourth, the new conception needs to be fruitful in that it can solve other problems.

These conditions of conceptual change need to be present for an individual to change their existing structure (Dole & Sinatra, 1998; Posner et al., 1982; Thorley & Stofflett, 1996).

Georghiades (2000) has gone a step further and suggested that conceptual change only occurs at a low level if the individual only proceeds through the conceptual change processes of intelligibility, plausibility, and fruitfulness, but is unable to transfer a scientific conception to a different context. He introduced, therefore, the importance of metacognition in helping students retain scientific conceptions and transfer them to new contexts. Simon (1995) also suggested the importance of contextual transfer. He noted that "learning involves being able to use the ideas beyond the narrow context of the original problem situation" (p. 120). "Permanent reconceptualization of phenomena that generalize beyond the classroom…require strategies that not only challenge existing views…but also provide for sufficient breadth of contextual experience to ensure generalizability of the reconstruction" (Anderson, 1992).

There is some difference in belief about how exactly changes in structure occur. Tytler (1998) noted that not all learning in science involves "a revolutionary shift in perspective" (p. 931). His study on children's conceptions of air pressure found that change should be seen as a "gradual extension of the range of conceptions as children learn to apply them to new situations" (p. 973). Dole & Sinatra (1998) noted that others suggested that conceptual change must be radical in order to be complete. Thagard (1992) believed that without a drastic change, conceptual change does not completely occur. Analogies were drawn between Kuhn's theory of scientific revolutions (Kuhn, 1970) and the process of knowledge change in learners by many of those who believed in the necessity of radical change. In this view, learners would continue to use their original schema to solve problems until enough anomalies occurred in their original schema. If enough anomalies were presented, a radical change in schema might occur. In a similar vein to a Kuhnian shift, Smith, Maclin, Houghton, and Hennessey (2000) noted that in order for students to master scientific standards, they would have "to make fundamental conceptual changes" (p. 352). This process of a radical shift, or a conceptual change, may be compared to Piaget's process of accommodation, while an extension of a conception, or conceptual growth, may be seen as Piaget's process of assimilation (Henriques, 1997).

Regardless of how conceptual change occurs, the presence of pre-existing knowledge cannot be ignored. Children have concepts constructed in their minds. Beginning at birth, children naturally interact with their environment and "they develop ideas, concepts, and theories to interpret that world" (Cleminson, 1990, p. 440). From these existing concepts children build their knowledge structures. Constructivist theory suggests the initial role of the researcher or teacher should be to assess students' prior knowledge structures so as to link new concepts to previous ones or to cause some dissatisfaction with the current schema for the student so that conceptual change processes can begin. Researchers and educators also need to understand the origins of children's informal ideas, not just the ideas alone (Bliss, 1995). By understanding where children's ideas develop, teachers can help them understand scientific knowledge by relating it to a familiar context that is fruitful for learning.

A child's pre-existing knowledge structures are sensible to the child but may not be scientifically acceptable; and this conflict between intuitive ideas and formal ideas presented in the classroom is what makes science difficult to learn (Cleminson, 1990; Collis, Jones, Sprod, Watson, & Fraser, 1998). The ideas that students possess are usually solidly grounded in their cognitive structures and are difficult to modify (Anderson, 1992; Cleminson, 1990). This is in part due to the fact the children's concepts are layered and complex and they provide "coherent and convincing" explanations for phenomena and "persist with considerable stability over time" (Tytler, 1998, p. 959).

Due to the belief that children's ideas are "robust" and "resistant to teaching," some researchers think that children do not give up on their conceptions until they can experiment with other ideas (Bliss, 1995, p. 148). It is important, then, to design activities that challenge or expand children's ideas based on their prior knowledge. Tytler (1998) suggested that presenting a group of activities that "represent multiple embodiments of the same principle" (p. 965) seem to be a factor in advancing children's understanding. This strategy, therefore, could be helpful in overcoming any alternative frameworks or misconceptions in the student's prior knowledge while also promoting understanding across different contexts, which has been deemed important for advanced cognitive learning (Anderson, 1992; Georghiades, 2000; Simon, 1995).

Language in Constructivist Teaching and Learning

Making student ideas public, by posters, concept maps, or oral presentations, also facilitates conceptual change by encouraging students to have explanations for their ideas (Novak, 1990; Smith et al., 2000). The use of language, then, becomes particularly important in understanding student's previous knowledge and also clarification of ideas. This is especially true for social or interactive constructivism. According to these constructivist approaches, interaction between students is essential for generating shared knowledge among the group (Henriques, 1997). Discourse is a means for generating this shared knowledge.

The use of discourse in constructivist science classrooms allows for both the child and the teacher to develop a clearer picture of the student's schema. The particular words that students use to describe phenomena, are context dependent and "thus require, and contribute to, a higher degree of intersubjectivity between speaker and listener" (Cazden, 1988, p. 111).

Constructing some form of shared meaning within the classroom setting that both students and teachers agree upon becomes essential. This "taken-as-shared" knowledge has been shown to evolve from classroom conversations facilitated by the teacher (Simon, 1995). Children's language may not correspond with generally accepted scientific language, but their use of terms makes sense to them and cannot be ignored. Language, therefore, complicates science constructivist learning because the scientific community has a language children do not posses that is generally accepted and is used as a means for facilitating information exchange (Anderson, 1992).

In some instances, children begin using scientific terms in the classroom if they have heard them used by others. However, the child may not be able to explain the meaning of the term and will generalize terms in patterns across different topics (Gallas, 1995). Educators and researchers must continually ask for clarification and definition of terms from students in order to ensure the vocabulary of the student matches their cognitive understanding.

Vygotsky (1978) stressed the importance of language development and believed that "the most significant moment in the course of intellectual development...occurs when speech and practical activity...converge" (p. 24). It is then that both practical and abstract intelligence become possible for the child. His zone of proximal development is based on the use of language as a means for measuring student potential development. Children use speech to solve problems. Vygotsky showed that children talk through problems they can not solve by using their present knowledge. This further addresses the importance of language in development of new mental constructs for children. Without some form of reflection and discourse, concepts "are often diffuse, mysterious, and laden with misconceptions" (Gallas, 1995, p. 54). Allowing student-led classroom discussion between students and the teacher and students and their peers brings forth new meaning and understanding for students while also encouraging the thinking process.

Learners that develop their own knowledge structure become "*meaningful* learners" (p. 10) as opposed to those who learn primarily by rote (Novak, 1998). Therefore, "instruction and evaluation emphasizing or favoring rote learning strategies lead to little improvement in learner's usable knowledge structures" (p. 12) while the opposite is true when learning for meaning is encouraged (Novak, 1998). From this line of thinking the objective of school science should be "*quality over quantity, meaning over memorizing,* and *understanding over awareness*" (Mintzes & Wandersee, 1998a, p. 56). Agricultural education could increase agriculture literacy levels by following science education in promoting meaningful learning as well.

Agricultural education research stands to benefit from this constructivist view of learning based on the positive results that science education has already experienced. This study, therefore, was based on a constructivist theory to aid agricultural educators in more completely understanding the depth of student knowledge about livestock and the meat industry.

Curriculum

Agricultural education does not need to be added to the curriculum as a separate subject, but can be integrated into current curricula in "art, science, math, writing, language arts, and social studies" (Needham, 2000, p. 8). By incorporating agriculture into curriculum, teachers will be able to link many subjects together, thereby helping students to see whole concepts rather than parts (Leising, 1998). Science education may benefit from this alliance because agriculture provides real world examples, which aid in capturing the students' attention. The NRC (1988) concluded that "teaching science through agriculture would incorporate more agriculture into curricula, while more effectively teaching science" (p.11).

Without understanding what students understand, however, educators have no basis to begin writing effective curriculum or developing learning activities that encourage the student to question his or her ideas and the ideas of others. By "[staying] out of the way" (Gallas, 1995, p. 71) of a child's curiosity, teachers give up the control they had assumed they had over the child's learning process. Letting the child take the lead allows him or her to build upon previous conceptions and question those that no longer make sense. Once teachers or researchers have developed a thorough understanding of a student's cognitive structures, they will be able to plan activities that cause disequilibrium in the mind of the learner or present phenomena that the student can assimilate into his or her previous knowledge structures. Only then can conceptual change begin to take place.

Once the student's prior knowledge has been unearthed and assessed, teachers can use a method of teaching that both builds on and challenges the student's conceptual framework. Because constructivism is a learning theory, and not a teaching strategy (Simon, 1995), a method or methods of teaching that promote constructivist learning are necessary. Driver and Oldham (1986) formed a curriculum development model based on constructivism that took into account four main types of input (Figure 1). One of the four inputs was students' prior ideas. According to this model what students' already understand has a direct effect on the design of the curriculum. Therefore, assessing this prior knowledge is essential and just as important as the content that students are to learn.

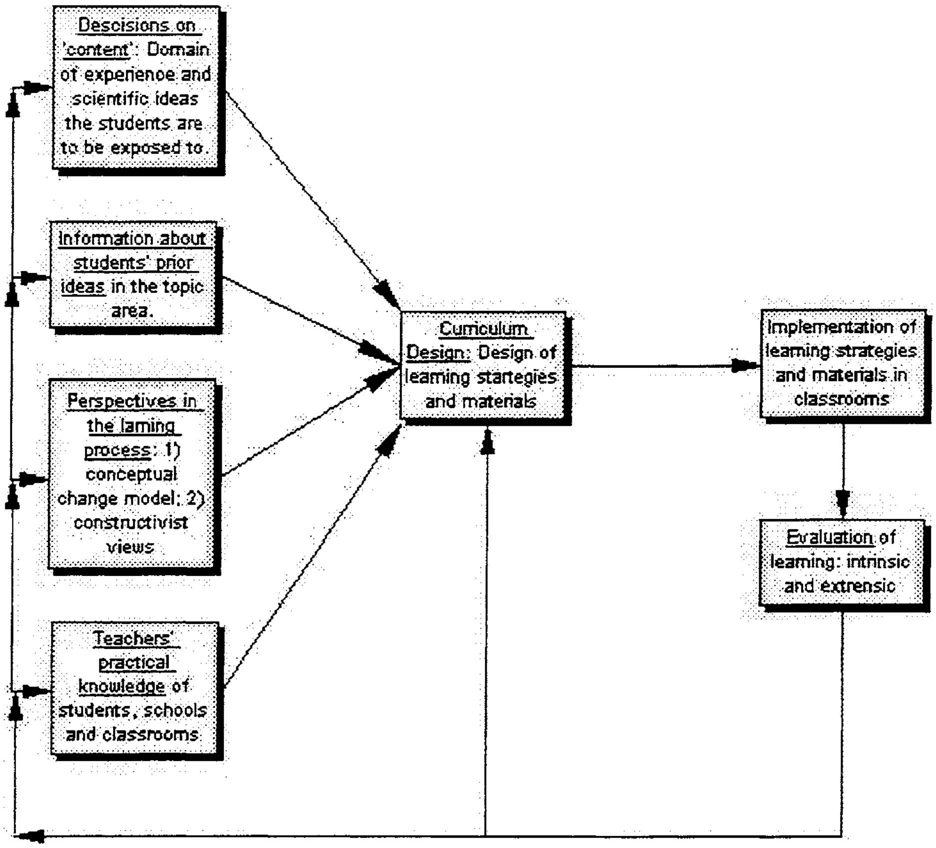

Figure 1. A constructivist model for curriculum development. (Driver & Oldham, 1986).

Simon (1995) also noted the importance of assessing students' prior knowledge structures in mathematics education from a constructivist perspective. In his mathematics teaching cycle, students' knowledge has an effect on not only the learning activities, but also on the learning goals that the teacher is setting for the students.

If a constructivist learning theory is to be followed, then understanding students' prior knowledge structures is the first step in the development of curriculum. Agricultural education researchers have begun to investigate students' schema, and this study attempted to add to that body of knowledge on student understanding.

Summary

In summary, the review of literature has found that both adults and children have little to no understanding of agriculture in today's society. Their loss of connection with the land has fostered this dearth of understanding. Agricultural educators realize this change in society, and have began to focus more on bringing all ages of people to a basic level of agriculture literacy. Benchmarks and objectives have also been set forth that would help curriculum developers raise the agriculture literacy level of school-aged children.

Studies conducted to determine what both children and adults know and understand have been mainly limited to survey research. Some researchers have argued that this type of research is ineffective in determining true understanding, and have therefore began using qualitative research methods that more completely discover understanding. Constructivist learning theory has become the basis for this new type of research.

Constructivists believe learning is based on prior knowledge and the construction of schema. Causing dissatisfaction in the learner leads to addition or reformation of the schema. Constructivism also supports contextual transfer to insure complete understanding. Many in science education believe in constructivist learning theory. Science educators partnering with agricultural educators can achieve contextual transfer and promote complete understanding through the use of agricultural and environmental concepts and examples.

Curriculum models developed from science education are based on constructivist learning principles and have been constructed to aid educators. One of the basis of these models is assessing prior knowledge. Agricultural educators have not fully explored prior knowledge, which has led to the reason for this study.

Chapter III. Methods

Introduction

All participants were treated in accordance with the APA guide for human subjects treatment (Appendix A). The research methods that I used to conduct this research are qualitative in nature. I believe that this type of research was necessary to achieve the objective of determining students' understanding of meat and livestock concepts. This chapter begins with a justification of why I chose qualitative research. I then explain the benchmarks on which this study is based. Next, I describe those who I studied and my rationale for this group. Finally, I elucidate the details of my research methods and analysis.

Justification

Agricultural education researchers often rely on surveys and statistical analysis as the basis for generating knowledge of what people understand. There is some question, however, as to whether these types of quantitative measurements are truly indicative of what people understand (Lincoln, 1998). Due to the fact the "knowledge cannot be separated wholly from the context in which it was generated" alternative methods of research are needed to "seek understanding which is holistic, emic, and intimate" (Lincoln, 1998, p. 17). According to constructivist learning theory, each person "possesses a unique educational history, owing in part to the novel or idiosyncratic way each individual interprets a learning experience" (Anderson, 1992, p. 1037). If each person has their own unique schema, then qualitative research and in-depth inquiry of the individual becomes essential in grasping deep understanding of the individual's cognitive structure.

Science education has taken advantage of this type of research to generate new understandings in that field (Anderson & Demetrius 1993; Hogan & Fisherkeller 1996; Smith, Maclin, Houghton, Hennesey, 2000; Tytler, 1998). Simon (1995) also used a qualitative research approach in mathematics education research. Some in agricultural education have begun to accept qualitative research methods as well. Trexler and Heinze (2001) and Trexler (2000b) were the first in agricultural education to use qualitative methodology to ferret out an individual's understanding. Their methods were similar to those of a science education study by Hogan and Fisherkeller (1996) where student conceptions of nutrient cycling in ecology were analyzed using student interviews. My study's methodology was an adaptation of Trexler and Heinze (2001), Trexler (2000b), and Hogan and Fisherkeller's (1996) studies in science and agricultural education. Like these previous qualitative studies, I used interviews to determine student understanding of agriculture and science benchmarks.

Qualitative inquiry allowed me to explore two research objectives:

1. To determine students' backgrounds and experiences, and
2. To describe how student understandings of the agri-food system compare to goal conceptions based upon a synthesis of agriculture and science benchmarks.

Benchmarks

Interview questions were based on 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). The benchmarks selected reflected understanding of meat and livestock concepts. Table 1 contains the benchmarks and the language necessary for demonstrating understanding of these concepts.

Table 1. Concepts, Benchmarks, and Language

Concept	Benchmark	Language
What is Agriculture?	1. Identify food products that come from animals. (K-1 FFSL[a] & K-2 AAAS[b])	1. meat, milk
	2. Describe by-products that come from animals. (9-12 FFSL)	2. clothing, sporting equipment, medicine, cosmetics, gelatin, tallow (soap, plastic, tires)
	3. Describe farms and their products. (K-1 FFSL & K-2 AAAS)	3. small, large
	4. Describe the journey a meat product travels through from farm to consumer. (2-3 FFSL)	4. production, transportation, processing, distribution, consumption
What is the role of science and technology in the food and fiber system?	1. Describe how foods may spoil before use and the advantages of and methods to slowing down food spoilage. (3-5 AAAS & K-5 FFSL)	1. heating, salting, smoking, drying, cooling, storage, heat, consumer, spoil, germs, 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).

To holistically visualize these benchmarks, I developed concept maps which were reviewed and verified by experts in the fields of science education, agricultural education, animal science, and the beef industry. Considering the notion that a person's cognitive structure is organized hierarchically, concept mapping was developed as a way to represent mental schema in a hierarchical manner (Novak, 1990). The concept maps I developed (see Figures 2 & 3) represent complete understanding of the benchmarks. A narrative describing the benchmark follows the figure.

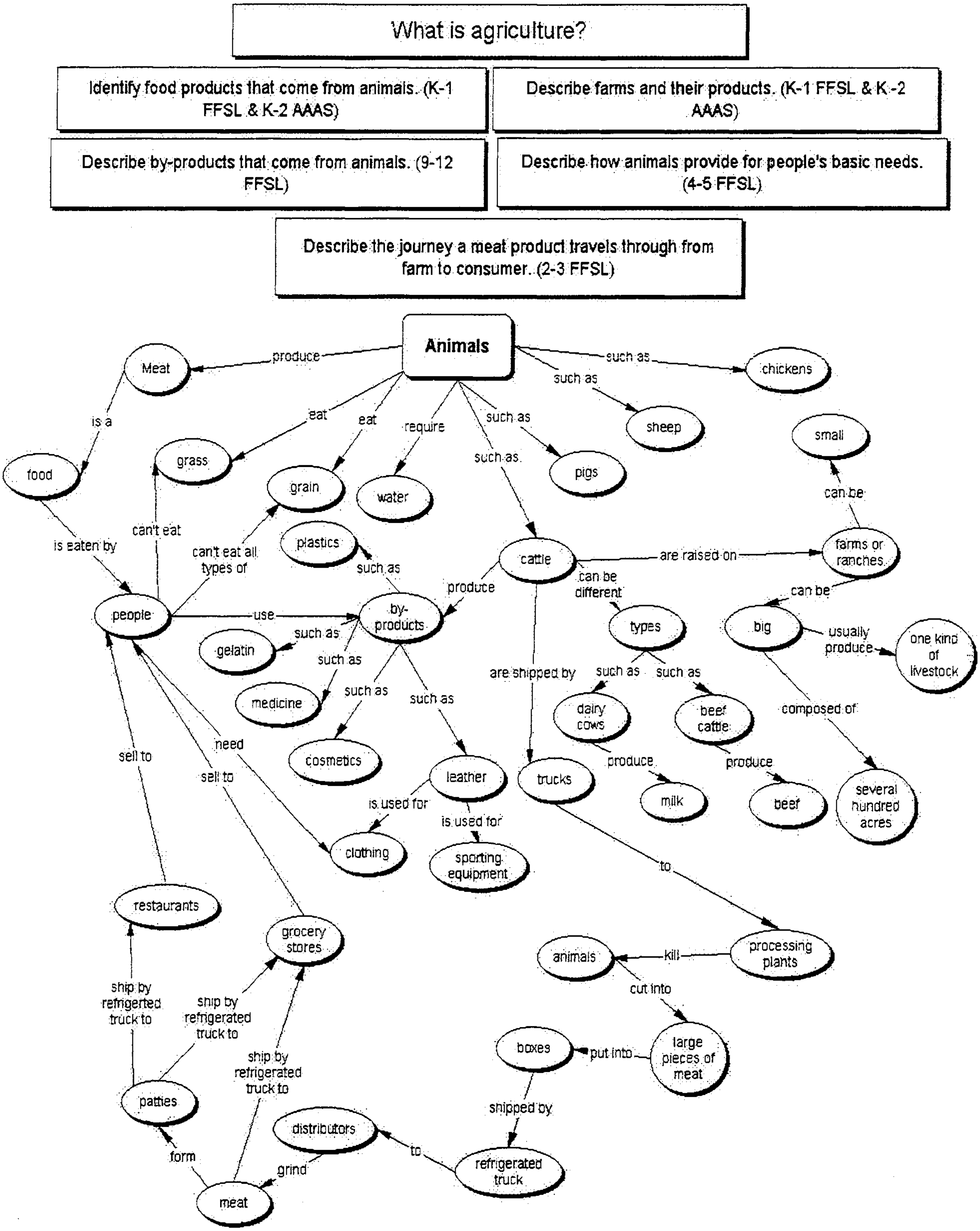

Figure 2. Concept map of complete understanding of the "What is agriculture?" concept.

Narrative: What is agriculture? (Concept 1, Benchmarks 1-4)

Animals produce the meat that people eat. These animals require water, shelter, and food such as grass and grain to survive. Animals convert grass that people cannot eat into a protein rich food product that people can consume.

Cattle are one type of animal that produce products for human use. Cattle not only produce meat and milk, but they also produce by-products. These by-products such as plastics, gelatin, cosmetics, medicine, and leather for clothing and sporting equipment, are used by people everyday.

There are different types of cattle. Some are raised mainly for milk production (dairy cows), while others are raised for meat production (beef cattle). They are raised on farms or ranches of varying sizes. Some are small and consist of ten to one hundred acres. Most farms, however, are quite large and are several hundred to thousands of acres. Farms usually raise only one type of livestock animal. Farmers sell the animals, which are transported by trailers to processing plants. At the processing plant, the animals are killed and cut into large pieces of meat that are placed in boxes. These boxes of meat are shipped via refrigerated truck to distributors who then process and ship the meat, by refrigerated truck, to restaurants and grocery stores. People then buy the meat at the grocery store and prepare it at home, or they purchase the pre-cooked meat at a restaurant.

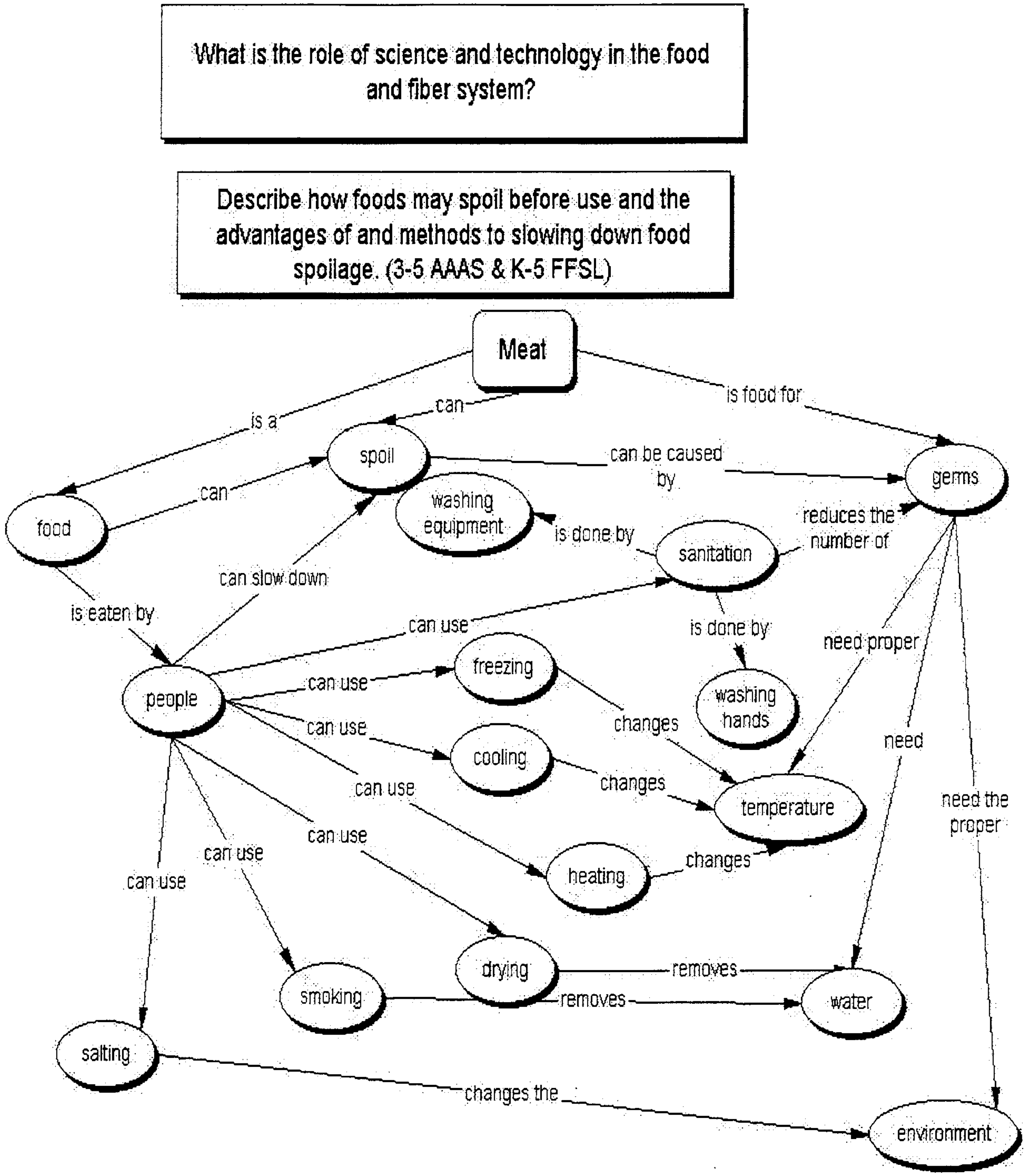

Figure 3. Concept map illustrating complete understanding of the food spoilage benchmark.

Narrative: Describe how foods may spoil and the advantages to and methods of slowing down food spoilage. (Concept 2, Benchmark 1)

Meat is a food product eaten by people. Meat products are not only food for people but are also food for microorganisms such as germs or bacteria and can spoil due to these organisms. People can reduce food spoilage by using sanitation, including washing their hands and equipment, which reduces the number of germs. Humans can also slow microorganism growth by storing meat in an environment that is undesirable for their survival.

Freezing and cooling are ways to store meat at a temperature that kills bacteria or slows down their growth. Heating from cooking also changes the temperature of the meat to a level too high for microorganism survival. People also use processes that smoke and dry the meat which removes essential water for microorganisms. Adding salt to meat is another method of altering the environment that the bacteria need to survive.

Population

To allow others to create transferability, the following is descriptive detail about the population for this study (Guba & Lincoln, 1989). I observed two classes of fifth grade students from two different class sections in a rural Midwestern consolidated school. Rural students were chosen to compare the results of this study with other studies of urban and suburban students. I selected fifth grade students because they possessed a large enough vocabulary to converse clearly about the benchmarks, and fell within the grade level range of the benchmarks. Students attending the school were bused in from several small towns. The towns were separated by less than 15 miles of farm land. A larger city was located approximately 35 miles from the school building; however, none of the students lived in the city. The two hours of observation time in each class allowed me to build rapport with the students by accommodating to their classroom routines and talking with them about my personal interests (Taylor & Bogdan, 1998).

After collecting signed permission forms from the students and their guardians (see Appendix B), I selected seven students for interviews out of the entire fifth grade. Four of the respondents were girls and three were boys. I attempted to purposefully select non-farm students; however, three of the respondents came from part-time farm operations. I also purposefully chose more females than males, as I felt that they would have had more experience with cooking and grocery shopping and as adults would likely be the main cooks and shoppers of their household. In the reporting of the data, pseudonyms were used in place of the students' real names.

Research Process

Interviews were used to gather student information relative to their knowledge structures. Because terms and phrases used in conversations can be understood differently, the interviewer tried to avoid ambiguities and generated shared meaning with the student (Collis, 1998). Clinical interviewing was used because it allowed for deep understanding but was non-intrusive in that the interviews are conversational rather than scripted. Posner and Gertzog (1982) have suggested the goal of clinical interviewing is "to ascertain the nature and extent of an individual's knowledge about a particular domain by identifying the relevant conceptions he or she holds and the perceived relationships among those conceptions" (p. 195).

The clinical interviews allowed for a "controlled but flexible conversational interview" that let the interviewee introduce what is relevant to him or her (Posner & Gertzog, 1982, p. 198). This was important because Anderson and Demetrius (1993) argued "the way interview questions are phrased and the kinds of accompanying information that are presented during interviews can influence the content and organization of information that is reconstructed and reported" (p. 955-956). Posner and Gertzog (1982) and Anderson and Demetrius (1993) have suggested using open-ended and non-directive questions as they are the most useful tools in understanding a student's conceptual framework. The interviews in my study, therefore, were modeled after "normal conversation rather than a formal question-and-answer exchange" (Taylor & Bogdan, 1998, p. 8). Examples of interview questions are found in Table 2. Because each student interviewed was unique in his or her experiences and understanding, I adapted interview questions while still following a general guideline established prior to the interviews.

Table 2. Sample interview questions.

Research Objective 1: Determine students' backgrounds and experiences
Where do you live? Can you describe the area? Who do you live with? What do they do for work? Does anyone in your family raise livestock or farm? Do you go grocery shopping with someone in your family? Do you know what 4-H is? Have you ever been involved in 4-H activities?
Research Objective 2: Determine students' understanding of benchmarks
Can you trace the meat back to where it originally came from? Explain as much as you can about the trip the meat takes. What does the place look like that the animals came from? About how many football fields big is it? How do the animals and meat get from place to place? What is raised on this farm? What do the animals eat? Can people eat the same food as animals? Are there any other things we get from animals other than the meat? Can you tell me about how you store the meat? Why do you think it is done that way?

The first interview lasted approximately 60 minutes. A hamburger from a nationally known food chain was used to initiate the interview. By using a recognizable food as a visual prompt, students were able to link this familiar product with the processes from production to consumption (Anderson & Demetrius, 1993; Trexler & Heinze, 2001). Questions focused on the meat, due to the nature of the study.

The students were asked to draw a concept map of their knowledge about the path the meat took to get to the restaurant and as much other detail as they could about that journey. They also were asked to develop a second concept map regarding food spoilage. I presented a short lesson on concept mapping at the start of the interview to be sure they understood how one was constructed. Participants were then asked to describe their concept maps. Through this description, I continuously asked for clarification and more details. The interviews were taped and transcribed. I also took notes during the interviews that were used as a secondary source of data.

After the first interview, I coded the transcripts and then expanded the students' concept maps by adding any additional information the student provided during the interview. A second interview then took place that served as a member check and established credibility of the research findings (Guba & Lincoln, 1989; Taylor & Bogdan, 1998). Member checks allowed the students to "correct errors of fact or errors of interpretation" and to "offer additional information" (Guba & Lincoln, 1989, p. 239). During the member check, the student reviewed the revised concept map and was given the opportunity to change or add to it in any way (see Appendix C and D for student concept maps). I also asked for clarification of ideas from the first interview in order to ensure my interpretations of their interview answers were accurate.

Analysis

Analysis began with identifying the students' background and experiences that was then reported descriptively. To analyze the data on student understandings of the benchmarks, Hogan and Fisherkeller's (1996) bidimensional coding system for responses was used to judge participants compatibility with experts and elaboration of each benchmark. I grouped and coded the students' transcripts according to the benchmarks under examination. Participants were coded based on their communication of the benchmark by language. The transcribed interviews served as the data for language communication. Because most of the students did not have the vocabulary that was deemed necessary by the experts, I adjusted the language to better conform to the students' language. The students' concept maps were used as a secondary data source for visual comparison with the expert concept maps. Table 3 shows the coding scheme used to identify the extent of elaboration and compatibility with expert conceptions. To ensure confirmability of my findings, I included detailed excerpts of the actual interview transcripts in the results section and also provided the student developed concept maps that supported my coding of the participants in the appendices (Guba & Lincoln, 1989).

Table 3. Coding scheme for comparing student responses to expert conceptions.

Code	**Definition**
Compatible elaborate	Statements concur with the expert proposition and 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 represent a correct guess among choices provided, but no ability to explain why choice was made.
Compatible/incompatible	Makes sketchy statements that concur with proposition, but which are not elaborated, and also makes sketchy statements that disagree. Contradictory statements are often 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 up. 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.

To determine the relationship, if any, between students' backgrounds and experiences and compatibility and depth of responses, I inductively and intuitively searched for patterns that developed from the data (Taylor & Bogdan, 1998). I grouped students with similar backgrounds and experiences together and looked for differences between groups of student response codings. I then compared the students' responses and codings to the urban and suburban students' in Trexler's (2000b) study of agriculture and science benchmarks to look for similarities and differences. Although my study was centered on meat and livestock concepts and Trexler's concerned plant and pest related concepts, the overall understanding of agriculture was compared.

Summary

The qualitative methods used for this study were chosen because they allowed me to discover the idiosyncratic understandings of the students. Clinical interviews and concept mapping were the particular methods I employed to reach student understanding of the agriculture concepts. I gave each student a code based on their language in the interviews and analyzed for similarities and differences between the students. Few researchers in agricultural education have employed research methods such as these in an attempt to understand students' cognitive structures on meat and livestock concepts.

Chapter IV. Rural Elementary Students' Understandings of Science and Agricultural Education Benchmarks Related to Meat and Livestock

A paper to be submitted to the Journal of Agricultural Education

Deanna L. Meischen and Cary J. Trexler

Abstract

Agricultural educators and agricultural industry leaders have called for a basic level of agriculture literacy for all ages of Americans. Benchmarks have been developed by science and agricultural educators for students at all levels regarding an understanding of meat and livestock concepts. This qualitative study ascertained rural fifth grade students' cognitive structures about these meat and livestock concepts. Through interviews and concept mapping, student understandings were unearthed. This study found that students were aware that food products come from animals, but they were not as aware of other products that animals produce for human use. The students did not understand the size and scope of modern agriculture, but most had a very basic understanding of the process that meat travels from farm to consumer. The language that these students used to describe the benchmarks was not the language experts deemed necessary. Although the students could describe the steps of the process, their discourse did not include the correct, "scientifically" acceptable terminology educators prescribed in national benchmarks for science and agricultural education.

Introduction

Literacy involves the mastery of language in both oral and written forms (Gee, 1990). Language, however, is more than simply vocabulary; it also embodies culturally based beliefs, values, and attitudes. As one becomes literate, he or she masters the ability to make judgments based on culturally based norms that reify or reshape the culture and its institutions. Agriculture is a culture unto itself.

The term "agriculture literacy" was coined from the National Research Council's 1988 report *Understanding Agriculture: New Directions for Education.* The report contended that an agriculturally literate person should understand many aspects of the food and fiber system, including "its history and current economic, social, and environmental significance" (National Research Council, 1988, p. 1). To further clarify the definition, Frick and Spotanski (1990), Frick, Kahler, and Miller (1991), and Russell, McCracken, and Miller (1990) also included an understanding of the production, processing, and marketing of agriculture products as components necessary for agriculture literacy.

The early definitions of agriculture literacy focused on identifying salient content but did not include an explanation of what literacy was and how agriculture literacy levels could be determined through discourse. The definition of literacy is constantly evolving as changes in society and cultures occur (Trexler, 2000a). The National Council on Agricultural Education's 1999 report *Reinventing Agricultural Education for the Year 2020* began to expand the definition of agriculture literacy by adding conversational literacy about agriculture as a goal. This was a beginning, however, the new definition needs to include discourse and understanding within the culture of agriculture as aspects of literacy.

From the definition of science literacy in National Science Standards (National Research Council, 1996) and Gee's (1990) definition of literacy in relation to discourse, an updated definition of agriculture literacy is offered. This new definition merges both agriculture content and linguists' definition of literacy relative to culture. The following is suggested as an updated definition: agriculture literacy entails knowledge and understanding of agriculturally related scientific and technologically based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. At a minimum, if a person were literate about agriculture, food, fiber, and natural resource systems, he or she would be able to a) engage in social conversation, b) evaluate the validity of media, c) identify local, national, and international issues, and d) pose and evaluate arguments based on scientific evidence. Because agriculture is a unique culture, an understanding of beliefs and values inherent in agriculture should also be included in a definition of agriculture literacy so people can become engaged in the system.

In 1988, the NRC report argued that "beginning in kindergarten and continuing through twelfth grade, all students should receive some systematic instruction about agriculture" (p. 2). Producers also agreed that because "students are the consumers of tomorrow" it was important to educate them early (Messenger, 2001, p. 34). Currently most Americans, and particularly youth, have little understanding about agriculture and its significance in their lives and to the environment (Leising, 1998). Roper Starch Worldwide (2000) conducted a study commissioned by Philip Morris and the American Farm Bureau Federation that indicated those directly involved with agriculture had miscalculated consumers' concerns about agriculture issues. Company leaders agreed that there is a lack of public education on agricultural topics and that the gaps in understanding must be identified.

Although there have been studies on adults' understandings and perceptions, few studies have measured the level of agriculture literacy in elementary students. The American Association for the Advancement of Science (AAAS, 1993) acknowledged that its agriculture concepts were based on recommendations from technology teachers, not research. Trexler (2000b) found that elementary students have little understanding of the scope of agriculture in today's society and of how new technologies effect agriculture and the environment.

Typically agriculture literacy efforts focused on urban and suburban areas. In a study that compared rural and urban adults, urban citizens lacked the most knowledge of agriculture, however, rural non-farm citizens also lagged behind their on-farm peers (Frick, Birkenholz, & Machtmes, 1995). Children living and going to school in rural areas (characterized by the U.S. Census Bureau as locations with a population of less than 2,500), may have no more ties to agriculture than urban youth. Messenger (2001) found there were no significant differences in perceptions of the pork industry between people living close to livestock areas and those in more urban environments. In 1990, only seven percent of the rural population was living on farms (Albrecht & Albrecht, 1996). In other words, "rural" can no longer be directly associated with "farm."

This study's theoretical framework is based on Piaget's research on developmental psychology, which is considered a basis of constructivism. Piaget posited that the ideas of children are based on pre-conceived thoughts about how or why things are in a certain state (Gardner, 1991). Only when these knowledge structures, or schemas, are challenged does a child's understanding of the new information begin to occur (Piaget, 1975/1985). Changes in schema occur through a process called conceptual change (Posner, Strike, Hewson, & Gertzog, 1982).

For conceptual change to occur, certain conditions must be met (Dole & Sinatra, 1998; Posner et al., 1982; Thorley & Stofflett, 1996). First, a person must be dissatisfied with their existing schema. Second, there must be a new conception that makes sense to the person. Third, the new conception must be plausible or have the ability to solve the problem. Fourth, the new conception needs to be fruitful, meaning it can solve other problems

Based on constructivist theory, the initial role of the researcher or teacher is to assess students' prior knowledge structures so as to link new concepts to previous ones or to cause students' dissatisfaction with their current schema and begin the conceptual change process. If a constructivist learning theory is to be followed in agricultural education, then uncovering students' prior knowledge structures through a process of discourse analysis is the first step in the development of curriculum. Agricultural educators (Trexler, 2000b; Trexler & Heinze, 2001) have begun to investigate student understanding. This study was designed to add to that body of knowledge in terms of livestock and meat concepts.

Purpose/Objectives

The purpose of this qualitative study was to determine rural elementary students' understandings of science and agricultural education benchmarks specifically related to meat and livestock concepts. The objectives of this study were:

1. To determine students' backgrounds and experience with meat and livestock.
2. To compare students' understandings of science and agricultural education benchmarks related to meat and livestock with expert understandings.
3. To conclude if relationships existed between students' background and experiences and their understanding of the benchmarks.

Methods

Agricultural education researchers often rely on surveys to determine what people understand. There is, however, some question as to whether these types of quantitative measurements are truly indicative of what people understand (Lincoln, 1998). Lincoln (1998) has argued that because "knowledge cannot be separated wholly from the context in which it was generated" (p. 17) alternative methods of research are needed. Because each person has their own unique understanding, qualitative research and in-depth inquiry are essential in grasping insight into an individual's cognitive structure.

Population

Seven students were selected for interviews from a rural Midwestern consolidated school. Of the purposefully selected students, four were girls and three were boys. Fifth grade students were selected for the study because they possessed a large enough vocabulary to converse clearly, and fell within the grade level range of the benchmarks. Students attending the school lived in several small towns that were separated by less than 15 miles of farm land. A larger city was located approximately 35 miles from the school building. In the reporting of the data, pseudonyms were used in place of the students' real names.

Data Collection

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

Students were interviewed twice. During the first interview a hamburger from a nationally known 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 knowledge regarding the journey meat takes from farm to consumer. They were presented a short lesson on concept mapping to be sure they understood how to construct one. The interviews were audio taped and transcribed.

After the first interview, we coded the transcripts and then expanded the students' concept map by adding additional information from the interview. A second interview then served as a member check and established credibility of the research findings (Guba & Lincoln, 1989; Taylor & Bogdan, 1998).

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). The benchmarks were designed for students from kindergarten to fifth grade with the exception of the by-products benchmark. Although this benchmark is designed to be a ninth through twelfth grade concept, many state beef councils use this type of material in their educational programs which is why it was also chosen for study. Table 1 contains the benchmarks and the language necessary for demonstrating understanding of these concepts.

Table 1. Concepts, Benchmarks, and Language

Concept	Benchmark	Language
What is Agriculture?	1. Identify food products that come from animals. (K-1 FFSL[a] & K-2 AAAS[b])	1. meat, milk
	2. Describe by-products that come from animals. (9-12 FFSL)	2. clothing, sporting equipment, medicine, cosmetics, gelatin, plastic
	3. Describe farms and their products. (K-1 FFSL & K-2 AAAS)	3. small, large
	4. Describe how animals provide for people's basic needs. (4-5 FFSL)	4. grow, food, clothing
	5. Describe the journey a meat product travels through from farm to consumer. (2-3 FFSL)	5. production, transportation, processing, distribution, consumption

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 identifying the background and experiences of the students which was then reported descriptively. Next, goal conceptions and an expert concept map were developed by the researchers and were reviewed by experts in science and agricultural education, animal science, and the beef industry. To analyze student understandings of the benchmarks, Hogan and Fisherkeller's (1996) bidimensional coding system was used to judge participants' compatibility with experts and elaboration of each benchmark. Participants were coded based on language. The transcribed interviews served as the data.

The students' concept maps were used as a secondary data source. To ensure confirmability of the findings, excerpts of interview transcripts that supported codings are included (Guba & Lincoln, 1989). In addition, another researcher also independently coded the data with 96% agreement with the primary researcher. Table 2 describes the coding scheme used.

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

Code	**Definition**
Compatible elaborate	Statements concur with the expert proposition and 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 represent a correct guess among choices provided, but no ability to explain why choice was made.
Compatible/incompatible	Makes sketchy statements that concur with proposition, but which are not elaborated, and also makes sketchy statements that disagree. Contradictory statements are often 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 up. 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 relationships between students' backgrounds and experiences and compatibility and depth of responses, we inductively and intuitively searched for patterns that developed from the data by grouping students with similar backgrounds and experiences together and looking for differences (Taylor & Bogdan, 1998).

Findings

By questioning students about their personal experience with livestock, the researchers were able to reach research objective one. All students were Caucasian. Three students lived on farms while the other four lived in small towns. 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, however, had direct experience with livestock. Most students' parents worked in a near by city. When asked what their parents did for a living, many of the students replied only with the company name and not the actual occupation. Table 3 lists the students along with their background 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

Research objective two was reached by the researchers directly asking students to describe their understanding of an agriculture and science concept about the nature of agriculture. The first benchmark identified food products that came from animals. Codings assigned to students based on an interpretation of the language are found in Table 4. Black dots were used to indicate students' understandings of the subconcepts that were necessary to understand the benchmark. A superscript to the coding gives further clarification as to the depth of understanding for each student.

Table 4. Student understanding of identification of food products from animals.

Benchmark	**Greg**	**David**	**Heidi**	**Jim**	**Jessica**	**Lynn**	**Melissa**
1. Identify food products from animals							
a. meat	•	•	•	•	•	•	•
b. milk	•	•	•	•	•	•	•
Coding	CE^2	CE^2	CE^2	CE^2	CE^2	CE^2	CE^2

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 in order to show differences in student understanding of the benchmark. The superscript was determined based on how many subconcepts the student identified.

All students effectively articulated an understanding that cattle produce meat and milk for human consumption. Some students said that different types of cattle were used for different types of production. Greg, Jessica, and Melissa all noted that dairy cows were used mainly for the production of milk and dairy products and that these cows were different than cattle primarily used for meat production. Heidi felt that only the "boys" were used for meat production and the "girls" give the milk. Although her understanding was partially correct, she did not seem to understand that different types of cattle produce different products. Lynn's understanding of different types of cows was linked with what she recognized in the grocery store. She thought some cows produced two percent milk and some whole.

The second benchmark required that students describe cattle by-products. Table 5 lists the codings assigned to each student.

Table 5. Student understanding of by-products from animals.

Benchmark	Greg	David	Heidi	Jim	Jessica	Lynn	Melissa
1. Describe by-products that come from animals							
a. leather -clothing -sporting equipment		 •	• •	• •			 •
b. medicine							
c. cosmetics							
d. other		•					
Coding	N	CS^2	CS^2	CS^2	N	N	CS^1

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 in order to show differences in student understanding of the benchmark. The superscript was determined based on how many subconcepts the student identified.

Four students had an understanding of how by-products from cattle are used in products they encounter daily. Heidi and Jim were the only students that mentioned leather as a product from cattle. David and Melissa both knew that clothing came from animals, but Melissa's conception was linked to her background with sheep. She thought that cattle were shaved and their fur was used to make coats rather than the hide used for leather. David also noted that fertilizer for farmers came from cattle bones. Jim knew about the exportation of niche products to other countries, specifically Asian markets, which was evidenced by this comment, "I mean like some things they might ship it over to the people in Japan cause they eat some of the weird things that we don't eat, like the brain and stuff like that." Also noteworthy about Jim's conversation was his conceptualization of meat.

I: What are some parts that we don't eat?
J: The muscle.
I: Tell me about that.
J: It's an organism in your body that helps you move your bones and it pulls on 'em and makes 'em move.
I: What part is the meat?

J: The stuff underneath the muscle.

Although Jim understood the function of muscle, he did not realize the muscle is what he eats as meat.

Those that had nonexistent codings repeatedly noted that the cattle parts humans do not consume are thrown away. Greg's interview was similar to others with a nonexistent understanding.

I: What does the butcher do with the things that we don't eat?
G: Um, he probably just throws them away.
I: What kinds of things don't we eat that he might throw away?
G: I know they throw away the bones, unless it's like a T-bone steak or something like that. I can't think of anything else.
I: What about the fur or the skin, what do they do with that?
G: They probably throw that away, too.

Greg, Lynn, and Jessica all said that what was not eaten was thrown away. No students knew that by-products from cattle are used in pharmaceuticals or cosmetics.

Benchmark two asked students to describe the size and scope of the farms where cattle were produced. Included in Table 6 are the student codings for this benchmark.

Table 6. Student understanding of farms and their products.

Benchmark	**Greg**	**David**	**Heidi**	**Jim**	**Jessica**	**Lynn**	**Melissa**
1. Describe farms and their products.							
a. large farm size							
b. one main type of animal							
Coding	IE	IE	IE	IE	IE	IE	IE

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 in order to show differences in student understanding of the benchmark. The superscript was determined based on how many subconcepts the student identified.

All students knew that cattle were raised on farms; however, they were coded incompatible elaborate because their conceptions of what these farms looked like was not in line with modern agriculture. No students understood that farm size where most cattle are produced is quite large, encompassing hundreds or thousands of acres. Because a football field was a visual image students could easily comprehend and is comparable to an acre, the students were asked to use this measure to indicate the size of the farms where the cattle were raised. Student responses varied from one to twelve acres.

The fourth benchmark required an understanding of the process that meat products go through on their way from the farm to consumer. The students' codings for these benchmarks are included in Table 7.

Table 7. Student understanding of the journey of meat products.

Benchmark	Greg	David	Heidi	Jim	Jessica	Lynn	Melissa
1. Describe the journey meat products travel.							
a. production	•	•	•	•	•	•	•
b. transportation	•	•	•	•	•	•	•
-trailer	•		•	•	•		•
-refrigerated truck		•		•	•		•
c. processing	•	•	•	•	•	•	•
d. distribution					•		
e. consumption	•	•	•	•	•	•	•
Coding	CS^5	C/I^5	CS^5	CS^6	CS^7	CS^4	CS^6

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 in order to show differences in student understanding of the benchmark. The superscript was determined based on how many subconcepts the student identified.

Although students had a general idea of the agri-food system process, six of the seven students were assigned compatible sketchy codings because they missed important details. The language students used to describe the process was not congruent with experts' conceptions. The codings were assigned based on their understanding rather than just on language alone. Many of the students, for example, used the term "butcher" instead of processor. Their understanding as to what occurred during that phase of the process (killing the animal and fabricating the meat), however, was clear by their explanation. The following narrative is Jim's brief explanation of his concept map.

I: Tell me about what you did.
J: A cow ate the grass, which gave it fat or meat to the cow. Which then got butchered for the meat. Which then got shipped to McDonalds™ and then McDonalds™ sold it to you.
I: Where did the cow come from?
J: A farm.
I: The cows then come from the farm. How do they get to this butcher place?
J: In a wagon, or a trailer or yeah, a trailer.
I: So what all happens at this place?
J: They bring the cow in and then they butcher it. They usually butcher it outside though. And then once they do that, he brings the meat in that he got out from [the animal] and then he might season it or dry it for jerky or something and then he'll put it in the freezer and then you'll come pick it up or he'll have it shipped to you.
I: After they butcher the meat you said it gets shipped to McDonalds™, how does it get there?
J: They get it in a big semi and they pack [the meat] in big crates and boxes in slices. And all the people at McDonalds™ have to do is they take it and they put it in little box things and then opens it up and then it warms them really warm and then they put it in the bun and then they serve it.
I: Is it cooked when it gets to McDonalds™ then?
J: No.

His description of what the butcher does allowed the researchers to equate that phase in the journey with processing even though his language was not the same as the prescribed vocabulary.

Most students had a basic understanding of meat's journey from farm to plate. David was unique because he thought the cow was killed and cut into large pieces by the farmer and then taken to a butcher where it was further processed and packaged. The other fifth graders knew that the cattle were shipped from the farm to a place where the cattle were killed and processed. The language that the students used, however, varied from student to student as well as the depth of description about the stops the meat made. Jessica was the only informant who included a distribution step in her description. Although she did not call the step "distribution," she said that there was a "second place" where the meat was further packaged and sold to stores.

Students whose families raised steers, Greg and Jessica, described cattle production in more detail than their classmates. These students, however, were not able to more elaborately explain the process after the cattle left their farms. This was evident in Greg's description of meat processing before it got to the fast food restaurant.

I: Who sent the meat to [McDonalds™]?
G: I don't know.
I: OK, so where did you say that the meat came from before it got to McDonalds™?
G: I don't know.
I: How do you think it got ground like that? Who did that?
G: Probably the butcher.
I: So it comes from a butcher then?
G: Maybe.

Greg thought the meat came to the fast-food restaurant as ground meat and then the restaurant employees made the patties before cooking them. Lynn, Jessica, and David's schema also concurred with Greg's. All informants knew some type of processing took place before it arrived at the restaurant, but the students' answers varied as to how much.

The students' answers also varied with regard to the type of transportation used to move cattle and meat. Neither David nor Lynn mentioned the use of a trailer to transport the cattle. In David's conception, there was no need to transport live animals, because he believed that they were killed on farms. David, Jim, Jessica, and Melissa all understood that once the animal was killed, the meat had to be transferred in a truck with some type of cooling system. Greg, Heidi and Lynn never mentioned refrigerated trucks to transport meat.

Heidi compared a mail truck with the type of vehicle used to transport meat; and Greg compared it to a "truck that you sell Doritos or chips" from. Heidi, Greg, and Lynn knew meat had to be kept cold in their homes, but said nothing about meat needing to be refrigerated during transport.

Conclusions/Implications

Objective One. Background and Experiences

None of the students' parents were primarily farmers. Therefore, even though these students grew up in a rural community, they, like other rural youth, can not be generally labeled as farmers. These students lacked understanding of agriculture concepts even though they were raised in rural areas. This, then, raises questions about agricultural education's primary focus of agriculture literacy for only urban and suburban students.

In general, students who raised animals for meat could more elaborately describe the production of animals; however, they had no greater understanding about the processing of the meat products than their non-livestock raising contemporaries. Few cattle were raised in the area and row crops (corn and soybeans) dominated local agriculture. If the study was conducted in an area where livestock production was a primary agricultural entity, the results of the study may have been different with regards to student language use and their conceptual frameworks.

Objective Two. Understanding of Benchmarks.

Benchmark one asked students to describe food products that came from animals. Students understood very well that meat and dairy products originate from animals. This supports Trexler's (2000b) finding that elementary students know that food comes from plants and animals. Many people continue to focus agriculture literacy efforts toward informing students about the origin of food. It seems, however, that resources could be reallocated to other areas where students actually lack knowledge, such as this study's second benchmark.

The second benchmark concerned student understanding of cattle by-products. Most students did not understand that cattle produce many products besides meat and milk. Those in the agriculture industry would benefit from consumers realizing that agriculture is not a wasteful industry. If students understand that many of the products they use everyday rely on by-products from animals, then they can better understand the impact of agriculture on their lives. This is important because it may generate support for the industry as policy issues surface. To foster schema development concerning by-products, educators could design activities that require students to discover the sources of ingredients in many everyday products, such as cosmetics and medicines, through research and discovery.

The third benchmark dealt with student understanding of farms and their products. Students had alternative frameworks to the expert conception about farm size and their scope and were able to elaborate on their understandings. These rural students did not have a correct schema for the large scale of modern production agricultural operations. This finding parallels Trexler's (2000b) study of urban and suburban students. Both the urban/suburban students in Trexler's study and the rural students in this study did not understand the large scale of farming today. These rural students were also similar to those in Trexler's study in that they believed that farms are diversified. This study's students believed that most farms raise many different species of livestock, which was akin to Trexler's urban and suburban student's ideas about crop production.

Agriculture literacy efforts may benefit from helping students reconceptualize their notions of a farm. Rather than teaching students that meat comes from cattle, it may be more productive to devise curricula and programs that help students change their conceptions toward a more accurate picture of modern agriculture. To better understand the environmental trade-offs manifest in large scale livestock production, students' conceptions of farms need to be challenged so they have the opportunity to change their inaccurate schema. Educators (whether formal or informal) of elementary students can challenge student conceptions by taking students to modern, large-scale production facilities and allowing them to experience first-hand the structure of agriculture today.

Benchmark four described the journey that meat took from the farm to the consumer. Most of these rural students seemed to understand that meat is processed, and that this processing is completed by different companies. All but one understood that the farmer's primary responsibility is raising the animal for slaughter, and that the farmer then passes the animal to someone else to perform the next step of processing. In a time of ready-to-eat food products, it is not surprising that most of the students were able to identify that fast-food restaurants receive meat that has been processed in some manner.

Although the students seemed to have a basic understanding of meat's journey from gate to plate, the results of this study indicate that the language that the AAAS (1993)suggested this age group of children should have is either too advanced or had never been introduced to these students. No students used words such as "processed" or "distributed" when describing the processes meat undergoes. The language they used instead was "butchered," "cut up" or "shipped." Further studies may indicate a need to change the expected benchmark vocabulary to one more appropriate for fifth grade students.

Further studies using a similar research protocol but different informants may lead to a more complete understanding of what students understand about livestock. 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). The current agricultural benchmarks developed by both agriculture and science educators have not been thoroughly tested to determine if they are suitable for the age groups for which they were designed. Once educators have a clearer picture of children's schema, they can more effectively develop agriculture literacy curriculum that causes dissatisfaction and pulls students into the conceptual change process.

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

A paper to be submitted to the Journal of Agricultural Education

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Abstract

The change in American lifestyle from home prepared meals to fast-food restaurants has contributed to a lack of understanding concerning food safety by many people. Science and agriculture researchers and educators have called for educational programs that teach both adults and youth about food safety principles. Educational benchmarks have been developed that call for fifth grade students to understand the causes of food spoilage and methods of prevention. Through the use of interviews and concept mapping, students' understandings related to these benchmarks were evaluated. The results of this study found that few students understood the causes of spoilage and were unable to discuss bacteria or germs role in the spoilage of meat. Those students that had an understanding of microorganisms were also able to explain methods of preventing spoilage, while their classmates without the microorganism conception could not. Agricultural and science educators that provide scaffolding for students regarding subconcepts (i.e. microorganisms) may find student understanding of more complex concepts (i.e. spoilage prevention) more elaborate. Leaders in government and the meat industry would benefit by supporting increased youth education about food safety for meat products due to food borne illness and the subsequent economic cost.

Introduction

The lifestyles of American society have changed along with the demographics, and many of these changes have influenced food safety and preparation practices in the home (Williamson, Gravani, & Lawless, 1992). The National Research Council (1988) noted that urbanization, life-style changes, global competition, public expectations, and new technology are but a few challenges with regards to agriculture and food safety. Studies in food and meat science have shown that there is a general lack of knowledge among American adults concerning food safety issues (Macirowski, Ricke, & Birkhold, 2000; Meer & Misner, 2000; Williamson, Gravani, & Lawless, 1992). These same studies call for increased education about food safety for not only adults, but for children as well. Williamson, Gravani, and

Lawless (1992) have suggested that this next generation of consumers should be a target of expanded educational programs concerning food safety issues because they have grown up in a society of fast-food and convenience where they have not learned the basic principles of food safety.

Both science and agricultural educators agree that food safety is an important concept for youth to learn (American Association for the Advancement of Science, 1993; National Research Council, 1988). The National Research Council (NRC, 1988), American Association for the Advancement of Science (AAAS, 1993), and the Food and Fiber Systems Literacy project (FFSL, Leising, 1998) are among those that have developed benchmarks and frameworks for introducing 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. The benchmarks developed for these students related to agriculture have not been fully explored to determine whether they are accurate and attainable goals for education. Therefore, before educators can develop curriculum to meet the needs of students, they need to have an accurate portrait of what students understand.

The theoretical framework of this study is based on Piaget's research on developmental psychology, which many consider the basis of constructivism. Piaget posited that children are not born with knowledge; instead they must construct their own form of knowledge over time (Gardner, 1991). Piaget suggested the ideas of children are based on pre-conceived 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 the new information begin to occur (Piaget, 1975/1985). Changes in schema occur through a process called conceptual change (Posner, Strike, Hewson, & Gertzog, 1982).

Posner et al. (1982) suggested conceptual change occurs under certain conditions. First, a person must be dissatisfied with their existing conceptions to have a reason to change his or her schema. Second, there must be a new conception that makes sense to the person. Third, the new conception must appear to be plausible or have the ability to solve the problem. Fourth, the new conception needs to be fruitful, meaning it can solve other problems as well. For an individual to change his or her existing schema, these conditions need to be present (Dole & Sinatra, 1998; Posner et al., 1982; Thorley & Stofflett, 1996).

Constructivists suggested the initial role of the researcher or teacher should be to assess students' prior knowledge so as to link new concepts to previous ones or to cause some dissatisfaction with the current schema resulting in the beginning of the conceptual change process (Driver & Oldham, 1986; Simon, 1995). By understanding where children's ideas are founded, teachers can help them understand scientific knowledge by relating it to a familiar context that is fruitful for learning.

If a constructivist learning theory is to be employed, then uncovering students' prior knowledge structures through a process of discourse analysis would be the first step in the development of curriculum. Agricultural education researchers have begun to investigate student schema (Trexler, 2000; Trexler & Heinze, 2001), and this study attempts to add to this body of knowledge, but heretofore overlooked – food safety and spoilage.

Purpose/Objectives

The purpose of this qualitative study was to determine rural fifth grade elementary 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 with relation to meat.
2. To compare students' understandings of science and agricultural education benchmarks related to meat spoilage with expert understandings.
3. To conclude if relationships existed between students' background and experiences and their understanding of spoilage related benchmarks.

Methods

Agricultural education researchers often rely on surveys to determine what people understand. There is, however, some question as to whether these types of quantitative measurements, based on positivistic epistemology and ontology, are truly indicative of what people understand (Lincoln, 1998). Lincoln (1998) has argued 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 their own unique understanding, then qualitative research and in-depth inquiry are essential in grasping insight into an individual's cognitive structures.

Population

Seven students were selected for interviews from a rural Midwestern consolidated school. Four respondents were girls and three were boys. Fifth grade students were selected because they possessed a large enough vocabulary to converse clearly about the benchmarks, and fell within the grade level range of the benchmarks. Students attending the school were bused in from several small towns that were separated by less than 15 miles of farm land. A larger city was located approximately 35 miles from the school building; however, none of the students lived in the city.

The researchers attempted to purposefully select non-farm students; however, three came from part-time farm operations. We also purposefully chose more females than males, because we believed that they would have had more experience with cooking and grocery shopping and, as adults, would likely be the main cooks and shoppers of their household. In the reporting of the data, pseudonyms were used in place of the students' real names.

Data Collection

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

Students were interviewed twice. The first interview lasted approximately 60 minutes. A hamburger from a nationally known fast food chain was used to initiate conversation. By using a recognizable food as a visual prompt, students were able to link this familiar product with the processes from production to consumption (Anderson & Demetrius, 1993; Trexler & Heinze, 2001). Questions were focused on the meat, due to the nature of the study.

The students were asked to draw and explain a concept map of their knowledge regarding causes and methods of preventing food spoilage. They were presented a short lesson on concept mapping at the start of the interview to be sure they understood how to construct one. The interviews were audio taped and transcribed. Notes taken during the interviews were used as a secondary source of data.

After the first interview, we coded the transcripts and then expanded the students' concept map by adding any additional information provided during the interview. A second interview then took place that 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 revised concept map and were given the opportunity to change or add to it in any way.

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). The benchmarks selected reflected understanding of meat concepts and were designed for students from kindergarten to fifth grade. Table 1 contains 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
	2. 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 identifying the background and experiences of the students which was then reported descriptively. Next, goal conceptions and an expert concept map were developed by the researchers and were reviewed and verified by experts in science education, agricultural education, animal science, and the beef industry. To analyze student understandings of the benchmarks, Hogan and Fisherkeller's (1996) bidimensional coding system was used to judge participants compatibility with experts and elaboration on each benchmark. Participants were coded based on their communication of the benchmark by oral language. The transcribed interviews served as the data for language communication. Because most students did not have the vocabulary that was deemed necessary by the experts, we accepted the students' language as equivalent when we interpreted their meaning. The students' concept maps were used as a secondary data source for visual comparison with the expert concept maps. To ensure confirmability of the findings, excerpts of interview transcripts that supported codings are included (Guba & Lincoln, 1989). In addition, another researcher also independently coded the data with 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 and 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 represent a correct guess among choices provided, but no ability to explain why choice was made.
Compatible/incompatible	Makes sketchy statements that concur with proposition, but which are not elaborated, and also makes sketchy statements that disagree. Contradictory statements are often 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 up. 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, we inductively and intuitively searched for patterns that developed from the data (Taylor & Bogdan, 1998). The researchers grouped students with similar backgrounds and experiences together and looked for differences between groups of student response codings.

Findings

By asking students questions regarding their experience with meat and spoilage, the researchers were able to obtain results for objective one. Of the seven students interviewed, four were females and three were males. 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, however, had direct experience with livestock. Most students' parents worked in a near by 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 along with their background 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 the researchers directly questioning the students about their understandings of a science and agriculture concept about the role of science and technology in the food and fiber system. The benchmarks students' were asked to discuss were (a) how foods may spoil before use and (b) the methods of slowing down food spoilage.

Findings A: Causes of Food Spoilage

Table 2 illustrates codings students' were assigned based on an interpretation of their interview and concept map development. A mark (black dot) indicates the student mentioned the term describing the benchmark or had an understanding of the subconcept. A superscript to the coding gives further clarification as to the depth of understanding for each student.

Table 2. 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 in order to show differences in student understanding 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 had compatible sketchy understandings of how food spoils. Those with compatible/incompatible codings had an alternative conception compared to that of the experts with regards to why food spoiled.

Jim, David, Jessica, and Melissa all believed that either air or humidity caused meat spoilage. Jessica talked about how moisture in the air and the warmth of the meat from sitting out caused spoilage, while Melissa also mentioned the warm temperature and "humidity" causing the meat to rot. Both Lynn and Greg had no schema for why the meat has to 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 the meat to spoil. Although she knew that the meat had to 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 [the 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 – Cause if it stays out too long, it will get rotten. But if you want to cook it 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 – Cause bugs and stuff can get to it. Cause 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, the 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 [the meat] in the freezer keep the bugs out?
> H – Cause they're too small, I don't think they can lift [the lid] up or anything.

Later in the interview Heather added that the meat needs to 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 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 as being 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 where the germs on the meat come from as is evidenced by his narrative.

> I – Why do the germs live on the meat?

J – Because they might of got in there while it was shipping or something. Cause 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. Is there any other ways 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 cause 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 then 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 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 cells.

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 3 indicates the students' levels of understanding.

Table 3. 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 in order to show differences in student understanding of the benchmark. The superscript was determined based on how many subconcepts the student identified.

All seven students were coded compatible/sketchy because they had a partial understanding of the benchmark, but were unable to elaborate 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 the consumption of undercooked, contaminated meat. Greg noted that the consumer could possibly get sick if hamburger meat had not been cooked until brown throughout, although he did not know why. Jim and David both explained how the heat could destroy the 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 and 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 – Cause 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 needed by bacteria people can slow down the spoilage of meat. Jim also understood the environmental requirement concept, but not as elaborately as David. Greg also had some understanding about environmental changes of the meat, but only 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 the proper 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 student background and experiences did not affect their understanding of meat product spoilage. David and Jim had the most well developed schema regarding food spoilage, but there seemed to be no connection between their experiences that would have led to their 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 effected her concerns over food safety.

Conclusions A: Causes of Food Spoilage

Overall, students lacked complete, and most lacked any, cognitive structures about the causes of food spoilage. This is an area where this school's health and science curriculum may not address the benchmarks found in national science and agricultural education benchmarks. Five students were unaware of bacteria and other microorganisms that cause food spoilage. This lack of knowledge might stem from a lack of proper 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 be substitutes for "bacteria" or "germs" because the students did not have the depth of vocabulary. At the time of the interviews, the students' science unit was 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 foodborne 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 effects 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 the consumers' responsibility in 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) about 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 casts a negative image on the agri-food industry. Food borne illness also translates to billions of dollars per year in expenses for the health care industry and government agencies (Meer & Scottie, 2000; Yang, Angulo, & Altekruse, 2000). The majority of the population gets food safety information from television and magazines rather than from formal educational settings (Macirowski, Ricke, & Birkhold, 2000; Meer & Misner, 2000). Considering this, a collaborative educational effort between both private and public organizations would help students understand proper food handling and cooking techniques that reduce disease, decrease expenses related to foodborne illness, and enhance the image of the agri-food industry. Agriculture education's role 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.

<u>Conclusions B: Prevention of Food Spoilage</u>

All students knew that meat had to be stored cold and cooked before eating, but only two mentioned the use of other methods of preventing food spoilage. The students (Jim and David) that had the most elaborate understanding of methods for preventing food spoilage also had the most elaborate understanding of the causes of spoilage. The students who didn't have an understanding of bacteria and its growth requirements were then unable to link how methods of prevention such as drying, salting, or smoking altered the meat in such a way as to make it undesirable for bacteria growth. It seems that without the subconcept of what causes spoilage (microorganisms), these students were not able to understand the underlying reasoning behind techniques used to prevent spoilage. This observation is supported by Trexler (2000), who found students needed to understand subconcepts before more complex concepts could be understood. For example, he found that incomplete understandings of subconcepts related to the impact of crop loss by pests and crop protection by humans led to incomplete or inaccurate understandings of the trade-offs in pesticide use.

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 methods that slow spoilage of meat. 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 of methods of food preservation and should therefore be included at early grade levels.

When designing food safety and spoilage curriculum, researchers play a role in determining students' conceptual frameworks for bacteria and their growth requirements 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. This prior knowledge 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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Chapter VI. Conclusions/Implications

Introduction

In this chapter I draw conclusions based on the findings of this study with regards to each of the four research objectives. Each conclusion includes links to the theoretical framework that undergirds this study. I also offer implications this work has for agricultural education and agriculture literacy. The research objectives are explored beginning with objective one and concluding with objective four.

Research Objective One. To determine informants' background and experiences.

Conclusions

The students in this study all lived in a rural community. Three of the students' families were directly involved in raising livestock, while the other four students' families were not. The rural students had parents that were not full-time farmers, in fact only one student's father was even a part-time farmer. This supports other research that has concluded that rural populations are not only farming communities, and that the majority of rural residents work in occupations that are not directly related to agriculture (Albrecht & Albrecht, 1996).

Implications

Agricultural educators can no longer assume that rural students have been directly exposed to farming practices. Although these students live in small, rural towns, there is an increasing possibility that the students have no direct access or relation to the surrounding agriculture enterprises. The students that live in and go to school in these rural communities cannot be ignored and passed off as "farm kids," but instead must be considered in agriculture literacy efforts. The change in rural society is essential to note when designing curricula that are based on students' experiences, as the students may not have the experiences educators presume they possess.

Research Objective Two. To describe how student understandings of the agri-food system compare to goal conceptions based upon a synthesis of agriculture and science benchmarks.

Conclusions

Under the concept of "What is agriculture?" there were four benchmarks explored. The first benchmark asked students to describe food products that came from animals. The students understood that meat and milk products were produced from animals. The students in this study do not need educational interventions that focus on the origin of the food they eat. Unfortunately, this is the focus of many agriculture literacy efforts.

The second benchmark concerned students' understandings of cattle by-products. This was an area where most of these rural students lacked complete schema and understanding. Although many organizations that promote beef have programs on cattle by-products, this state's beef council has decided to not focus on by-product education due to the recent outbreaks of mad cow and hoof and mouth diseases (N. Degner, personal communication, October, 2001). This lack of support for these educational efforts may contribute to the lack of understanding that these students have.

Benchmark three dealt with students' understandings of farms and their products. All seven students had alternative frameworks concerning the size and scope of modern agriculture. No student was able to describe the large size of most cattle operations nor that most farms raise only one species of livestock. This lack of understanding may be a result of the location where the students lived. The primary agricultural focus of the area where these children lived was row crops. If the students had lived in an area where cow-calf operations were abundant, the results of this study may have been different.

The fourth benchmark under the agriculture concept asked students to describe the journey meat travels from the farm to the consumer. All of these rural students understood that meat was processed in some way, and most had a basic cognitive structure of the production to consumption journey. The language that the students used, however, was not congruent with the language the AAAS (1993) designated for this age group. Even without the prescribed language, the students were able to effectively communicate their understandings. The AAAS prescribed vocabulary may not be a part of a typical fifth grade student's curricula, or it could be age inappropriate and change to the AAAS vocabulary may be necessary.

The second concept that was explored was the role of science and technology in the food and fiber system. One benchmark was studied that included an understanding of how meat spoils and the methods of preventing spoilage. Only two of the seven students were able to correctly identify bacteria or germs as the cause of meat spoilage. Subsequently, those two students were able to more elaborately explain the methods of preventing spoilage. These results demonstrate the need for scaffolding of the students' understanding with regards to the causes of food spoilage before education about prevention can be effective.

Implications

Student understandings of the concepts and benchmarks studied have direct implications for not only agricultural educators, but industry and government leaders as well.

Agricultural educators may need to focus their agriculture literacy efforts on helping students understand the size and scope of modern agriculture rather than the origin of food. This study and others before it (Trexler, 2000b) found students already had a well developed schema for the origin of food. Conceptual change begins with causing dissatisfaction in the mind of the learner (Posner, et al., 1982), therefore by challenging students current schema with regards to agriculture's structure, agricultural educators can initiate the conceptual change process that results in student understanding.

Education about modern agriculture operations would also be beneficial to industry leaders. Without a well developed understanding of agriculture's structure, society will not be able to make informed decisions regarding agricultural and environmental policy. Although these students are only fifth graders, they are developing cognitive structures concerning these issues and will influence policy within eight to nine years.

Another area of concern for industry leaders could be the lack of understanding about cattle by-products. To generate support for the cattle industry, consumers want to know that the industry is not wasteful and utilizes as much of the animal as possible. By educating the public on the many products that come from animal by-products, people would see their dependence on the cattle industry for more than just meat and milk.

Although the students had a basic understanding of the journey meat takes from farm to consumer, vocabulary describing the journey was lacking. This absence of vocabulary was not a barrier in uncovering the students' understandings, however, due to the fact that clarification was continually sought and a shared meaning between the students and me became apparent. Generating shared meaning is important for educators when discussing concepts with students in order to have similar understandings among those involved in the discourse (Henriques, 1997; Simon, 1995). Further studies may indicate a need to change the expected benchmark vocabulary that the AAAS (1993) had prescribed to one more appropriate for fifth grade students.

The results from the benchmark that asked for student understanding of spoilage and spoilage prevention brings forth implications for educators and government and industry leaders. Students in this study needed a basic understanding about the causes of food spoilage (microorganisms) before they could assimilate the concept of spoilage prevention. Educators would benefit from providing scaffolding for students about simple concepts before exploring more complex concepts. Both government and beef industry leaders would benefit by supporting food safety education due to the economic losses that food borne illnesses cause (Meer & Scottie, 2000: Yang, Angulo, & Altekruse, 2000). Public perceptions of the beef industry and food and fiber system as a whole might also improve with greater understanding of food spoilage and prevention.

Research Objective Three. To determine if a relationship exists between student experience and background and agriculture literacy knowledge.

Conclusions

It seemed the students did not have many experiences with livestock or meat production. Those students who had experience finishing cattle for slaughter, were able to more elaborately explain the live animal production step. These students, however, had no greater understanding of the process after production or of the structure of farms. All students had seen their parents put meat in the refrigerator or freezer and many had seen meat products that were spoiled, but those experiences alone were not enough to create an understanding of food spoilage.

Implications

In this study, student experience with livestock allowed them to better understand animal agriculture. Educators could more effectively help students understand agriculture concepts by allowing the students to have direct experiences with the animals and food products. For example, by creating curricula that includes activities for students to experience first hand the large size of production agriculture, which would be in conflict with their existing cognitive structures, the students would begin the first step in the conceptual change process of dissatisfaction (Posner et al., 1982). The cattle industry working in conjunction with educators could help provide the experiences necessary to challenge student thinking.

Research Objective Four. To compare these findings of rural children to the findings from a previous study of urban and suburban children.

Conclusions

The results from this study of rural students found similar results to Trexler's (2000) urban and suburban students with regards to student understandings. Although this study focused on meat and livestock topics and Trexler's (2000b) study focused on agronomic concepts, some similar results arose, particularly with regards to the structure of farms. Both studies found students' conceptions about the size and scope of farms were not congruent with modern agriculture. The students in Trexler's study envisioned production agriculture as a comparison to a family garden, where many different crops were produced side by side.

They did not understand that modern farms produce one or two types of crops in fields encompassing several hundred to thousands of acres. In the same vein, the students in this study believed farms raised several species of livestock on acreages of no more than twelve acres. These students were unable identify that livestock production facilities typically produce only one species and encompass large numbers of acres as well.

Another area of similar findings was in regards to the understanding of subconcepts before more complex concepts could be understood. Trexler's students were unable to understand the use of pesticides on crops because they did not have the conceptual framework about the types of pests that were harmful to crops and food production. Similarly, the students in this study that lacked conceptual framework for the causes of meat spoilage, were unable to explain why altering the environment the microorganisms needed to survive prevented or slowed down spoilage.

Implications

More studies that utilized qualitative research methods such as the ones employed by Trexler (2000b) and this study would allow researchers to more deeply understand students' agriculture literacy levels. The findings of this study have added to the body of knowledge on agriculture literacy by providing data about the understandings of seven, rural, Midwestern students with regards to meat and livestock benchmarks. Studies that explore a different population of students' understandings about these concepts would give educators a better assessment of the prior knowledge of students with regards to agriculture literacy.

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). Once educators have a clearer picture of children's schema, they can more effectively develop agriculture literacy curriculum that causes dissatisfaction and pulls students into the conceptual change process. The current agricultural benchmarks developed by both agriculture and science educators have not been thoroughly tested to determine if they are suitable for the age groups for which they are designed. An assessment of prior knowledge, then, is essential to designing a curriculum that causes disequilibrium in the mind of the learner, which is the first step in conceptual change and therefore, learning.

Appendix A

Human Subjects Review Form

Iowa State University Human Subjects Review Form

OFFICE USE ONLY		
EXPEDITED X	FULL COMMITTEE ____	ID# 02-118

PI Last Name Meischen **Title of Project** Rural Elementary Students' Livestock and Meat Concepts Literacy: Understanding Agriculture and Science Benchmarks

Checklist for Attachments

The following are attached (please check):

13 ☒ Letter or written statement to subjects indicating clearly:
- a) the purpose of the research
- b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see item 18)
- c) an estimate of time needed for participation in the research
- d) if applicable, the location of the research activity
- e) how you will ensure confidentiality
- f) in a longitudinal study, when and how you will contact subjects later
- g) that participation is voluntary; nonparticipation will not affect evaluations of the subject

14. ☒ A copy of the consent form (if applicable)

15 ☐ Letter of approval for research from cooperating organizations or institutions (if applicable)

16 ☒ Data-gathering instruments

17 Anticipated dates for contact with subjects:

First contact
10/15/01
Month/Day/Year

Last contact
11/30/01
Month/Day/Year

18. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

11/30/02
Month/Day/Year

19 Signature of Departmental Executive Officer: Robert A. Martin — Date: 10/3/01 — Department or Administrative Unit: Agricultural Education and Studies

20 Initial action by the Institutional Review Board (IRB):

☐ Project approved ☒ Pending Further Review 10/11/01 Date ☐ Project not approved ____ Date

☐ No action required ____ Date

21 Follow-up action by the IRB:

Project approved ☒ Project not approved ____ Date Project not resubmitted ____ Date

Rick Sharp — Name of IRB Chairperson

10/19/01 — Approval Date

Rick Sharp — Signature of IRB Chairperson

Appendix B

Informational Letter to Students and Parents and Student Permission Form

Date

Dear parent/guardian:

I am a master's student in the Department of Agricultural Education and Studies at Iowa State University. I am conducting a research project on student understandings of the human food system with a focus on the meat industry.

My research will involve rural elementary school students. I plan to determine elementary student understandings, and compare them with what educators in both science and agriculture believe this age group of children should understand. There is little research on this topic. Through this research, educators will be better able to write curriculum for elementary students in agricultural and science education.

To conduct this research, I will interview students from the group described above. Two interviews will be conducted. The first will last 60 minutes and students will be asked to develop a concept map, with the help of the researcher, of their knowledge about agriculture and science concepts. The second interview will last 15 minutes and the student will be asked to review the concept map developed in the first interview to determine if it is correct. These interviews will be taped so I can refer back to them at a later date. I will pay students $5.00 for each interview.

All responses will be kept in strict confidence. Participants' have the right to stop the interview or to stop the tape recording at any time. Because my work involves minor children, I need to obtain permission from their guardian for the interview. If you will allow your child to participate, please fill out the attached form.

Thank you for considering to allow me to interview your child. If you have any further questions, please contact me.

Sincerely,

Deanna Meischen
Graduate Student
Email – deanna01@iastate.edu
Work – (515) 294 – 4349
Home – (515) 232 – 4721

Dr. Cary Trexler
Assistant Professor
Email – trexler@iastate.edu
Work – (515) 294 - 0897

I, (participant's name)________________________________ ,agree to participate in the research study described in the attached letter. The study has been explained to me and I have been informed of the potential risks of participation.

I further understand that a pseudonym (false name) will replace my real name in any report of the research findings and that any identifying information about me will be deleted or protected with pseudonyms. My identity will be known to the principle investigator but will be kept confidential. I may refuse to answer any questions or to stop the interview at any time. I may ask for the tape recorder to be turned off at any time during the interview. $5.00 will be paid to the student after each interview.

____Participant's Name
please print

____Participant's signature

___________________Date   _________________________Phone

My child has permission to participate in the research study described in the attached letter.

____Parent/Guardian name
please print

____Parent/Guardian signature

___________________Date   _________________________Phone

I, ______________________________________, would prefer not to participate.

Appendix C

Student Concept Maps for "What is agriculture?" Concept

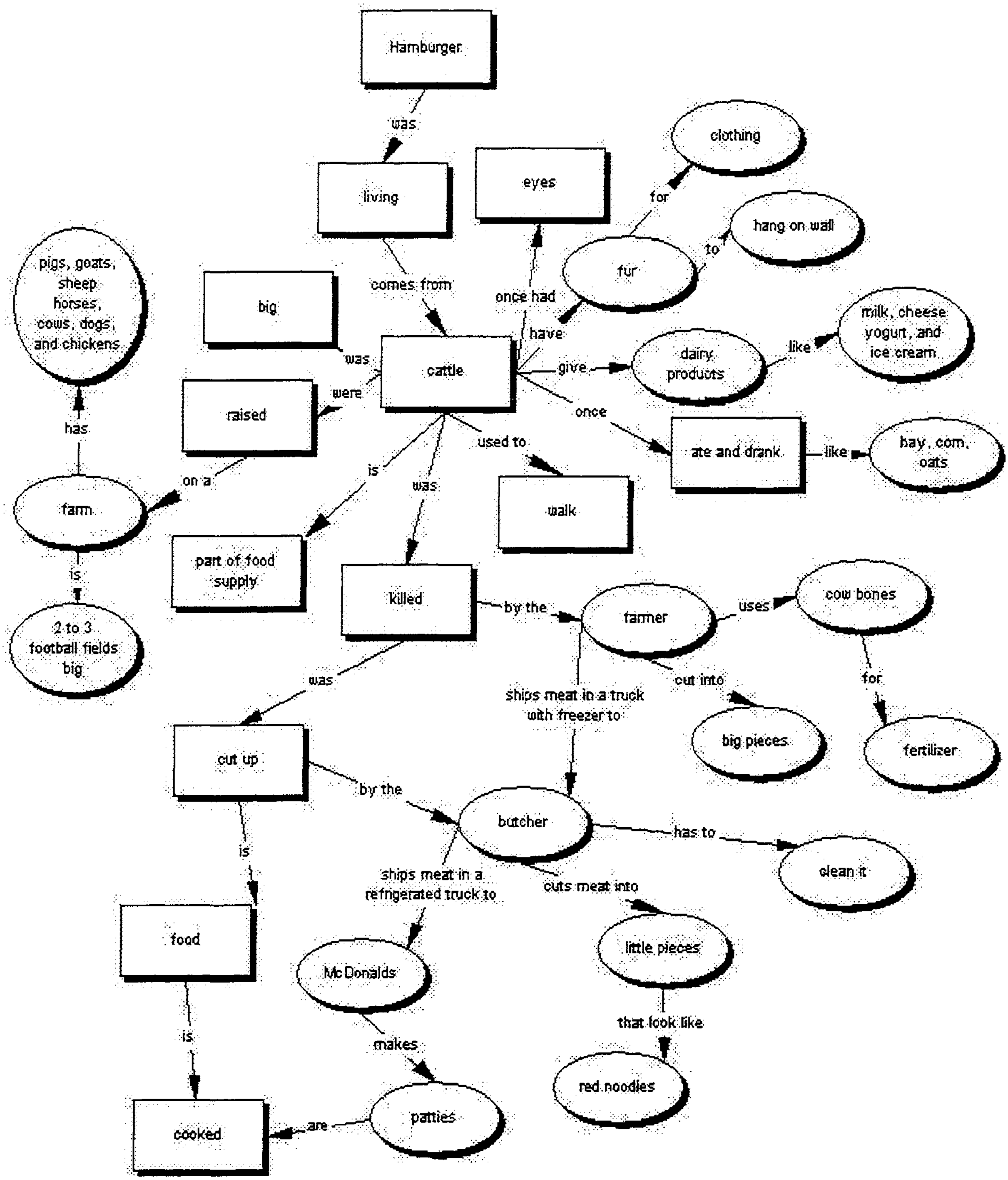

Figure B1. David's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

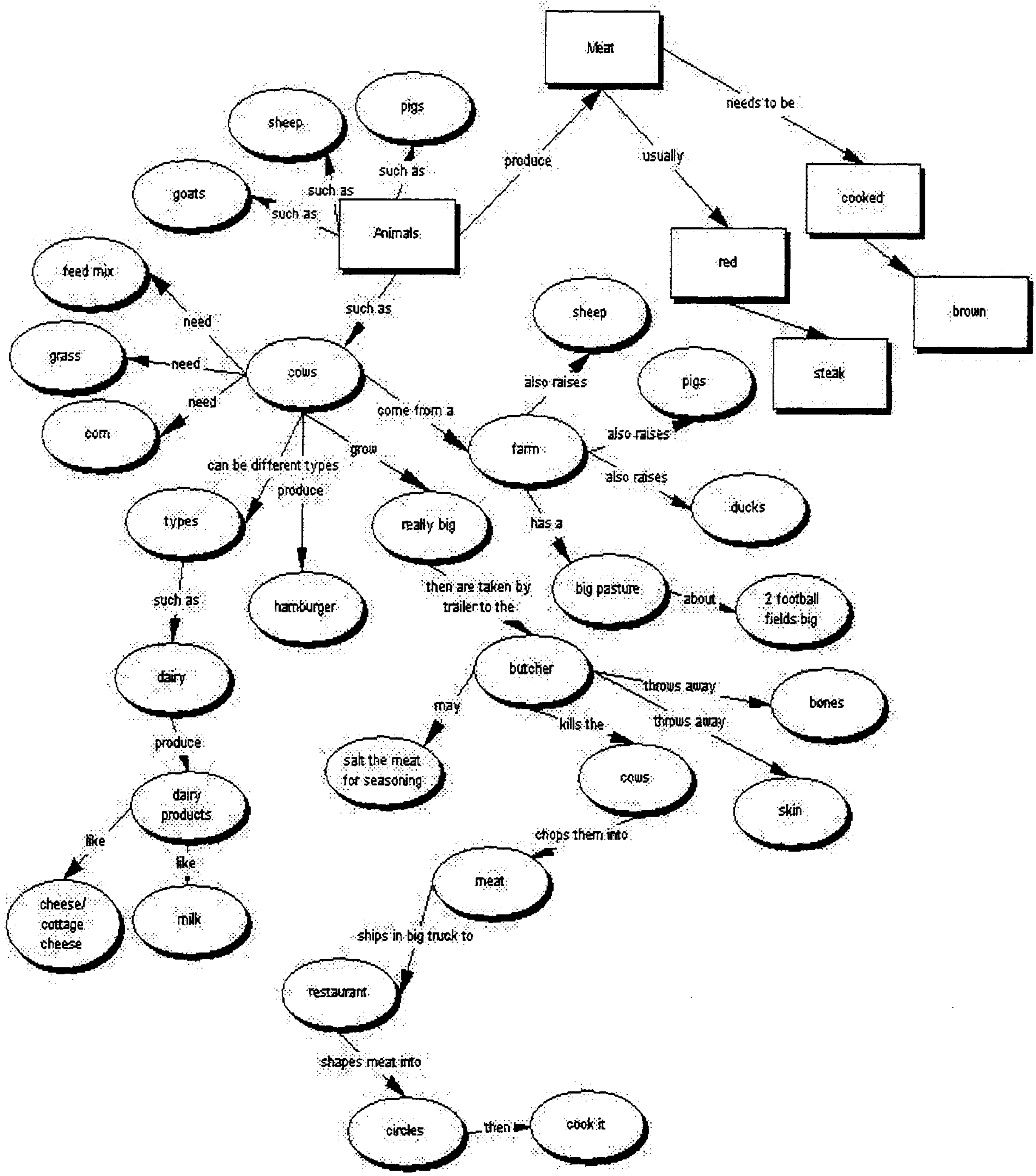

Figure B2. Greg's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

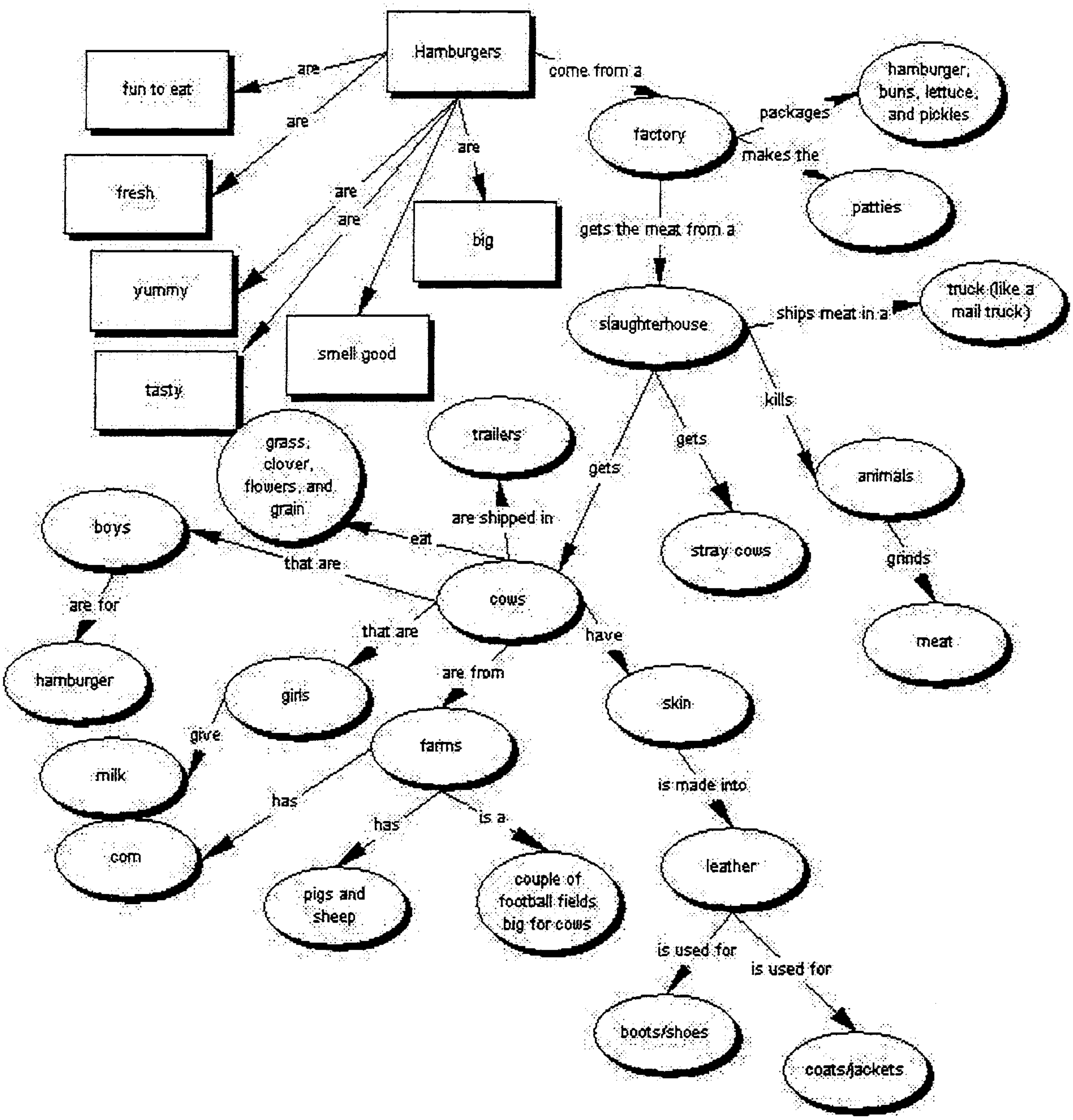

Figure B3. Heidi's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

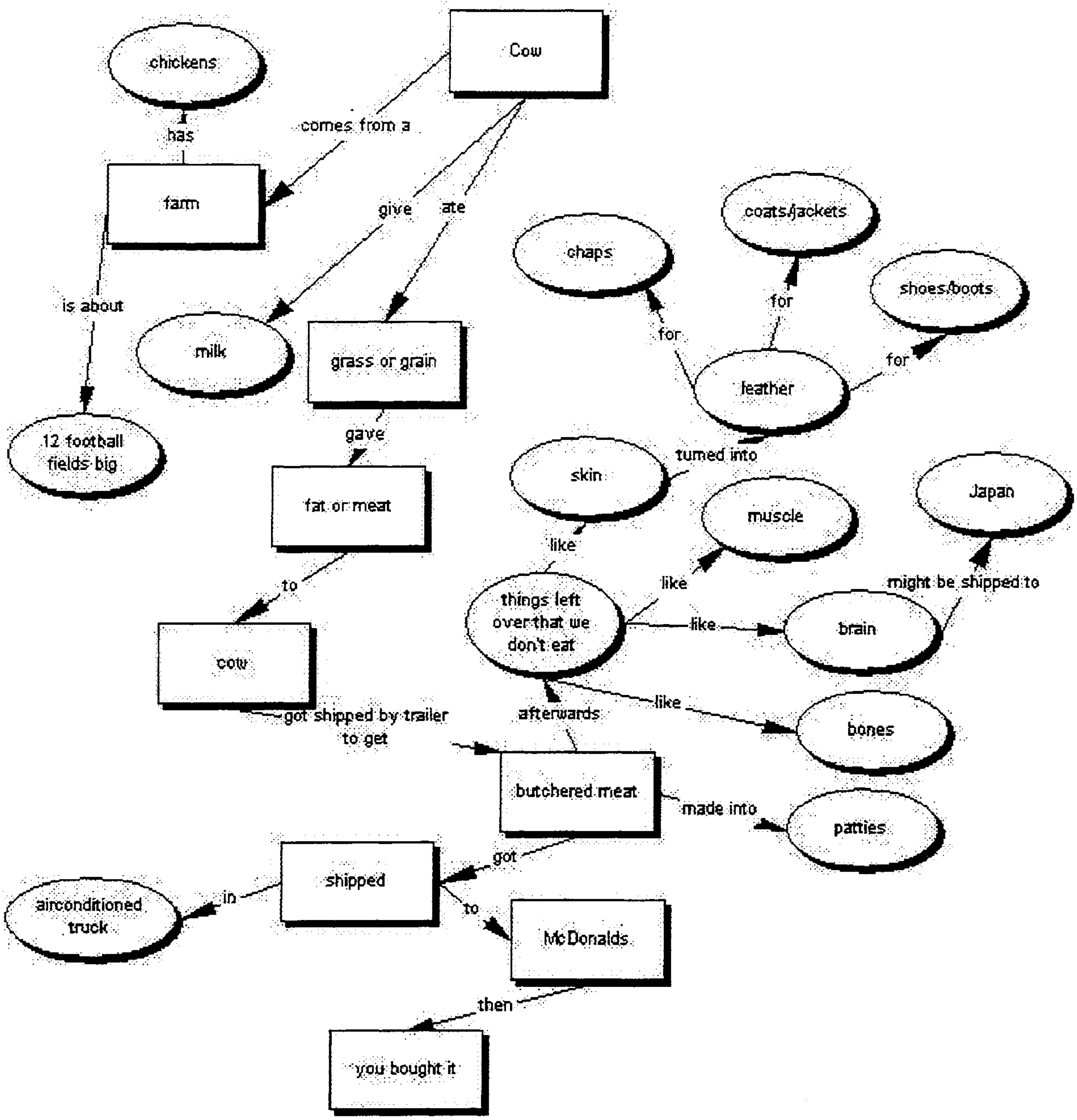

Figure B4. Jim's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

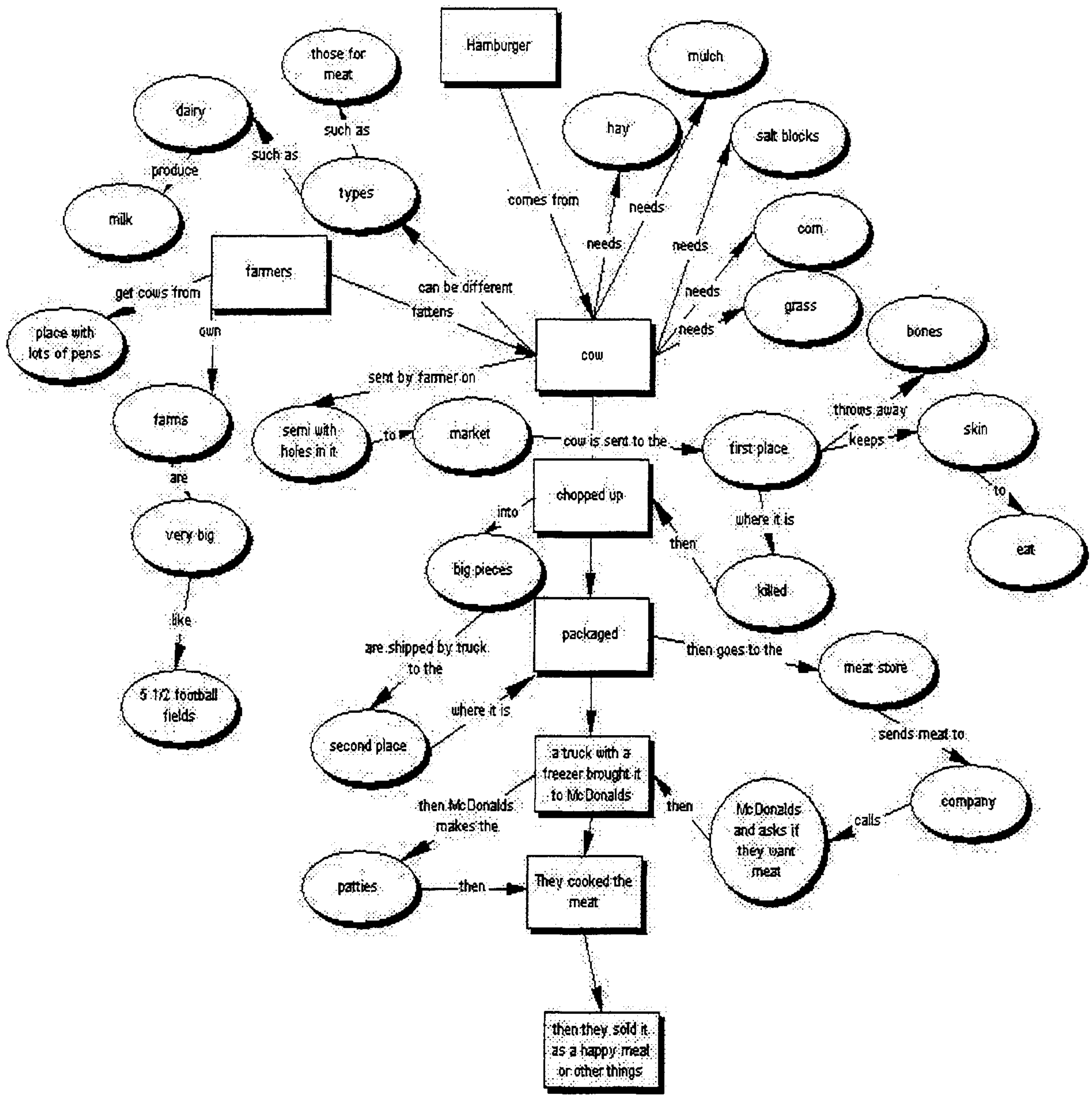

Figure B5. Jessica's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

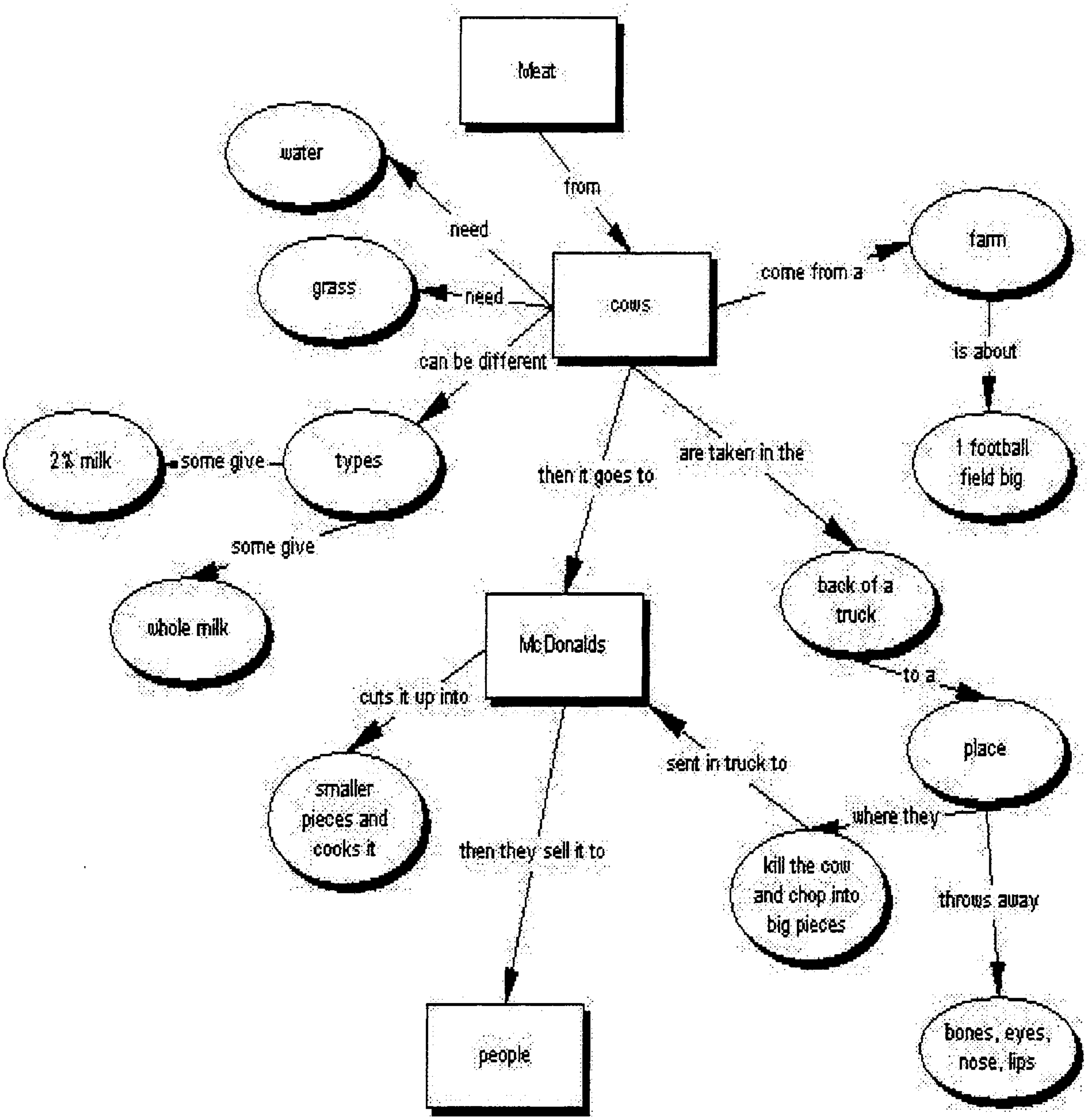

Figure B6. Lynn's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

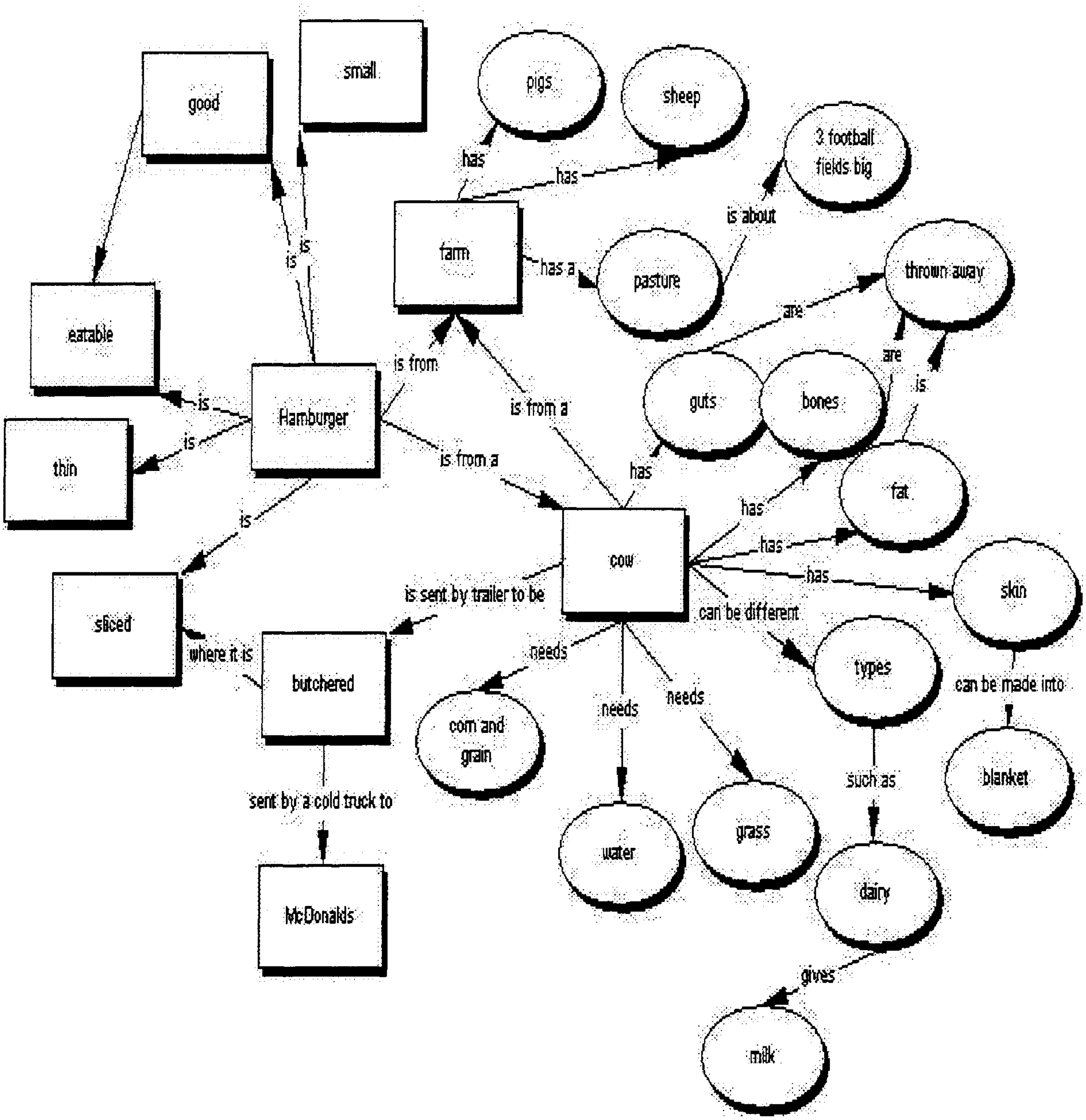

Figure B7. Melissa's concept map of "What is Agriculture?" concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

Appendix D

Student Concept Maps for "What is the role of science and technology in the food and fiber system?" Concept

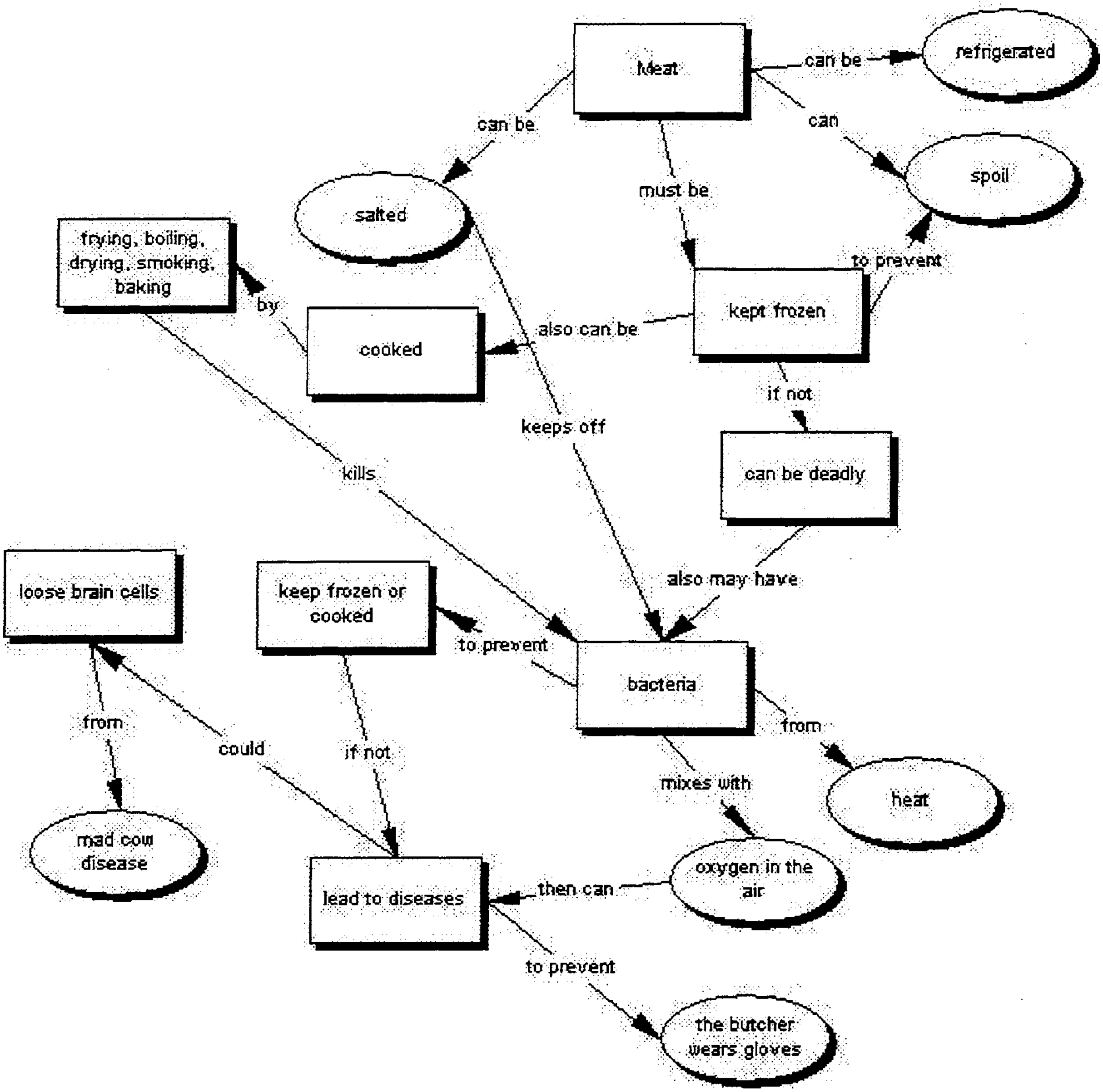

Figure C1. David's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

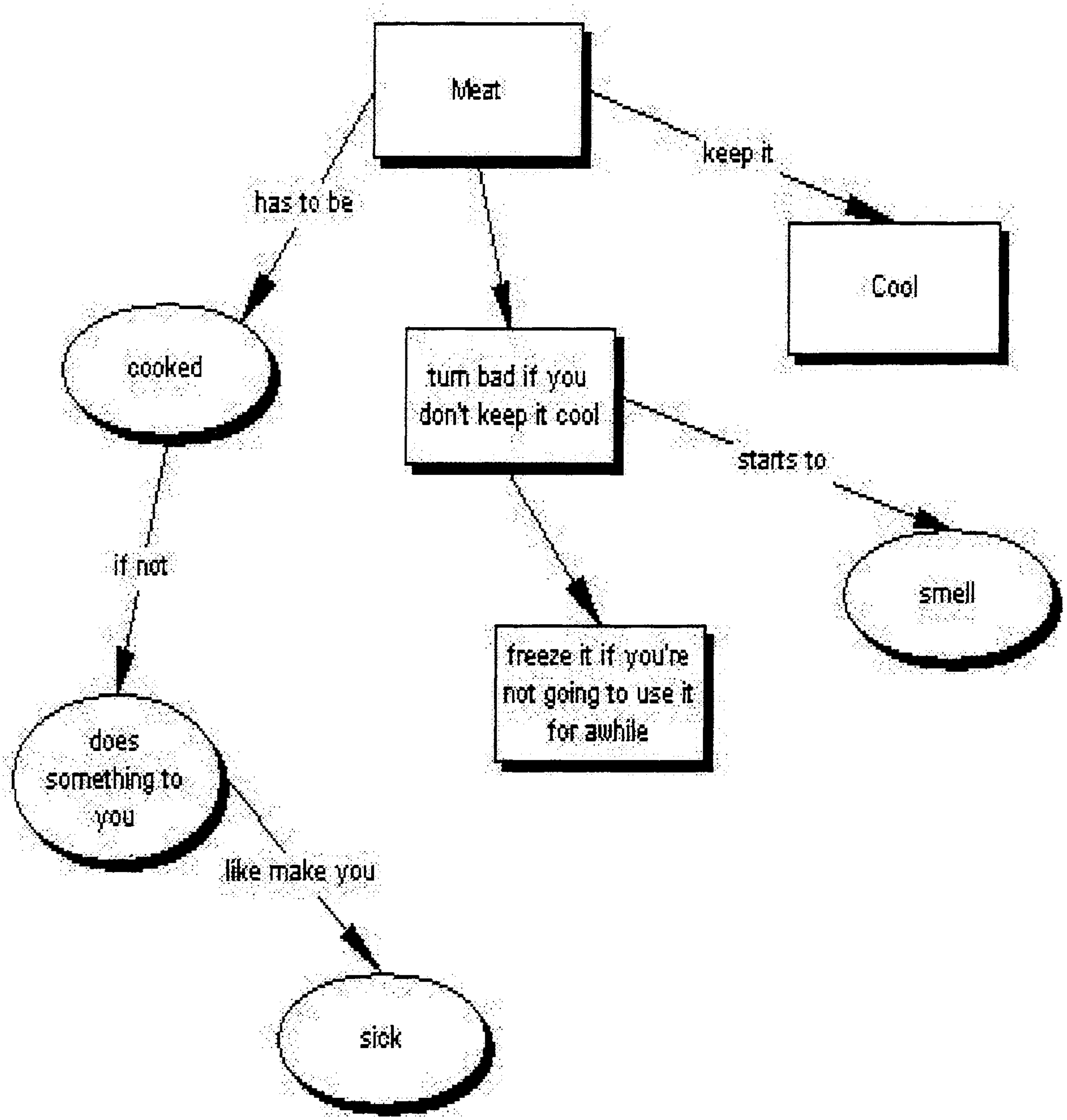

Figure C2. Greg's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

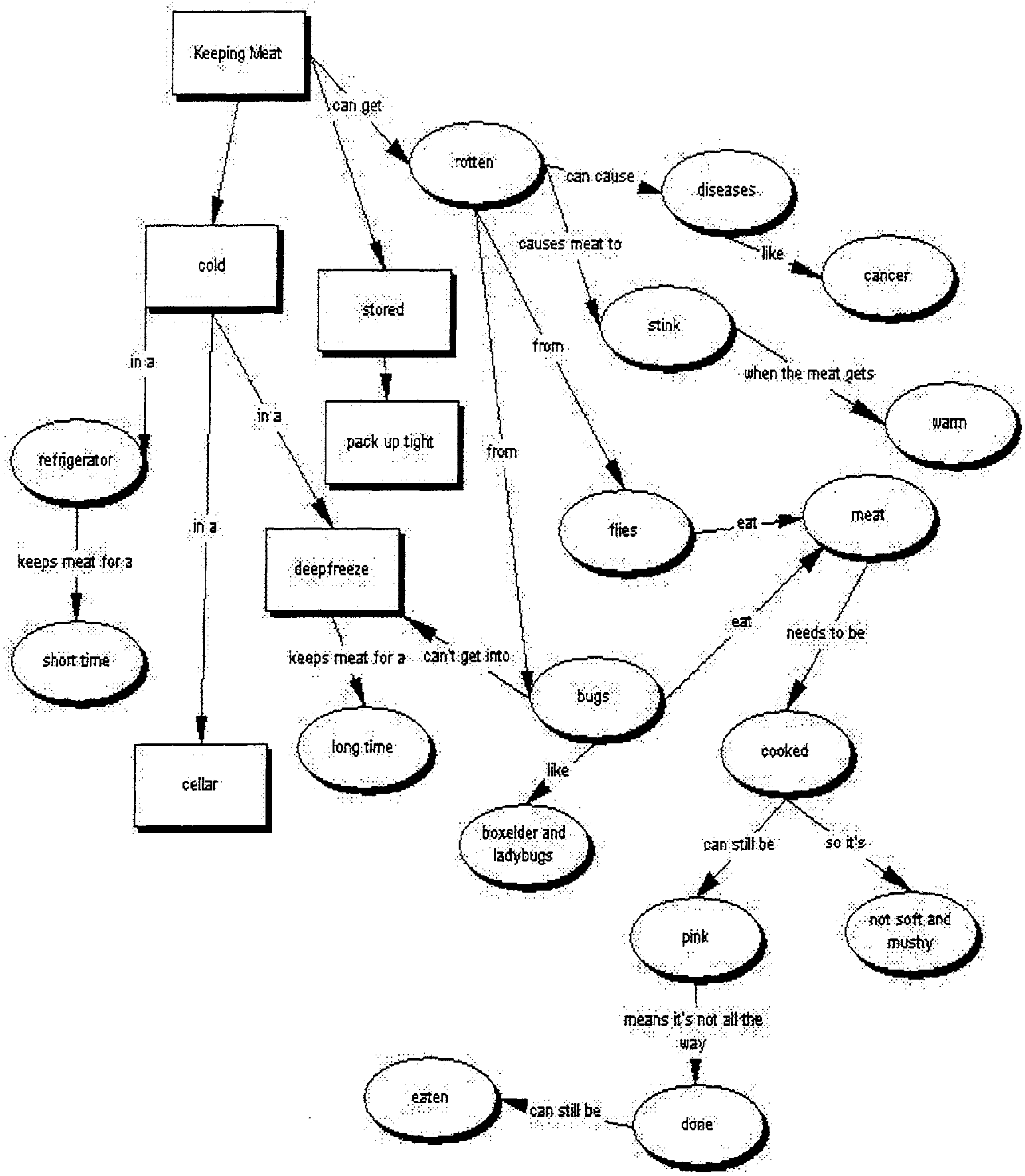

Figure C3. Heidi's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

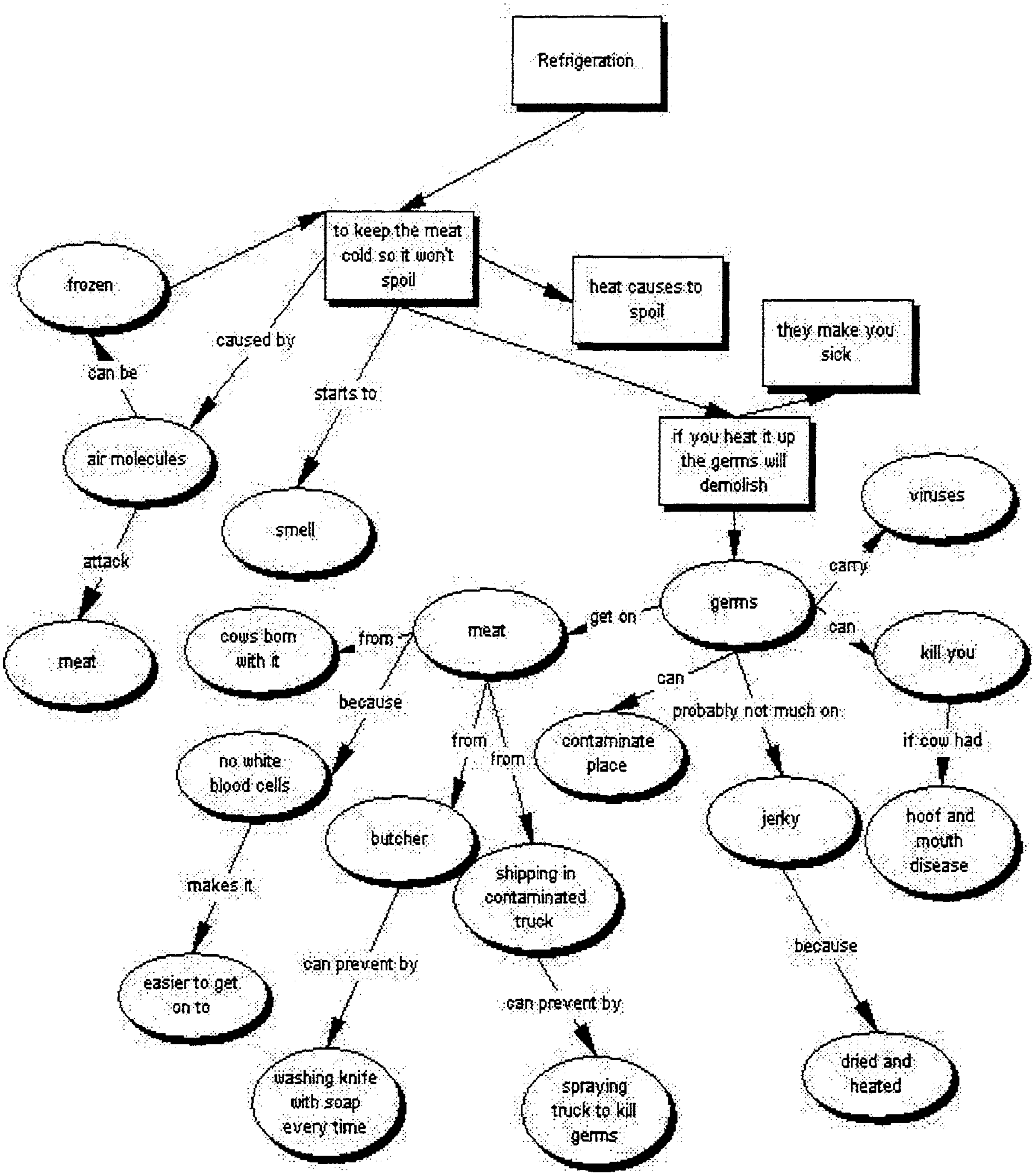

Figure C4. Jim's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

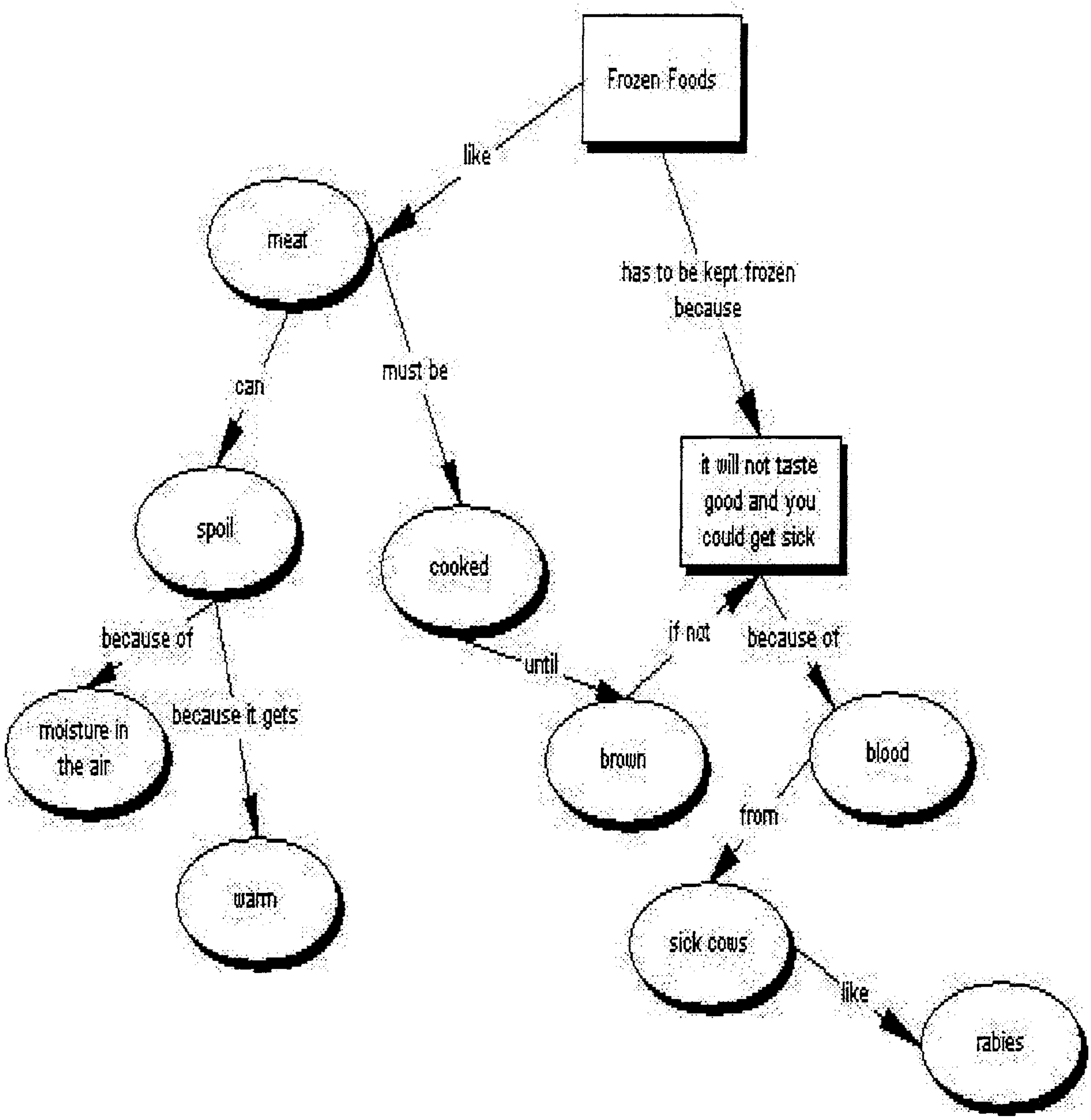

Figure C5. Jessica's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

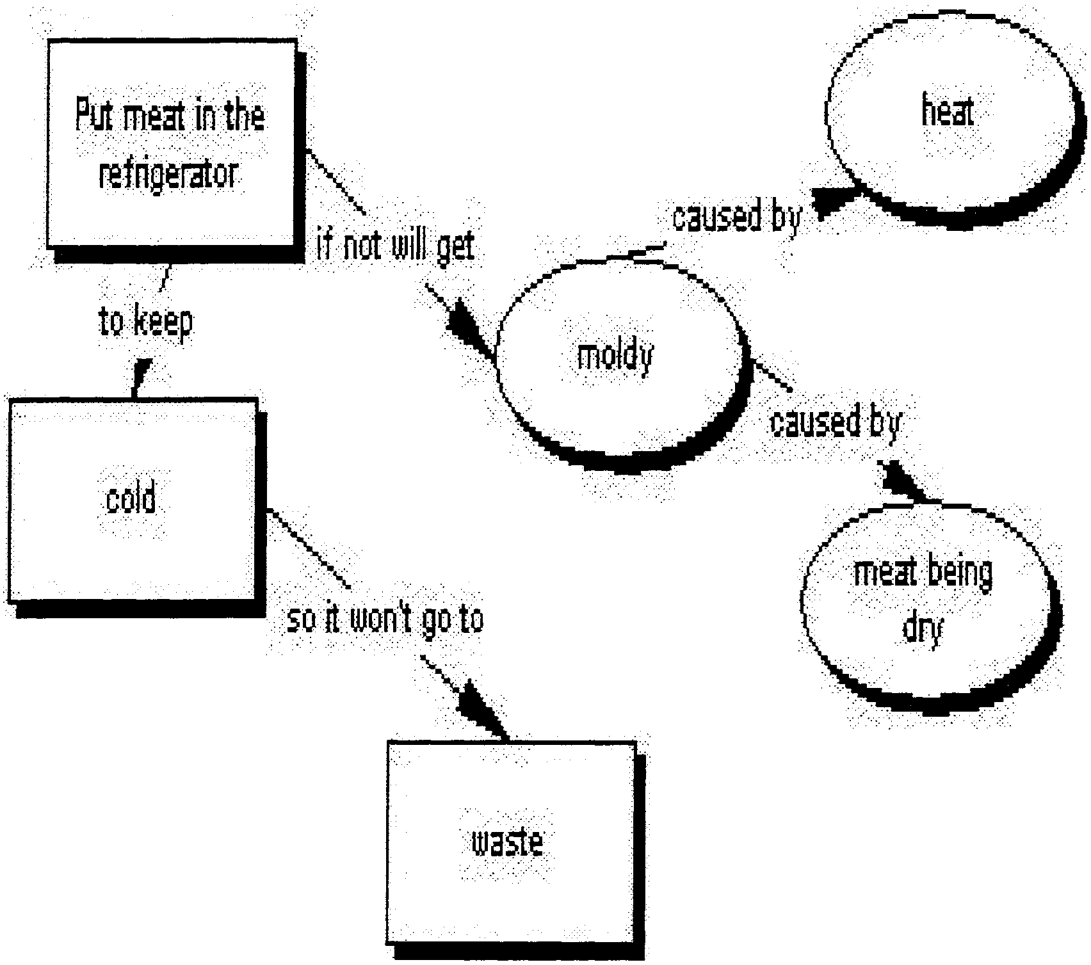

Figure C6. Lynn's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

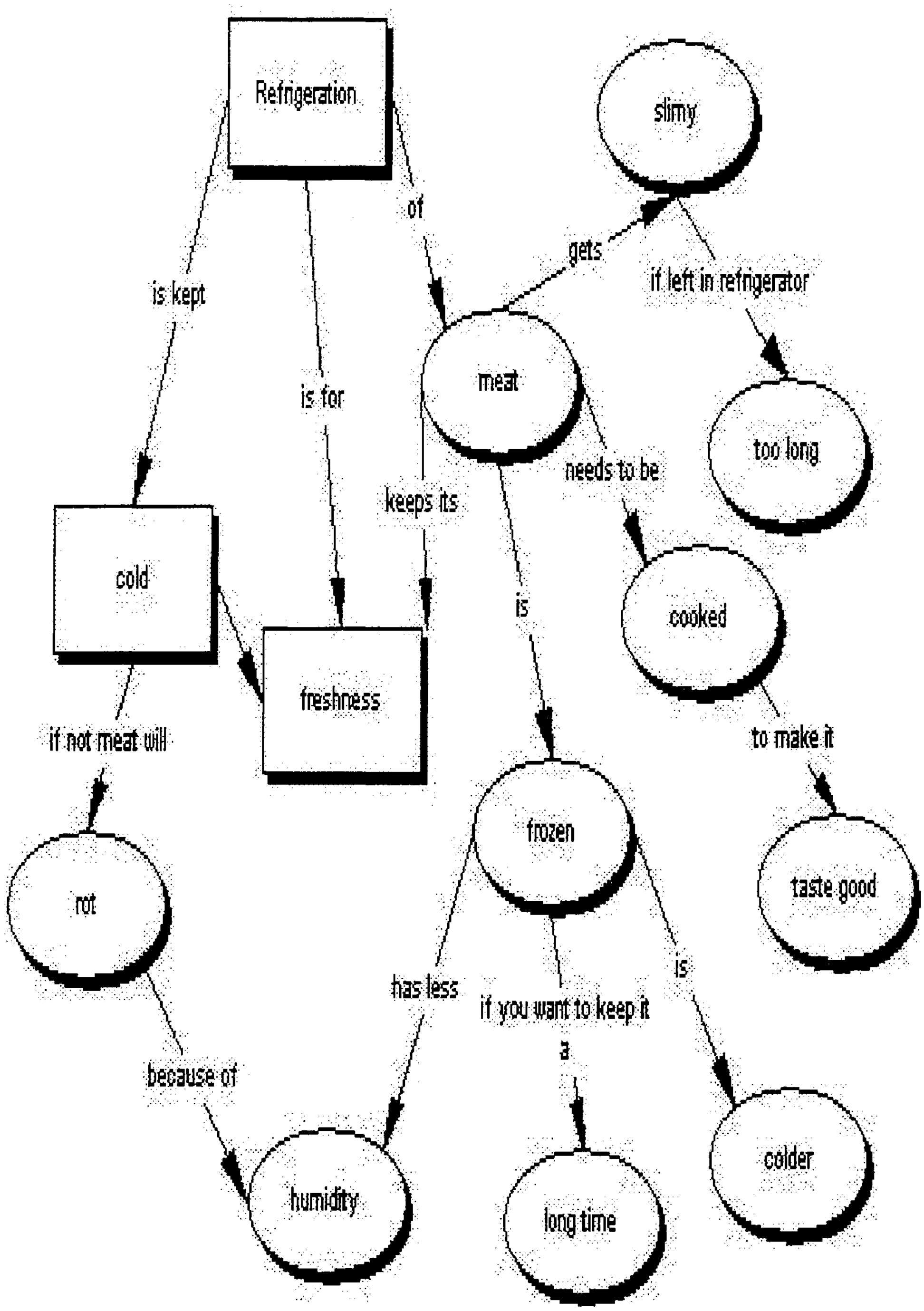

Figure C7. Melissa's concept map for food spoilage concept.

Note. Squares represent student's original concept map, circles are additions by researcher based on interviews.

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