

Food safety training as adult education: Determining prior knowledge
in the service of scientific conceptual change

by

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ABSTRACT

A common recommendation for addressing the serious issue of foodborne illness is to train foodservice managers to handle and store foods safely. Typically, food safety education is considered successful when managers become certified through such programs as ServSafe[®], which is offered by Cooperative Extension and other organizations. However, sustained behavior change has been limited. The research contributed to understanding the nature of the limitations of current programs, toward betterment of food safety education. The goals of the research was to describe the type and extent of conceptual understandings possessed by trained and certified foodservice workers of scientific principles relevant to preventing foodborne illnesses, specifically, the role of heat and thermal dynamics in cooling foods. The theoretical framework informing the research combined science education's conceptual change model and adult education's transformational learning theory. Both theories posit that knowledge is more widely applied, more easily transferred to novel contexts, and more robust when learners develop conceptual understandings of scientific concepts versus algorithmic, rule-based knowledge. Both theories emphasize the necessity of learners connecting new knowledge to prior knowledge, experiences, and personal perspectives. Applying these theories to food safety curriculum and instruction had been explored very little. Methods included semi-structured interviews (with visual prompts and physical models), observations, document analysis, and concept mapping with 18 cooks at two Midwest hospitals. The study confirmed that neither managers nor workers were able to convey an understanding of cooling beyond routine practices associated with on-the-job training. Overlaid with

Bloom's taxonomy of the cognitive domain, data also showed that understandings of the role of heat in cooling was situated at lower levels compared to knowledge about heat in cooking. Consistent with adult education literature, employees' personal identity as a 'cook' strongly influenced food safety knowledge and practices. Results explained, in part, the poor uptake of conventional training. Recommendations included increasing employees' motivation to learn scientific concepts by tapping their desire to be better cooks instead of forcing a new identity of 'food safety workers'; increasing problem-solving abilities across contexts by teaching principles instead of rule-based behaviors; and involving all employees, not just managers, in food safety educational experiences.

CHAPTER 1. GENERAL INTRODUCTION

Introduction

Illness from food is a serious issue in the United States. An estimated 76 million foodborne illnesses occur each year, with 5,000 resulting in death (Mead et al., 1999). In addition to the personal cost of being sick, foodborne illnesses also impact economies nationwide. Illnesses from five common foodborne pathogens caused \$6.9 billion in economic loss to the United States in 2000 (Economic Research Service [ERS], 2004). United States federal agencies spent nearly \$1.6 billion dollars on food safety activities and staffing in 2003 (ERS, 2004). Food prepared both at home and by foodservice operations is responsible for causing illnesses.

Federal agencies have examined causes and pathways of foodborne illnesses associated with foodservice operations. Foodservice operations include institutional operations (hospitals, nursing homes, and elementary schools), restaurants (fast food and full service), and retail stores (deli departments, meat and poultry departments, seafood departments, and produce departments) (Food and Drug Administration [FDA], 2001). Food safety risk factors identified as problem areas in retail foodservice establishments in 2000 (FDA, 2001) and as described in the 2001 Food Code were still in need of attention in 2004 (FDA, 2004). The 2004 FDA report included a comparison between 2004 and 2001 results. The FDA reported that in general the number of violations had not positively changed between the two studies. These results indicate that there are still issues that current actions, whether training or inspection, are not correcting and should be subject to further investigation.

The source of standards and procedures about food safety practices is the same for both groups. The primary guide to safe food handling is the United States Food Code (2001) issued collectively by the United States Food and Drug Administration (FDA), the Centers for Disease Control and Prevention (CDC), and the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA). The official document provides recommendations for preventing foodborne illness (FDA, 2001). The inspection guide of the Food Code, for example, contains more than one hundred different inspection points.

Managerial and Supervisor Education

Out-of-compliance results would be a place to start given the severity of impact of foodborne illnesses. A proposed remedy for continual out-of-compliance results by foodservice operations is strengthening “industry and regulatory efforts to promote active managerial control of these risk factors” (FDA, 2004, p. 4). One recommendation focuses on increasing food safety knowledge among operation managers as a means of controlling foodborne illness. The educational thrust is anticipated to work in this way: If the person in charge (supervisor or manager) is knowledgeable about the relationship between the foodborne illnesses and the operations, practices, and behaviors that take place in the food establishment, then he or she will exert active managerial control over the important foodborne illness risk factors, reducing sources of potential harm (FDA, 2004). This program theory (per Weiss, 1998) explains the framework presumed by most educational interventions related to food safety in food service establishments.

In practice, managerial control of risk factors is typically understood as a multi-level process. First, managers must understand what constitutes an out-of-compliance

result based on applicable health codes. Once managers know what is necessary to be compliant with pertinent regulations, they exercise control over employee behaviors such that employees follow the guidelines. Based on this program theory, one recommendation for increasing compliance is to increase foodservice workers' knowledge of proper food handling procedures. This is typically done by training more managers (Almanza & Nesmith, 2004). For example, more than a third of all states require a person in charge to be certified through a food safety training program, with another four states considering similar legislation (Almanza & Nesmith). This approach, however, assumes that the person in charge, typically an owner or some level of manager, is responsible for and can positively affect employee knowledge and practices (FDA, 2001). Figure 1.1 is a visual representation of the program theory currently implemented with food safety training programs. Foodservice managers or other people in charge are responsible for and presumed to influence knowledge and practices of employees in their facility.

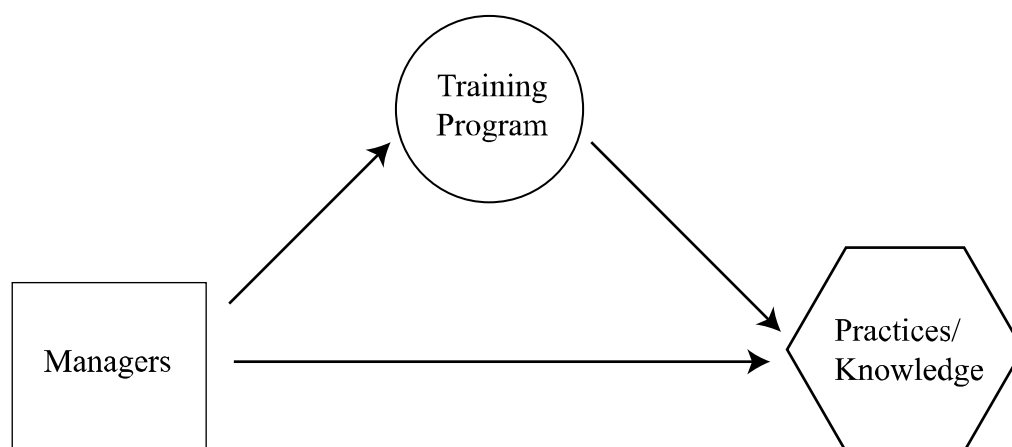


Figure 1.1. Proposed program theory of contemporary food safety training which emphasizes managers' knowledge with regard to implementing and enforcing proper food handling practices.

An assumed impact of a manager successfully completing a food safety certification program is a positive change in managerial behaviors (their own) and *a positive change in employees' behaviors* (people who did not receive the training). Moreover, the safety of food served in foodservice establishments is typically dependent, in whole or part, on large numbers of non supervisory employees (compared to the number of managers and supervisors) who handle, prepare, and serve the food, e.g., food service workers, line cooks, relief cooks and prep cooks. This proposed two-step positive impact would consist of new, reinforced, or changed behaviors with respect to handling food safely in all employees. A presumed second-level result would be passing inspections more frequently or with fewer infractions. There is evidence that the program theory works in some contexts. For example, Nadler and Nadler (1998) used this model as a basis for program development related to organizational learning, which served as the basis for their book. Depending on the type of problem being addressed with training, a change in behavior can occur (Nadler & Nadler, 1998) but a shift in program structure, emphasis, and delivery may be necessary to increase training effectiveness (Thorley & Stofflett, 1996). Nonetheless, it is crucial to face the untoward conclusion that if the program theory does not work, (e.g., if the spill-over effect does not occur), or provides limited benefit under some conditions, then food safety behaviors may be thwarted. Food safety education programs should examine their program theory and determine to what extent the desired changes in behaviors persist. We should be able to defend the claim that long-term understanding and application of knowledge works, but we can not. In light of this, this study investigated understanding and knowledge application, which is a presumed outcome of current programming but an unmeasured

impact. Figure 1.2 depicts the assumption that managerial or employee knowledge will result in some degree of implementation of appropriate food handling practices (Martin et al., 1999; Martin Lo et al., 2004, McElroy & Cutter, 2004).

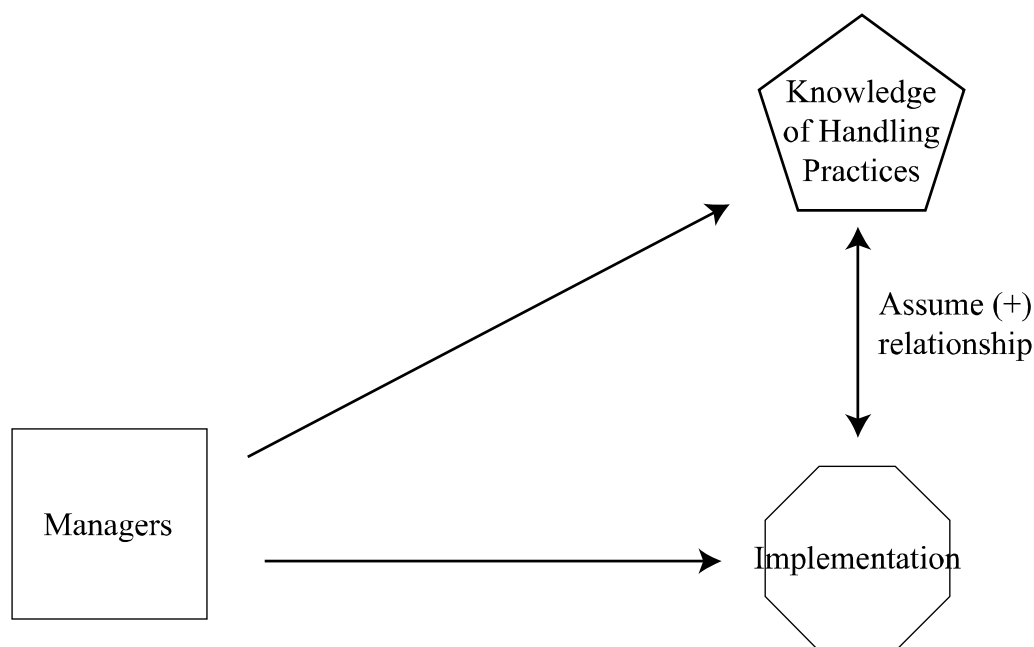


Figure 1.2. Relationship between foodservice managers' knowledge of proper food handling practices and implementation of prevention practices.

Education through Cooperative Extension

One of the educational arms of the food safety training conglomerate is Cooperative Extension (Dooley, Van Laanen, & Fletcher, 1999). Food safety training programs conducted by Cooperative Extension work in concert with its mission to meet public using non-formal education based on research conducted at the nation's land-grant universities (Thompson, Schielack, & Vestal, 2004). Cooperative Extension programming specifically related to food, health, and nutrition is administered from the state level through the individual counties and to the individual. Subject or content

responsibilities for Cooperative Extension personnel that relate to food are vast and diverse. There is no centrally coordinated food safety programming efforts for Extension on the national level. As a result, there is typically a small percentage of time dedicated to food safety training by Cooperative Extension trainers compared to programs such as the Children, Youth, and Families at Risk (CYFAR) program and the Expanded Food and Nutrition Education Program (EFNEP) (Iowa State University Extension, 2005). For training programs to improve their effectiveness at influencing employee food safety practices, a shift in training program theory and frameworks for food service education by trainers may need to occur (Thorley & Stofflett, 1996). This dissertation focuses on food safety education in context of Cooperative Extension programming.

Current Training

Training foodservice management to handle food properly, resulting in safe food products, is widely accepted in extension and other venues (Dooley, Van Laanen, & Fletcher, 1999; Martin Lo, Fukushima, Rippen, Gdovin, & Hahm, 2004; McElroy & Cutter, 2004). There are several curricula in use nationally. Three certification programs have been accredited by the American National Standards Institute using the standards developed by the Conference for Food Protection. These accredited certification programs are used by Extension educators as well as private wholesale food distributors, state and local sanitation inspectors, internal trainers of food corporations, and other segments of the food industry.

Accredited Food Safety Programs

1. ServSafe[®] food protection manager certification from the National Restaurant Association Educational Foundation;

2. Thomson Prometric (formerly Experior Assessments) food protection manager certification program; and
3. National Registry of Food Safety Professionals food protection manager certification program (American National Standards Institute, 2005).

Training programs offered through Iowa Cooperative Extension include content that addresses science-based concepts that are a basis for the Food Code. However, the curriculum focuses more on specific rules or behaviors than science concepts; specifically (a) those observed during an inspection and (b) the items that appear on the certification exam. Knowledge included on the certification exam can be classified as rules based, or ‘algorithmic,’ per Bloom’s taxonomy (1956). Rule-based, algorithmic learning has limitations. Learners may not easily adapt rigid, standards-oriented knowledge to situations beyond the original learning situation. In clarifying Piaget’s genetic epistemology, Kitchener (1986) explains that developing knowledge requires both a concern for how knowledge, defined as beliefs and theories, changes over time—called epistemic kinematics—as well as how the evidence base for these beliefs also change over time—called epistemic dynamics. This means that the development of knowledge is a progression and an evolution of beliefs rather than an accumulation of rules, which restricts knowledge to the lower levels on the taxonomy. As the situations or underlying evidence change, then so will the beliefs (Kitchener, 1986). This has implications for food safety practices in that increasing employees’ knowledge, but also their evidence base of experiences, requires strategically developed curricula and instruction that address both elements. Assessment of this revised program theory and

planning will need to also move beyond simple counting of correct lower-level behaviors if both epistemic kinematics and epistemic dynamics are to be evaluated.

An employee's ability to perform specific behaviors can not be used as a measurement of competence in regard to an area of content knowledge (Kitchener, 1986). Using Piaget's program of genetic epistemology as a guide, competence of a subject is not a single measurable element but a construct that is only estimated through ability to perform a variety of behaviors that serve as indicators (Kitchener, 1986). This abstract idea of competence is what also has been described as conceptual knowledge or understanding.

Conceptual Knowledge

Conceptual knowledge of food handling procedures is likely essential both for proper managerial supervision and also for affecting behaviors of employees who handle food. It may even be *essential* for employees to gain a conceptual understanding to add, change, or sustain desirable behaviors. This claim, if taken seriously, would require revamping transformation of current food safety education. Conceptual learning is the process through which conceptual understanding or competence is developed in the learner.

Framework for Conceptual Learning

What has not been examined is how to teach any level of employee food safety concepts in a manner that maximizes high-level knowledge retention and application beyond the classroom through an emphasis on conceptual learning. Education and training that develop conceptual understandings among attendees move knowledge from short-term and working memory to long-term memory and accessibility for recall and use

in the future. Transfer of knowledge—generalizing to novel contexts—is also then achieved more readily. Conceptual understanding permits greater transferability of knowledge to new and novel situations. Rule-based learning is less flexible and is less sustainable or ongoing. It may be vitally important for us to move in this direction to lower the incidence of foodborne illness.

This transition from lower level information to facilitating higher level, longer long-lasting learning is the goal of the conceptual change model based on the constructivist theory of learning (Posner, Strike, Hewson, & Gertzog, 1982). Given the failures of current educational interventions to significantly improve handling procedures in foodservice establishments that serve as a “last defense” for controlling foodborne pathogens that cause foodborne illness, a new approach is warranted. This research investigated an approach to learning food safety concepts using the conceptual change model in an adult educational setting. Correcting improper food handling practices, if already present in an operation, appears to be resistant to current training techniques (FDA, 2004) that are formulated around a rule-based learning model. The necessity for effective food safety training is increasing as the demand for completing said training also increases (Almanza & Nesmith, 2004). The hope was to understand the potential for constructivist education to transform or radically improve both the pedagogical and epistemological bases on which food safety training is developed.

Purpose of the Dissertation

This research examined the practice of and contributes to non-formal education using a set of lenses that values conceptual learning versus rule-based, algorithmic learning (Appleton, 1989, 1993; Hauenstein, 1998; Mezirow, 1990, 1995; Posner et al.,

1982; Strike & Posner, 1985, 1992; Thorley & Stofflett, 1996; Tyson, Venville, Harrison, & Treagust, 1997). Effective training is defined, according to the conceptual change model, as developing an understanding of content that is generalized and is flexible enough to be applied to unique or novel situations after training. Delivering training programs that maximize impact and increase knowledge retention, understanding, and application beyond the classroom would benefit society as the movement toward required food safety training continues (Almanza & Nesmith, 2004). Developing a training program in conceptual knowledge was beyond the scope of this research. This research took a first, crucial step to investigate something we know nothing about—prior knowledge.

This research addresses how adults' prior knowledge, training, and experiences related to basic science principles influence the use or adoption of proper food handling practices on the job. Specifically, the study examines foodservice employees' knowledge of a specific science concept important to food safety: heat, temperature and thermal dynamics regarding practices for cooling hot foods.

Research Questions

This dissertation blends educational theory from the formal (K-12) science and mathematics education literature with constructivist theories of adult education.

Constructivism in science and mathematics education is mainly based on Piaget's view of intelligence of thought and its development in children (Appleton, 1993; Cheung & Taylor, 1991; Etchberger & Shaw, 1992; Korthagen & Lagerwerf, 1995; Perkins, 1991; Posner et al., 1982; von Glasersfeld, 2001). Piaget's ideas have been applied to science education and serve as a common thread to this review and research. The use of

constructivism in youth science teaching is brought into the area of food safety training, which mainly is offered to adults, because the basis of food safety is science oriented, primarily related to disease etiology and prevention. Adult education theory is applied to food safety training to understand the roles of affective and symbolic dimensions of prior knowledge in learning and behavior change.

The long-term goal of the research is to devise programs and instruction designed as constructivist-based teaching in food safety education programs for adults. Findings from the research are anticipated to reform food safety curricula such that foodservice employees consistently and correctly apply knowledge and skills that protect consumers and themselves from food-borne illnesses. The goal of the dissertation research was to describe the type and extent of conceptual understandings (i.e., prior knowledge) of scientific principles relevant to the prevention of foodborne illnesses. Because such work had not been completed with adults, the dissertation necessarily devised methods to investigate this area. The research focused on conceptual understandings related to heat and thermal equilibrium. These concepts provide the theoretical foundation for common food safety practices such as proper methods for taking temperatures, procedures for cooling foods, maintaining foods at proper temperatures on a buffet line, and safe defrosting of meat products. Heat concepts also were chosen because unlike epidemiology or microbiology, there was an existing K-12 physics literature from which to draw.

Objectives

1. **Objective #1:** Develop a concept map for employee understandings with regard to heat and food. The map will provide a summation of employees' understandings that can inform future reform to food safety training curricula.
2. **Objective #2:** Determine the extent to which foodservice employees' conceptual understandings of the indicator temperature (hot and cold) in food preparation maps onto a physics-based conceptual framework for heat transfer and thermal dynamics. The research will investigate employees' conceptual understandings by focusing on processes associated with cooling and storing a large pot of hot chili in a naturalistic kitchen context.
3. **Objective #3:** The research will link employees' conceptual understandings of heat transfer and thermal dynamics. Establish the relationships between employees' established concepts (right, wrong, or incomplete) and behaviors (correct, incorrect, or irrelevant) with regard to properly cooling hot foods. Establish, through objective #1, actions (or failures to act) of the employee with regard to handling the pot of chili.
4. **Objective #4:** Determine two to three hypothetical learning trajectories for heat and thermal equilibrium that can be used by constructivist curriculum developers as starting points for food safety training related to heating and cooling foods. The trajectories will link the research to standard food safety practices by using the results of objectives one, two, and three to establish preliminary mechanisms

for entry into instructional situations when specific heat transfer concepts are wrong or incomplete in adult foodservice employees' knowledge bases.

Organization of Dissertation

This dissertation is organized into five chapters. Chapter one introduces the problem addressed by this research and provides background necessary to understand the importance of the educational challenges in food safety education. Chapter two reviews the literature of the learning theories and assessment methods used in the research. The third chapter defines the research methods used for this study. Chapter four reports and discusses the findings from the research described in Chapter three. Chapter five is a set of generalized conclusions and recommendations regarding additional research and application of this research.

CHAPTER 2. LITERATURE REVIEW

Introduction

The design of nearly all United States food safety training programs are based upon two principles that are critically examined and critiqued in this dissertation: (a) a certified individual possesses high quality, and a sufficient amount of, food safety knowledge; and (b) completing a certification program results in a positive change in food handlers' practices (Almanza & Smith, 2004). Many programs also assume that positive changes in an individual have a spill-over effect that brings knowledge and behavior of others into compliance as well. The assumption of effects on behavior is dependent on numerous factors, but assuredly includes knowledge (Gordon, 2002; O'Boyle, Henly & Larson, 2001). Consequently, the "knowledge issue" is addressed in this chapter from perspectives relevant to food handling and food safety: (a) adult education and social learning; (b) constructivist-based teaching and learning; and (c) teaching for conceptual understanding.

Adult Education

As the basis for the chapters of his book *Program Planning for the Training and Continuing Education of Adults: North American Perspectives*, Cookson (1998) utilized the definition of adult education provided by a founding father of the profession, Cyril O. Houle (1972). Cookson (1998) focuses on the idea that the "process" in Houle's definition (1972) is a central theme that can be applied to all adult education situations, regardless of the other elements of the definition. Education, whether for adults or children, is about the process through which the learners go about learning, which can be

construed as the “improving themselves” element of Houle’s definition. Program planners, teachers, professors, or trainers all work to identify the process through which they intend to educate the learners who attend their classes, sessions, seminars, or lectures. The focus on the process of learning is an important component of teaching to higher levels of Bloom’s (1956) taxonomy. Teaching effectiveness is more prominent than teaching efficacy in such situations. This model—and derivatives of this model—commonly underlie adult education programs. However, not all program planning models are based upon such premises.

Extension Education

Extension training programs, like the food safety training programs emphasized in this dissertation, are nonformal educational settings designed for the benefit or betterment of the adult attendees. Cervero and Wilson (1994) point out that the framework for curriculum development posed by Tyler (1949) “undergrids most program-planning theories in adult education” and has been “the dominant curriculum theory in education since it was published” (Cervero & Wilson, 1994, p. 14). The Tyler model emphasizes identifying educational objectives, determining how to instructionally meet these objectives, and developing appropriate assessment methods for the objectives. This also holds true of most food safety education programs. Program objectives are established, the instructional practices are developed, and an assessment component is included. The educational objectives and instructional methods also constitute the thrust of investigation in this dissertation.

The adult education models to be discussed are included in adult education and program planning courses that are completed by Extension educators, so providing an

explanation of these models may help explain the sources of Extension program planning techniques and practices. Secondly, explaining two of the models commonly used in adult program planning provides an opportunity for comparison and contrast to the science and mathematics education models for youth on the basis of learning theory and cognitive development. Such a discussion also provides an avenue for examining how the adult and educational models might complement or contradict current practices. The first step to examining how Extension programs and food safety training are designed and implemented is to understand the Extension system, its development, and how it is used as a medium for transferring research-generated knowledge to the public through non-formal education.

The Extension System

The Extension system is coordinated through the land-grant colleges and universities in the United States. Extension's establishment in 1914 by the Smith-Lever Act was intended to provide a conduit through which research-based knowledge from the universities could be relayed to American agriculturists. The name Cooperative Extension originates from the formalized relationship between the land-grant system and the United States Department of Agriculture from the Smith-Lever Act (USDA, 2006) and its local partners, such as states and counties.

Extension is a primary provider of food safety training in Iowa. The degree to which Extension is involved in food safety training of foodservice employees varies among states, depending on what requirements the state has implemented for employee training. The design of Extension food safety training programs in Iowa is similar to other systems. However, peculiarities unique to the Extension model will be noted.

Among educational frameworks, Extension education is probably most similar to the Critical Element Model (Nadler, 1982). The Critical Element Model is a problem-based model in that it focuses for methods to fixing problems within organizations or groups rather than enhancing education. Though introduced here, the Critical Element Model is more extensively explained in a later section.

Although other educational models may be applicable and possibly more beneficial to the learning process of the individual, Extension food safety training typically aims at fixing a problem through modified behaviors resulting from increased knowledge. This approach to program development and implementation is consistent with the Critical Events Model of Nadler (1982) and will be elaborated in a later section. This knowledge, moreover, is a particular type. Using the taxonomy of Bloom et al. (1956) as a gauge, the thrust of traditional food safety training programs is situated in the “knowledge,” “comprehension,” and “application” levels. However, long-term retention and use of knowledge from training in novel situations requires using higher levels of the Bloom et al. (1956) taxonomy, which is addressed with the learning theories discussed later.

Knowledge of food handling and preparation practices an important part of maintaining food safety in a foodservice operation. However, just learning (or knowledge and comprehension per Bloom et al., 1956) appropriate behaviors from a certification program does not always directly lead to an increase in the frequency that appropriate behaviors are performed by employees (Speer & Kane, 1990). For learners to achieve learning on the level of conceptual change or understanding that results in knowledge synthesis and evaluation of knowledge requires the learner to incorporate the

new knowledge they are presented into existing knowledge schema by revising or adding to conceptual models. Then, adapt that knowledge to answer new problems outside of the experience from which it was learned (Bloom et al., 1956; Posner et al., 1982). Strike and Posner (1985) explain the process in the following manner.

Much of the way we talk and act about education seems to presuppose an image of the student as a retainer of, rather than a processor of, experience and information. We believe that this is untrue. We suggest instead that learning is best thought of as a process of inquiry. ...the task of learning is primarily one of relating what one has encountered...to one's current ideas. The student who learns something is the one who understands a new idea..., is the one who judges its truth value..., and is the one who can judge its consistency with other ideas.... To learn an idea any other way is to acquire a piece of verbal behavior which one emits to a stimulus, rather than to understand an idea which one can employ in an intellectually productive way. (p. 211)

Mezirow (1995) attributes the ability for adults to apply knowledge to new situations (as part of transformative learning) to their capacity for critical thinking and questioning of how the knowledge relates to and corresponds with societal practices and expectations. Adults' critical thinking skills are generated through a process described by Finster (1989) as Perry's model of intellectual development. This model includes four phases through which a person passes during the process of intellectual maturity. These phases include dualism (one true answer, or opposites of right and wrong, etc.); multipism (multiple opinions can be present and all have a right to exist); relativism (knowledge is

contextual and personal commitment must be, but is not, made to obtain an individual identity); and commitment to relativism (students make the commitment to a position, which develops the identity) (Finster, 1989).

Training programs developed for foodservice employees on numerous practices and procedures have focused on increasing knowledge with little, if any, attempts to identify conceptual understanding and ability to adapt knowledge beyond the learning situation. Two such examples are the work of Dooley, Van Laanen, and Fletcher (1999) and Martin, Knabel, and Mendenhall (1999). Both of these works were evaluative reports on two different HACCP education programs developed for foodservice employees. The focus of both program evaluations was to determine participant change in knowledge from before the program to after the program. Knowledge in these cases was limited to rules retention on a certification exam or posttest following the instruction period. Martin, Knabel, and Mendenhall (1999) did include a follow-up component two months later that involved self-reported behavior changes in the respective operations. Such programs provide useful information to participants but stop at what Strike and Posner (1985) identify as learning a verbal behavior to be repeated on a test with no validation of adaptability to other situations.

One exemplary program and evaluation was reported by Lisa Leimar Price (2001) regarding interventions for pest management practice adoption by Philippine rice farmers. The interventions, called “farmer field schools,” included two techniques, one a simple rules-based education program that focused on the “what to do” elements of pest management, and the second was a program focused on building conceptual understanding of pest management principles that could be adapted by each farmer to

their unique production situations. This approach with Philippine rice farmers parallels food handlers in that they first must understand what to do to be proficient at their jobs, but also need to understand the conceptual or principles-based knowledge so knowledge transfer to unfamiliar situations can occur. Programs evaluation reports of programs utilizing interventions that educate to the point of changing personal beliefs (what Mezirow called transformative learning) that can be adapted to life situations are infrequent in adult and Extension education (Grudens-Schuck, Cramer, Exner & Shour, 2003).

Psychology and contemporary education research on learning theory and knowledge formation, coupled with the introduction of new or revised program development models, may provide a new basis on which Extension programming can be developed. Specifically, constructivist theory of learning and a descendant educational model, both of which have been used in science and mathematics classrooms, may be applied to the design and implementation of food safety education and curricula to improve participants' understanding, post-training retention of content, and behavior change. What is remarkable, given the long history of constructivist approaches to teaching and learning in other fields (for example, applications of Piaget to education theory and models; Posner and Strike to science and mathematics education) is the scant nature of application to extension education. Exceptions include works such as Price (2001) with Philippine rice farmers, but on the whole, the literature is drawn from work with children (Appleton, 1989, 1993; Posner et al., 1982; Simon, 1995, 2004; Strike & Posner, 1985, 1992; Trexler, 2000, Trexler & Heinze, 2001; Trexler & Meischen, 2002; Tyson, 1997).

To structure and present food safety training in such a fashion requires trainers who understand constructivism (Thorley & Stofflett, 1996), educational models based on the constructivist theory of learning, and instructional practices consistent with constructivist-oriented teaching. The foundational elements that constructivist-based teachers must do when preparing to teach are a self-assessment of their own understanding of the content and to identify hypotheses about students' current knowledge (Simon, 1995). These assumptions, theories, models, and propositions will be discussed and explained in this review of literature.

Program Planning Models

The Critical Elements Model

The Critical Events Model (CEM) was originally introduced in *Designing Training Programs: The Critical Events Model* (Nadler, 1982). A summarized version of the model, with commentary based on experience of use of the model by the authors, was published in 1998 (Nadler & Nadler, 1998). The CEM focuses on correcting problems that exist within organizational systems through training that modifies behaviors in order to improve or standardize job performance.

The CEM provides program planners with a list of critical elements that must be included to have an effective training program. The elements may be completed in a different order than presented in the model, but all must be included for success. The authors emphasize that the model, as presented in the 1998 piece, is intended for use with training, but could be adapted for use in an education setting as well. The distinction between training and education per Nadler and Nadler (1998) is that training is “learning

related to the present job of the learner” and training is “learning related to a future job of the learner” (Nadler & Nadler, 1998, p. 58).

Nine elements comprise the CEM. Eight are organized into a linear (or cyclical) pattern and the remaining element of evaluation and feedback is included in all but two of the elements. The eight elements, in suggested order of completion, are 1) identification of needs of the organization; 2) specify job performance; 3) identify learner needs; 4) determine objectives; 5) build curriculum; 6) select instructional strategies; 7) obtain instructional resources; and 8) conduct training. The one element that does not contain evaluation and feedback is organizational needs identification. Points for each of the nine elements that are relevant for comparison of planning and education models are summarized in the rest of this section.

A unique aspect of the CEM in relation to the models discussed later is the focus on the organization rather than the learner. Identifying organizational needs is used to first determine if there is a problem within the organization and if one exists, that it is an agreed upon problem that exists within the organization (Nadler, 1982). If no generally accepted problem exists, there is no reason to continue with the remaining CEM elements.

The second element, specifying job performance, contributes to the de-emphasis of the learner. The learner is the focus of the training program, but for the purpose of bringing about organizational change or improvement (Nadler, 1982). The specification of job performance is part of a systems view of the organization. Nadler and Nadler (1998) frame the job in regards to inputs and outputs: “input → job → output” (p. 61). A problem within the organization that is preventing an organizational goal from being met

is the result of a job within the interdependent system failing (Nadler & Nadler, 1998). Evaluation of this element may result in a decision that training is unnecessary because changes to the organization, inputs, or output expectations rather than the expectation that employee(s) can correct the problem.

Identifying learner needs, the third element, quantifies the learner's needs based on what the learner needs so the job assigned to the employee meets its expectations. Nadler and Nadler (1998) represent this in the equation " $JP - AK = LN$ " where JP is job performance, AK is knowledge already known by the employee, and LN is what needs to be learned. This model assumes that behaviors will be changed with the training of employees. Two questions that must be answered 'yes' before proceeding on to the fourth element are "If the employee accomplishes this learning, will performance then be as determined by the Specify Job Performance event?" and "If the employee accomplished the learning, will the problem have been solved?" (Nadler & Nadler, 1998, p. 62). This model is similar to some food safety education programs in that it assumes there is a gap in knowledge, or the LN part of the afore mentioned equation, that once filled will result in satisfactory job performance (JP). Inferring from the equation, it appears that this model assesses existing knowledge, or "already known" (AK), before instruction begins. Most food safety programs do not perform any prior assessment, whether it is of prior knowledge or existing behaviors. Based on the theories used for this research, these assessments should be conducted to inform components of the curriculum and educational objectives.

The elements of determining objectives and building curriculum are similar to those components included in other models. Objectives need to be developed with the

input of learners and other organizational members. The planner must again refer back to the organizational problem by asking the question “If the learning objectives are met, will the problem solved?” (Nadler & Nadler, 1998, p. 64). Curriculum building involves the assistance of a subject matter specialist (SMS) who is solely responsible for understanding and providing content for the training program. “An SMS does not have to know anything about how adults learn, since that is the specialty of the designer” (Nadler & Nadler, 1998, p. 64).

The selection of instructional strategies involves the expertise of an instructional designer. The planner is responsible for understanding learning theory and the instructional designer selects the instructional strategies used to implement the curriculum during the training (Nadler & Nadler, 1998). Factors affecting the selection of instructional strategies include the learner, budget, facilities, culture of the organization, and the instructor. The primary evaluation criterion for strategy selection is whether the strategies will implement the curriculum (Nadler & Nadler, 1998). Physical, financial, and human resources, which includes the learner, supervisor, and the instructor, all comprise the obtaining instructional resources element. An emphasis is placed on the supervisor’s involvement.

It is also the supervisor who will want to know the results of the program, for those results should have a direct impact on performance for which the supervisor is responsible. The supervisor, who had the problem, also wants to make sure that the training program will contribute to solving that problem. (Nadler & Nadler, 1998, p. 71)

The final element is conducting the training. The program developed by the planner is turned over to the instructor(s) for implementation. The role of the planner at this stage is reduced to minor modifications and obtaining evaluation information that will assist with future program planning projects (Nadler & Nadler, 1998).

The CEM focuses on organizational problems and uses training of personnel only when an increase in knowledge will improve job performance. This model is markedly different from the other training and education models to be discussed because of its focus on the organization and outcomes, its emphasis on changing behavior with knowledge, the inclusion of multiple experts in planning and development, and the disconnect between planner and instructor.

The Andragogical Model

The conceptual idea of andragogy versus pedagogy was introduced by Malcolm Knowles (1970). The idea of adult learners as different from children is what formed the basis of andragogy, or “the art of helping adults learn” (Knowles, 1998, p. 46). Five primary assumptions were identified to create the pedagogical model against which Knowles would compare and critique his early andragogical model. These assumptions were that 1) learners were dependent personalities that required the teacher to make learning decisions; 2) learners have a limited set of experiences that are of little value to learning; 3) learners are subject-centered and require teaching to be organized by subject; 4) learners will learn when told they have to learn; and 5) external factors are what motivate learners to learn.

The five assumptions of the early andragogical model presented by Knowles in 1970 were in essence opposites of the five from his pedagogical model. Knowles (1970;

1998) said that adult learners 1) are self-directed and do not like being ordered by others; 2) have a wealth of prior experiences that are relevant to and can influence learning; 3) can perceived a relevance to their learning based on their lives, jobs, and responsibilities; 4) will learn when the new knowledge will solve a problem; and 5) are motivated not by outside forces such as grades, but learn because they want to better themselves and their lives.

A revised version of the andragogical model was published by Knowles in 1980. In the revised model and in a summary of his works related to the andragogical model (Knowles, 1998) Knowles acknowledged that his early definitions and assumptions of pedagogy and andragogy were wrong in that they in a way put the two into opposition. The explanations of these assumptions put them as dichotomous items with little or no area of association in between, rather than as ends of a continuum. The “current andragogical model” consists of the same five assumptions, but couples the pedagogical and andragogical definitions as a starting point (the pedagogical assumptions) and a destination (the andragogical assumptions). The journey between the two is a progression of life, experience, maturation, mental and physical development, and an adaptation based on the learning situation and environment.

Both versions of the pedagogical and andragogical definitions can be paralleled with the constructivist theory of learning and the conceptual change model. The first assumption from Knowles (1998) about the degree of self-dependence of the learner is about the perception developed by the learner of the new knowledge. Students, whether adults or children, are presented with new knowledge that begins to solve a problem or conflict they have between existing knowledge and a situation for which this existing

knowledge does not work during the teaching and learning process. When this new information helps resolve the conflict, students are more apt to become engaged in learning.

The second pair of assumptions is focused on learners' prior experiences. Though young learners may not possess a rich set of prior experiences directly related to the subject being taught, they do bring all of their prior knowledge and experience to the learning situation. Constructivism is driven by the idea that new knowledge must "fit" with the existing body of knowledge or a conflict of some degree will develop. The resolution of this conflict results in learning whether the new knowledge is assimilated, an accommodation occurs, or the new knowledge is dismissed. Adult learners, through the virtue of age and development, will have more directly and indirectly related experiences with the subject as well as life experiences that include cognitive and affective elements. However, the constructivist paradigm states that prior knowledge is no more or less important to the learning environment of adults than children. The complex body of prior knowledge for adults may make it harder for them to learn because a more complicated web of ideas, or schema, have been developed. If one part of a schema must be revised for the learning of new knowledge, then all other cognitive ideas related to that concept must also be revised.

Learners' orientation toward the purpose of learning is the basis for the third pair of assumptions. Children's readiness to learn "tends to be the products primarily of physiological and mental maturation, those of the adult years are the products primarily of the evolution of social roles" (Knowles, 1970, p. 46). The readiness to learn of Knowles is similar to the plausibility in the conceptual change model (Posner et al.,

1982). The new knowledge “must at least appear to have the capacity to solve the problems” (Posner et al., 1982, p. 214), whether it is to overcome some physiological or social barrier or issue or the learning will not occur.

The final two pairs of assumptions are related to learners’ readiness to learn, like the third pair, but focus on the need to learn and the source of motivation. Young learners become ready to learn when they are told to learn and when learning will help them advance in schooling or in a job. Adult learners are more willing to learn when the new knowledge “will contribute toward their achieving some life goal” and when the learning has some intrinsic value (Knowles, 1998, p. 47). Learning for resolution, a component of both assimilation (per Appleton, 1989) and accommodation (per Posner et al., 1982) is a process associated with both adult and youth learning and development. Learning for promotion, which was described earlier as learning for advancement in school or a job, differs from learning life skills in that it is not unique to either youth or adults but rather is common to these two learner groups and is dependent on learner motivation.

The fundamental purpose of learning theories is to characterize and predict how students, both youth and adults, learn and then apply these theories to curriculum and instruction so learning is maximized or optimized according to some standard. The critical event model and the andragogical model focus on problem solving and outcomes in regard to teaching, not learning. Analysis of the andragogical model proposed, redefined, and discussed by Knowles (1970, 1980, 1998) identified areas in which learning theory is included, whether intentional or as a result of observation of the model in application. The previous two adult education models are examples of how adult

education or program planning can nearly ignore learners as a variable in the planning process or how the learners can be a key element in the design.

Transformative Learning

Transformative learning is an adult learning theory that has a different perspective on the students' roles in adult education programs. The transformation theory of learning from Mezirow (1990, 1995) is focused on the meaning constructed by learners from an experience and the process through which this meaning is made. The extent to which learners will build the expected knowledge is dependent on how they use the experience to critically reflect upon prior knowledge, experiences, and existing meaning structures. Tenets of this theory claim that the course of learning can not be predicted because it is dependent on the individual learners' prior experiences as well as their experience in the present, combined with critically reflective experience (Mezirow, 1990).

To this end, transformation learning is not focused on the acquisition of knowledge artifacts to increase the expanse of the cognitive knowledge structure or domain. Rather, transformation learning utilizes the affective elements that serve as underpinnings of cognitive organization and memory structure to assess existing meanings through the process of critical reflection. The result of this process is learning (Mezirow, 1995). In essence, transformation learning works beyond what the learner "knows" to why the learner has that knowledge, under what conditions or for what reasons the learner has remembered that knowledge, what meaning that knowledge has to the learner. It then asks the learner to challenge all of this through critical or analytical questioning. What the learner may get from this analytical process is transformational learning, whether that learning is reinforcement of existing meaning and knowledge,

restructured meaning schemes, or a change in meaning and redefining the relevance or usefulness of prior knowledge and experiences to the learner.

Transformative learning occurs at multiple levels and incorporates a multitude of components that all build to the end of meaningful learning (Mezirow, 1995). A basic building block of transformative learning is through a change in meaning schemes. These meaning schemes are how the learner incorporates a small part of knowledge or an isolated experience into their entire knowledge and experiential schema. In short, Mezirow states that “creating meaning refers to the process of construal by which we attribute coherence and significance to our experience in light of what we know” (Mezirow, 1995, p.40).

Another way of viewing a meaning scheme is the way one fact or experience fits or relates to the rest of the facts or experiences acquired during life and committed to the learner’s memory. Though changing a meaning scheme may seem significant at the time of its occurrence, this change is relatively small in comparison to the entire holistic range of cognitive knowledge and experiential relationships of the learner. The transformation of meaning schemes is similar to the concept of assimilation that is a common component of constructivism and conceptual change, which will be elaborated upon in a later section of this review.

A more expansive and impacting, yet less frequent, component of transformative learning is 'perspective transformation' (Mezirow, 1995). Perspective transformation is a different quality from transforming meaning schemes. Mezirow set this process apart from a change in meaning schemes because perspective transformation is a much more profound change of knowledge or beliefs for the learner. The perspective transformation

has two primary causes - “accretion of transformations in related meaning schemes or through an epochal transformation triggered by a life crisis” (Mezirow, 1995, p. 50). The 11 components of perspective transformation are not necessarily linear or progressive. Completing all eleven steps, however, is anticipated to lead to long-lasting perspective transformation in the learner.

A comparison between the perspective transformation components and the primary conceptual change components proposed by Posner et al. (1982) shows great similarities. Both processes begin with the learner becoming uncertain about how things are, whether it is through dissatisfaction (per Posner et al., 1982) or a disorienting dilemma (Mezirow, 1990). Whether dissatisfaction or a disorienting dilemma, the thrust of impact on the learner is emotionally based and stimulated from the affective domain processes. Here is where the cognitive and affective domains work in tandem to drive learning. The learners’ awareness of shortcoming in their existing knowledge base may be considered a cognitive artifact, but the emotional state of unhappiness and motivation to actively seek information to overcome this imperfection of knowledge is affective. The learning occurs as the learner proceeds through a process of assessing prior knowledge in regard to the new knowledge and making a significant change (accommodation per Posner et al., 1982) or Mezirow’s (1995) perspective transformation. Briefly introduced here, the conceptual change model will be further discussed in a later section to provide more clarity and to discuss additional perspectives and criticisms of Posner et al.’s work.

Constructivist Theory of Learning

The constructivist theory of learning, hereafter referred to as “constructivism”, is the development of new knowledge by a person using prior knowledge as a base or organizing structure (Duschl, Hamilton & Grandy, 1992). That is, individuals have a base of knowledge termed cognitive memories that may be imagined as being built or made larger by the contribution of new knowledge. Where the points of discussion and debate come into the literature is identifying how new knowledge is added to the existing bank of knowledge (i.e., prior knowledge) and describing the process a learner must complete for learning to occur.

The origin of constructivism as it is currently understood and used in science education literature stems from the work of Jean Piaget (Appleton, 1993; Cheung & Taylor, 1991; Etchberger & Shaw, 1992; Korthagen & Lagerwerf, 1995; Perkins, 1991; Posner et al., 1982; von Glasersfeld, 2001). Many of the works related to constructivism in science examine what students do as well as what they say about what they did and why they did it. This string follows the focus of Piaget’s work (Duckworth, 1996). Early works of Piaget focused on what students said, the complexity or simplicity of vocabulary, and the extent to which the words explained the students’ thoughts. However, later works by Piaget focused on the actions of children as an assessment of thought and logic (Duckworth, 1996). Piaget posited that children could perform actions requiring much greater levels of intellect than they were able to articulate through speech. In doing so, Piaget also brought about the argument that words may not be necessary to generate knowledge (Duckworth, 1996). Actions, behaviors, experimentation, and self-

reflection of children take new knowledge and create personal meanings that are based off of prior knowledge.

One such example of difference is the residence of the knowledge and the process of learning. Simon (1995) distinguishes between “a social process or a cognitive process” (p. 116). An extreme view proposes that knowledge exists on a societal level and that learners only make personal meaning when the knowledge is ubiquitous to society. Simon argues this social perspective originates from the line of work in symbolic interactionism of Blumer (1969). The other extreme view purports that knowledge is unique to the individual learner and that learning is solely a cognitive process. In this view, social interaction may help learners make meaning, but only on a personal level; society does not have its own body of knowledge. Simon attributes this position to the radical constructivism work of von Glasersfeld (1991), which is based on Piaget (von Glasersfeld, 2001).

An intermediate view is that knowledge exists on both levels (Simon, 1995), which is the view with which my philosophy is most aligned. Learners may understand or at least agree with some concept or idea on a societal level but have their own meaning or interpretation of that concept on a personal level. Society here can be defined as the community, the school, the classroom, the learning environment, or any other host of external influences that are outside the mind of the learner. However, only the learner can decide what to learn and how these external influences will affect learning, if at all.

Elements of Conceptual Change

The 1982 work of Posner et al. was the introduction of what is now called the conceptual change model. This model is based on constructivism but expounds into how

the process of a significant cognitive change occurs. Conceptual change emphasizes a process of learning that is based on forming and testing alternative conceptions (Tyson et al., 1997). The basis for conceptual change as a learning theory was brought to science education by Posner et al. (1982), who claimed that conceptual change was “what learning is.” “The initial formulation of our theory is not a general theory of cognitive development. It is an attempt to suggest how concepts that have proven resistant to instruction might be altered” (Strike & Posner, 1992, p. 155). The theory behind conceptual change advances learning from “the acquisition of a set of correct responses, a verbal repertoire” (Posner et al., 1982, p. 212), which is a simplistic, short-term memory exercise, to a level involving long-term cognitive memory. The behavioral or rules-based learning they step away from is what constitutes the first major class of the cognitive taxonomy (Bloom et al., 1956). The taxonomy of the cognitive domain developed by Bloom et al. (1956) progresses from comprehension of knowledge to evaluation and judgment. Comprehension is considered no more than the simple understanding of knowledge without connecting it to anything else in the learner’s existing knowledge base. Deeper levels of learning are reached when students are able to work with knowledge at the higher levels of the cognitive domain. Learning becomes more meaningful through association with prior knowledge and is more likely to be used by the learner at a later time.

Conceptual change, no matter its form, indicates that learners experience a change in knowledge. Tyson et al. (1997) reviewed the use of the term “conceptual change” and concluded conceptual change can be summarized into either an addition of new knowledge or assimilation (Appleton, 1993), or a revision of prior knowledge. The

revision can be further segmented into a “weak revision”, assimilation by Posner et al. (1982), or a “strong revision”, called accommodation by Posner et al. (1982). The cognitive process of conceptual change described by Posner et al. (1982) is a method through which constructivist learning occurs, thus building knowledge in something robust and long lasting.

Primary Processes

Piaget’s (1977/1978) knowledge development and learning elements are comprised of three primary processes or results: assimilation, accommodation, and disequilibrium. Assimilation and accommodation will be discussed to provide the constructivist’s perspective of what happens when a learner is presented with new information. An illustration of the learning process as described by Piaget (1977/1978) was developed by Trojcek (1979) and is used as the basis for Appleton’s learning model (1989).

Assimilation and Accommodation

When learners are presented with a new piece of information, it is processed through a filter (Appleton, 1993) at which time they determine if it fits with previous knowledge or if it is in conflict with previous knowledge (Piaget, 1977/1978). If the new information is consistent with what the learner already knows, then the new information is readily added and becomes part of the existing knowledge. Upon completion, the learner leaves the learning experience (Appleton, 1989). Appleton (1993) considers the phenomenon of adding new knowledge without conflict to be assimilation. In contrast, when the new information is in conflict with existing knowledge, it creates “disequilibrium” according to Appleton (1989) or dissatisfaction, a term used by Posner

et al. (1982). Mezirow (1990) used the term “disorienting dilemma” in his transformational theory of adult education. The concept of a disorienting dilemma also has its roots in cognitive discourse between existing knowledge and new knowledge. If the disequilibrium can be resolved with minor adjustments to existing knowledge that result in the addition of the new knowledge, this too can be considered assimilation (Posner et al., 1982).

If knowledge is successfully restructured to resolve disequilibrium, then accommodation will occur (Appleton, 1993). Posner et al. (1982) state that “the student must replace or reorganize his central concepts. This more radical form of conceptual change we call accommodation” (p. 212). This type of conceptual change in learners is highly prized and is what teachers subscribing to these theories of learning want to occur with their students. Accommodation could also be understood as a paradigm shift in what students know as true and is in the direction teachers expect learning to occur.

An additional element to consider is the possibility of what Appleton (1989) and Piaget (1977/1978) call “false accommodation”. False accommodation occurs when learners experience disequilibrium, learn the correct answer, but do not change their prior knowledge. False accommodation results in two sets of knowledge that are held simultaneously and are potentially incompatible: the student’s prior knowledge and the school-based knowledge (sometimes termed “book learning”), which is often learned for the purpose of assessment but is not applied outside the learning environment (Appleton, 1993). The basic elements for the conceptual change model and how they were derived from but differ from Piaget’s work will be further elaborated in the following section.

Disequilibrium as a Process

It is necessary to focus more on disequilibrium because it is the beginning element by which students start toward assimilation. Posner et al. (1982) propose that without disequilibrium or dissatisfaction students' learning will only go as far as assimilating new knowledge rather than a change of conceptions. Appleton (1989, 1993) supports this idea in his path of student progression through learning. The premise of disequilibrium is that conflict is created by a mismatch of learners' existing knowledge and new information. Disequilibrium is an important internal state rife with emotion. In the conceptual change model, learners are considered by nature reluctant to give up ideas or change their present knowledge structure. As long as learners' current knowledge structures are sufficient to solve problems, answer questions, and so forth, they will hesitate to embrace new knowledge that is contradictory. First, because it may motivate learners by revealing that their current knowledge is not flawless, it may open them up to considering new ideas. Until learners are faced with situations where their existing knowledge does not work or is incomplete, and become conscious of this fact on a cognitive and affective level, they will not likely consider other alternative ideas or knowledge. Under the ideas of disequilibrium, constructivism, conceptual change, and transformative learning, conflict must become evident to learners before they consider modifying or moving from what they already know. Disequilibrium is the grounding concept on which dissatisfaction in the conceptual change model (Posner et al., 1982) is based and parallels Mezirow's concept of disorienting dilemma.

Constructive Teaching Practice

Efforts to teach based on the constructivist theory of learning have attempted to integrate both the cognitive and affective domains. “What is learned in a given situation therefore depends as much on the learner’s present knowledge structure and beliefs as on the characteristics of the learning environment” (Driver & Oldham, 1986, p. 110). The learning environment is critical in that it impacts students’ reception of the new information, such as the operation of filter (Appleton, 1989). Although the work with the conceptual change model focuses on cognitive change, the affective domain must also be considered. Posner et al. (1982), however, focused their model and studies on the cognitive development because that is “what learning is, not what learning depends on” (p. 212). We will have to go beyond Posner to fully address the affective domain.

The Affective Domain

Writings about the affective domain and its application to teaching and instructional design commonly have the affective domain linked to cognitive learning with little effort of examine the two separately. Posner et al. (1982) acknowledge the affective domain exists, but focus on the cognitive learning component. Tyson et al., (1997) point out that Strike and Posner (1985, 1992) included the affective domain in their theory of conceptual change. Further explanation in a later section raises the question that the mere presence of dissatisfaction – the initiating and differentiating component of conceptual change (termed accommodation by Posner et al.) – in and of itself is a function of the affective domain. “This artificial separation is more pronounced at levels beyond the elementary grades ... with a greater emphasis on subject matter content in junior and senior high school, cognitive outcomes dominate” (Brodeur, 1998,

p. 37). While stating other reasons may exist, Krathwohl et al. (1965) primarily attribute what they call the “erosion of affective objectives” (p. 16) to student assessment for grades. Student achievement on the cognitive level is a more appropriate means of assessment than on the affective level of attitudes and emotions.

Hynd, Alvermann, and Qian (1997) reported from their study that conceptual change can be attributed partially to the subjects having a positive attitude and an interest in learning the subject. Their findings of a partial relationship between attitudes (an affective attribute) and conceptual change, which focused specifically on conceptual change and not the broad concept of learning, is supportive of the discussion of Mayhew (1958) in Krathwohl, Bloom, and Masia (1965). Krathwohl et al. (1965) wrote that “a relationship between these domains [aptitudes and interests] is too low to predict one type of response, effectively, from the other” (p. 7).

Formalized cognitive objectives and assessment may be more socially acceptable as they are often used as a societal symbol (Krathwohl et al., 1965). Achievement of cognitive objectives often is assessed with standard tests that then are used to determine students’ grades or achievement levels. Krathwohl et al. (1965) argue that affective objectives and outcomes, such as emotions and attitudes, are more private in nature and typically are not shared in a public manner when compared to the use of cognitive outcomes that are the primary basis for calculating grades and ranking student performance. This argument holds true with assessment strategies today. Results of tests and other frequently used cognitive knowledge assessment tools are commonly used as a status symbol. Recognition of valedictorians, graduating with honors, making the honor

roll, and grade point averages are but a few ways that assessment results are publicly shared.

Hynd et al. (1997) go as far as stating that they examined conceptual change in preservice elementary school teachers “in light of the research and theory regarding ... affective dimensions” (p. 2) yet little attention was paid to theory, only interpretations or applications of the affective domain. They concluded that the success of creating conceptual change was partly due to uncontrolled influences, such as epistemology and attitude. This conclusion implies to me that they contend the affective component is either not controllable or not worth attempting to control even though it can influence the ability for conceptual change to occur. The idea that the affective domain is uncontrollable or even not teachable also has been discussed by researchers such as Price (1998).

The challenge does not lie in the claim that the affective domain can not be taught (and thus, can not be assessed), but that the affective component is not seen to be as easily observed or measured by practitioners as the cognitive domain. “This is partly due to our deep Western suspicion of the irrational” (McLeod, 1987, p. 426). Krathwohl et al. (1965) admit that it was much more difficult to write the taxonomy of the affective domain than for the cognitive domain because of a lack of evaluation materials aimed at the affective domain.

Prior Knowledge and Misconceptions

For conceptual change, or an equivalent to Piaget’s assimilation (Strike & Posner, 1992), teachers typically assess a student’s prior knowledge. This prior knowledge is defined by Posner et al. (1982) as the “conceptual ecology”. A conceptual ecology is a

core of cognitive elements that include anomalies, analogies, metaphors, epistemological beliefs, metaphysical beliefs, knowledge from other areas of inquiry, and knowledge of competing conceptions (Posner et al., 1982; Strike & Posner, 1992). The “cognitive artifacts” comprising the conceptual framework that is intended to be changed through teaching for conceptual change are compared and contrasted with new information to create disequilibrium or dissatisfaction. Since these original cognitive artifacts are the basis for students’ cognitive knowledge, they also are the core of misconceptions. A misconception is learners’ knowledge or understanding of a concept that is believed by them to be correct (primarily through the learners’ success of solving problems with this knowledge) but contradicts socially accepted knowledge.

The previous knowledge with which the new knowledge is inconsistent also has been termed “alternative conceptions” by Hewson and Hewson, who are researchers from South Africa. They studied alternate conceptions, misconceptions, and the importance quantifying misconceptions has for student learning in physics with high school aged children. In their argument for the importance of “conceptual conflict” in science education, Hewson and Hewson (1984) refrain from using the term “misconception”, which they attribute to Helm (1980), because although these conceptions held by the students may be inaccurate or wrong based on some given standard (e.g., the physics community), the students believe them to be true.

It has even been surmised that some misconceptions do not formally exist as part of a student’s conceptual ecology, but rather are formed by elements of the conceptual ecology to address a specific problem at a given time (Strike & Posner, 1992). Strike and Posner (1992) elaborate that the important component of such an instance, or any related

to assessing misconceptions, is not identifying the misconception itself but what components or elements of the conceptual ecology are used to support and maintain the misconception. Knowing the critical conceptual ecology elements is where instruction then can be focused, rather than on the specific misconception. How Strike and Posner (1992) describe this instantaneous development of a misconception to solve an immediate problem is similar to improvisation. If the students do not understand how to solve the problem, they will use what they know to create a solution, or improvise, to get the answer. Without supervision this testing behavior may arrive at a false conclusion.

This idea has implications for food safety in that observations are made of specific food handling practices. If employees know some basic or partial knowledge and are provided a situation that does not benefit from application of what they know, then a perceived solution will be generated to address the problem. Instantaneous misconceptions result from necessity. Learners may encounter a problem that their existing knowledge base does not address. As a result, components of knowledge are combined in response to the foreign problem and an ad hoc solution is formed. This can create problems in food handling when the ad hoc solution appears to solve an immediate problem but violates safe food handling practices. The haste in which such instantaneous misconceptions may be formed (e.g., a busy kitchen during the lunch hour) may not allow for reflection on the action to determine whether the decision was the most appropriate one.

The ability to prevent the development of instantaneous misconceptions can be addressed by teaching underlying principles that form the employee's conceptual ecology. Understanding of core concepts prepares for knowledge transfer by employees

when an unfamiliar situation is encountered on the job. The proper building blocks (i.e., conceptual knowledge) are present to form an adequate solution in situations of uncertainty.

Age and Development

This phenomenon of the development of instantaneous misconceptions provides a significant challenge to instructional planning and assessment. For example, eliciting prior knowledge intended to identify robust, long-standing misconceptions would not be effective because the instantaneous misconception would not have existed at the time of pre-assessment. Developing instantaneous misconceptions may become a greater challenge as learners age. Based on the work reported thus far, I believe age and experience allow the learner to develop a more complex conceptual framework of knowledge from which these misconceptions can be more readily formed, thus possibly making the learner more resistant to instances of disequilibrium. Strike and Posner (1992) discuss this in regard to the novice learner. Younger or novice learners “have not been initiated into a scientific community with its current conceptions and commitments. Nor do the politics or social behavior of such communities figure in learning” (Strike & Posner, 1992, p. 152).

In reference to work by Labouvie-Vief, Mezirow (1995) contends that younger learners are more trusting and are more likely to learn without questioning or reacting. Adults in contrast, will be more critical of what is being taught, including societal standards.

Meaning structures...may be considered more ‘developmentally advanced’ when they are more inclusive, discriminating, permeable, integrative of experience and

are validated through rational discourse. Development, especially in adulthood, centrally involves movement toward more developmentally advanced meaning structures. (Mezirow, 1995, p. 51)

Such dilemmas are demanding of an instructional model that incorporates continual feedback of the learners' knowledge and understanding of the concept in question at any given point of the learning experience. Only through this continual feedback, coupled with learning focused instruction, can causes of misconceptions be identified and addressed.

Dissatisfaction

The conceptual change model per Posner et al. (1982) is comprised of four basic conditions: dissatisfaction, intelligibility, plausibility, and fruitfulness (Posner et al., 1982; Strike & Posner, 1992). As with conceptual change theories generally, these conditions also have taken on different names, and have been added to and combined. Dissatisfaction is the condition critical for initiating conceptual change (accommodation) and distinguishes conceptual change from assimilation (Posner et al.). For a major revision of prior knowledge to occur (Tyson et al., 1997), or for a student to experience Posner et al.'s accommodation (1982), the learner first must experience dissatisfaction. This conflict between existing and new knowledge is what begins the learner on a path of considering a new conceptual knowledge framework. Otherwise, current knowledge is modified or added to and the result is assimilation (Posner et al., 1982).

The adult education parallel is the disorienting dilemma. Dissatisfaction in this model is similar the disorienting dilemma outcome of Mezirow's transformational

learning (Mezirow, 1995). The result of the disorienting dilemma might be described as dissatisfaction in that is a conflict or disagreement between current perspectives (or existing knowledge) and new meaning perspectives (or new knowledge)—the definition of dissatisfaction from Posner et al. (1982).

In all models, a core precept is that learners will work to maintain a sense of cognitive equilibrium or satisfaction. Using teaching techniques that successfully and purposefully create a sense of dissatisfaction for the students is crucial. Students' learning occurs as they work to regain comfort by reestablishing equilibrium. Equilibrium is achieved by modifying or replacing existing knowledge that does not solve the problem with new knowledge that resolves the disequilibrium.

For students to learn a new concept that is not consistent with their present knowledge, an event (or a series of events) must occur that brings the learner to question what they know, which then allows them to begin consideration of the new concept or knowledge (Posner et al., 1982). Posner et al. (1982) labeled these events as “anomalies” (p. 214). Dissatisfying anomalies are presented in many forms by teachers, particularly those trained in constructivist pedagogy. Teachers start learners toward conceptual change by creating anomalies in the learning experience. Learners take one of four courses of action the point of dissatisfaction: 1) assimilation – the reinforcement of the existing idea; 2) false accommodation – previous ideas unchanged but a new set is developed with the “right answer”; 3) accommodation – previous knowledge changed; and 4) opting out – student disengages from the learning and previous knowledge remains unchanged (Appleton, 1993).

Dissatisfaction is what opens learners to accepting new information, but it does not guarantee learning has been achieved. Per the conceptual change model, a second but not necessarily linear component is getting the new material to be comprehensible to the learners.

Intelligibility

The idea of “intelligibility”, along with plausibility and fruitfulness discussed in the following two sections, was posed by Posner et al. (1982) as a result of a study of conceptual change college physics students. Intelligibility “requires an understanding of the component terms and symbols used and the syntax of the mode of expression” and “also requires constructing or identifying a coherent representation of what a passage or theory is saying” (p. 215). After experiencing dissatisfaction, a learner may see the new knowledge as useful for resolving the issue that has created the conflict between new and existing knowledge. Teachers assist students make a new concept intelligible by using elements in Posner et al.’s conceptual ecology, which consist of anomalies, analogies and metaphors, epistemological commitments, metaphysical beliefs and concepts, and other knowledge.

A challenge of preparing teachers to employ pedagogy based on the conceptual change model is to make the idea of intelligibility compelling to student teachers (Thorley & Stofflett, 1996). In other words, pre-service students learning about the conceptual change model may need to experience conceptual change before they can understand, describe, and apply the conceptual change model to their own teaching experiences. This literature claims that for this to happen, each element of the model, as well as individual components, must become intelligible to the students. In an attempt to

prepare preservice teachers to use the conceptual change model in their classrooms, Thorley and Stofflett (1996) attempted to apply the principles of the conceptual change model to the teaching of the conceptual change model. As a result, they identified a key element of creating intelligibility was the learner's ability to "represent the new idea" (p. 320). Representation was based on the elements of the conceptual ecology and was accomplished with one or many forms of what they describe as modes of representation. These modes included linguistic expressions, criteria attributes, exemplars, images, analogies or metaphors, kinesthetic or tactile representations, and other specialized modes and are similar to the aspects of a conceptual ecology (Posner et al., 1982; Strike & Posner, 1992).

Plausibility

"Plausibility" is how well the new concept matches the existing conceptual ecology (Posner et al., 1982). Posner et al. identified the fit of new knowledge with the learner's current epistemological commitments as being the best predictor for plausibility of a concept. What this means for the teacher is that by first understanding the learner's existing knowledge base and structure, some form of prediction can be made as to the degree of fit between the new knowledge and the current knowledge. Knowing the learner's existing knowledge base can help shape the pedagogical methods used to help learners so that the new knowledge is represented in a manner most compatible with the learner's constructs.

Another approach to defining plausibility is as "the grounds or justification for believing an idea" (Thorley & Stofflett, 1996, p. 322). The justification plays a role in the extent to which a new concept is accepted into the learner's existing knowledge base.

Determining plausibility is similar to making a value judgment where in the learner may employ reasons related to prior experience, existing knowledge, the learning environment, the format in which the new knowledge was presented or experienced, or the pedagogical method used to present the new knowledge. In this component of the conceptual change model, plausibility should not be considered as a “yes or no” decision, but a decision on reasons a new concept is acceptable (Thorley & Stofflett, 1996). The answer to “Why may the knowledge be plausible?” has been labeled as the “causal mechanism” (1996, p. 332). Establishing a causal mechanism allows the teacher to determine what part(s) of the new knowledge may allow the learner to associate a new concept with their “real world” knowledge, prior experiences, and existing conceptions. This causal mechanism may be unique to the individual learner, the individual situation, and the new knowledge.

Fruitfulness

“Fruitfulness” is more of a solidifying component of the conceptual change model. Whereas intelligibility and plausibility play a role in resolving dissatisfaction, fruitfulness describes a process by which a learner is able to use the new knowledge to solve additional problems or create new thoughts and ideas into the future (Posner et al., 1982). Fruitfulness may also play a role in motivating the learner to retain the new knowledge (Thorley & Stofflett, 1996).

Summary

The operant usefulness of the new knowledge is imperative to achieving conceptual change in the learner and is completed, in part, by demonstrating that existing knowledge is insufficient; providing evidence that the new knowledge solves an existing

problem; building evidence to support use of the new knowledge in future situations; and facilitating use of the new knowledge over time. The conceptual change model assumes that a radical change in learners' conceptions can occur. The change results in accommodation, not just a simple addition to an existing set of working concepts (Posner et al., 1982). This radical change may not be quick and may not progress sequentially or linearly through the four elements of conceptual change. As new moments of dissatisfaction arise, the new knowledge is repeatedly tested for intelligibility, plausibility, and fruitfulness. If at any time newly assimilated knowledge fails to meet these conditions, (Posner et al., 1982) accommodation—the real prize—may not occur.

Lines of argument within the literature include the necessity to progress through the conceptual change steps consecutively, the importance of creating dissatisfaction, and the need for learners to completely shift to the new conceptual beliefs (Thorley & Stofflett, 1996). Though they are all pertinent discussions, the purpose of discussing the conceptual change model of Posner et al. (1982) in this review was to demonstrate how constructivist theory of learning was interpreted and used in one of the most commonly used constructivist-based educational models in science education. Parallel concepts exist for children in Piaget's work, and for adult education for social and cultural learning. For science-related concepts, however, the conceptual change model is the most detailed and is supported by the greatest amount of empirical study.

Pedagogical Model for Constructivist Teaching

Up to this point, the theoretical aspect of constructivist learning, the methodological approach to adult education program development, and the epistemological basis of conceptual change have been discussed in relative isolation of

teaching contexts. The model that is presented, reviewed, and critiqued in this section combines pedagogy (practice) with theory. The perspective discussed in the remainder of this section is that teaching is centered on learning and instruction in mathematics. As with most pedagogical models, the practices work best in the hands of teachers whose epistemological beliefs are in sync with practice. To help illustrate this point, the components labeled A through F and the three elements of the hypothetical learning trajectory from Figure 2.1 will be explained.

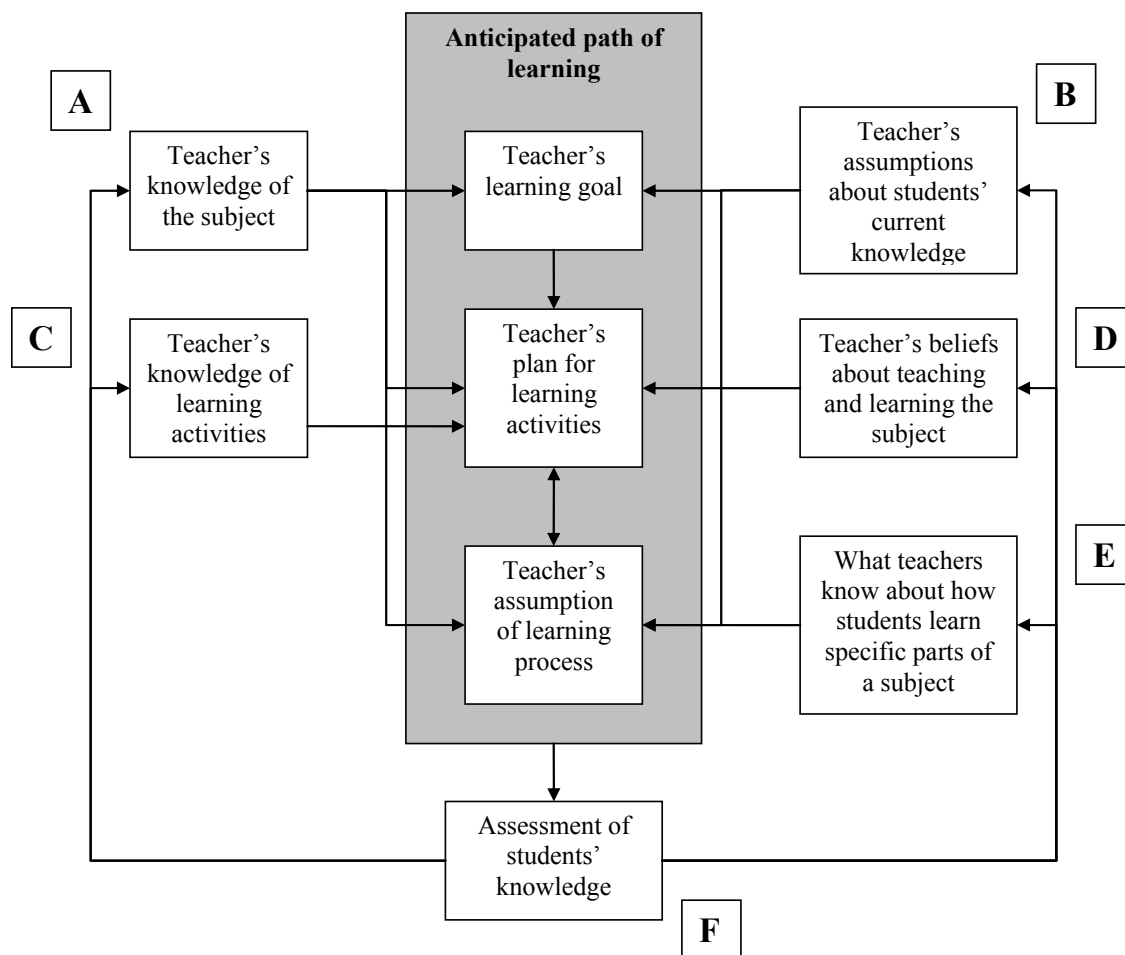


Figure 2.1. The mathematics teaching cycle from Simon, M. A. (1995).

The mathematics teaching cycle has two core elements, the hypothetical learning trajectory (HLT) and assessment (Simon, 1995). The HLT is “the teacher’s prediction as to the path by which learning might occur” (Simon, 1995, p. 135). The development of the HLT is based on a complexity of teacher’s knowledge, hypotheses and theories, as evident in Figure 2.1. Each of the elements (boxes outside the HLT in Figure 2.1) will be discussed in regard to their role and impact on student learning based Simon’s work (1995) and a review and critique of the diagram.

“A” – Teacher’s knowledge of mathematics (content knowledge)

For teachers to develop conceptual goals that serve as the root of the HLT, a thorough conceptual understanding of the subject matter content must be possessed by the teacher. Simon (1995) wanted the students to learn about the link between multiplication and area. To set such a goal, Simon first needed to have a conceptual understanding of this relationship and why it was crucial to mathematics learning.

The process of teachers conducting self-examination of their own subject knowledge serves several purposes. A “picture” of the teacher’s content knowledge is developed that allows for identification of a central point or concept of the subject on which teaching can be focused. In creating this picture, the smaller points or ideas are identified and related to the one central concept. “Mapping the landscape” of a subject helps teachers focus students toward the central concept because the nature of students’ comments or responses can be interpreted using the knowledge map. Once the organizing concept of the subject is understood, teachers can begin to think about how students will learn the concept. This mock role-playing helps teachers to plan instruction.

“B” – Teacher’s hypothesis of students’ knowledge

The assumptions about students’ current knowledge come both with experience and elicitation. An observant teacher who has taught a certain concept to a similar group (pre-service mathematics teachers in the case of Simon) will begin to identify certain stumbling blocks in the concept. The teacher also can identify which elements of the concept are most easily grasped by the students. Simon (1995) also used previous research and pretest data to facilitate the development of his hypotheses.

Assumptions about current knowledge are different however, than assessing an individual’s prior knowledge, which is a primary element of constructivist-based learning. Prior knowledge assessment focuses on measuring what a student already knows so teaching can start from that point. Assumptions about current knowledge does not require student’s prior or existing knowledge but the base of subject content that will be taught where students may typically have problems. In Simon’s experiment, it was “that identifying ratio relationships tends to be difficult and that additive comparisons are often used where multiplicative comparisons (ratios) are more appropriate” (Simon, 1995, p. 122) and that “their knowledge would be rule bound and that the concepts underlying the formula for the area of a rectangle would be unexplored” (p. 132).

Once the challenging points are determined, the teacher should then focus on why these areas cause problems. Only after the problem and the reasons for difficulty are clarified can teaching be adjusted to help alleviate or solve the problems.

“C” – Teacher’s knowledge of mathematical activities and representations

Learning activities in this context is a very general term that are not exclusively hands-on or inquiry-type activities. Instead, activities also may refer to lectures,

demonstrations, readings, assignments, discussions, games, videos, etc., that are used to help students learn (Simon, 1995). A teacher's knowledge of activities is not just having a laundry list of items to use, but knowing which ones are most effective for which concepts. The teacher's belief of how learning occurs dictates how an activity will be used. A teacher who believes in constructivist learning will use a demonstration much differently in the classroom than a teacher who believes in behaviorist learning. The variation in activity use is why clarifying a teacher's belief about learning plays an important role in teaching.

“D” – Teacher's theories about mathematics learning and teaching

Identifying teachers' beliefs about how learning a specific subject occurs can be used to shape teaching, to choose which activities are appropriate for the subject and the students, and how those activities are used. Fulfilling this component of this perspective requires experience, time, and attention on the part of the teacher. Having an articulated belief of learning and teaching is a beginning, but taking it to the level of specific subjects is much more involved. Teachers need to reflect on how they have been taught in the past and its outcomes to help formulate their beliefs for this specific subject.

“E” – Teacher's knowledge of student learning of particular content

What teachers know about how students learn a particular component and what students know about it is the essence of this piece of the perspective. The fundamental part is that it is about specific parts of a subject rather than the overall concept. This item relates to the conceptions about sub-points identified and explained in item B, “Teacher's hypothesis of students' knowledge”. Item B was a projection based on prior experiences

with teaching the subject, where this component is what the teachers have learned about those projections during the current teaching experiences.

“F” – Assessment of students’ knowledge

The purpose of assessment is to gauge where students are at in their understanding of the subject. The more familiar forms of assessment occur after the lesson or subject is taught, such as a quiz or test in school or an evaluation form at the end of a meeting. Assessment also can occur before and during teaching in forms such as pretests, preliminary student knowledge mapping, or reflective writing.

As presented in Figure 2.1, the results of student knowledge assessment influence all of the previous components of the presented perspective. The purpose of the anticipated path of learning is so that students gain knowledge about a particular subject, which is accomplished through a combination of the components in Figure 2.1. The assessment gauges whether learning occurred during the process and if so, what was learned. If the assessment determines that proper and adequate learning occurred, then the teaching is reinforced and the stage is set for the next session. If inadequate or improper learning occurred, the teacher can revise the previous steps for next time and determine a strategy to continue teaching so that the learning goal is achieved.

Such a process of reflective assessment was completed by Simon (1995). When the pre-service teachers did not understand the mathematical concept presented using the tiling of tables with rectangles, for example, the situation was reanalyzed and revisited using additional problems that challenged the students’ ideas and existing knowledge.

The Hypothetical Learning Trajectory (HLT)

The hypothetical learning trajectory (HLT) is the key to Simon's mathematics teaching cycle. The HLT consists of three components: the teacher's learning goal, the teacher's plan for learning activities, and the teacher's hypothesis of the learning process (Simon, 1995). I have generalized Simon's application of the HLT to science learning more broadly.

Developing a HLT prior to instruction provides the teacher with a tentative map of how the instruction will shape the learning. The learning goal is similar to a learning outcome: The anticipated result of the teaching. Just as the conceptual change model can not be effective in changing students' conceptions without first understanding the students' current conceptual ecologies, an HLT can not be developed without first knowing the students' present frame of the subject being taught, in Simon's case mathematical concepts (Simon & Tzur, 2004). The plan for learning activities is a framework of activities to get the students from their current conceptions to the learning goal. The final element of the HLT, hypothesis of the learning process, is the teacher's assumptions of how the students' learning will occur based on the activities that are chosen and how they are used. The HLT is 'hypothetical' in that as instruction and interaction progress, the teacher may need to alter the learning plan based on assessment of the students' thinking and understanding.

The dissertation used the HLT as a model for implementing constructivist-based teaching for conceptual change in an adult education setting. Based on this proposition, the research focused on the constructivist component of learners' prior knowledge, experiences, and existing behaviors.

Psychomotor Domain

A last, next area to address is the psychomotor domain that was organized by Harrow (1972) after both the cognitive domain (Bloom et al., 1956) and the affective domain (Krathwohl et al., 1965) were developed. The psychomotor domain is a classification of movement, originating from studies of children's movement. The term "psychomotor" was described in Krathwohl et al.'s work (1965) with the affective domain. To this extent, psychomotor is a term "concerned with manipulative skills, motor skills, and acts requiring neuromuscular coordination" (Harrow, p. 163). Using this definition, Harrow indicates that psychomotor is related to voluntary movement rather than involuntary reflexes.

Hauenstein (1998) addresses all three domains in *A Conceptual Framework for Educational Objectives*. The three domains are assessed individually based on a literature review that examined published variations of the three domains. He devised a standardized domain within each area that was consistent with the others in regard to numbers of levels, nomenclature, and so forth. The goal of Hauenstein's work was to provide a mechanism for integrating all three domains rather than focusing on each individually.

The psychomotor elements, described by Hauenstein (1998) as what one "does", are a product of what one knows and how one feels. The resulting behavior is based on knowledge (cognitive domain); and attitudes, beliefs, feelings, values, etc. (affective domain). Hauenstein also purports that the psychomotor domain and affective domain can be interchanged so that a person's experience (the psychomotor element) and knowledge will influence how they feel. Positive experiences combined with the

appropriate knowledge can result in favorable attitudes toward the experience and lend to repeated performance. To this end Hauenstein contended that “experiential learning is critical in developing the whole individual, particularly the affect” (1998, p. 105). The affective domain and subdomains are what open a learner to receiving or constructing new information. By offering a learning situation or climate favorable to the learner, receptiveness is improved; cognitive knowledge is assimilated or accommodated; desirable values and beliefs are developed; and correct behaviors are established, reinforced, or changed.

Consideration of the psychomotor domain in adult education is important because as Hauenstein (1998) affirms, the behaviors result from development of and interaction between the cognitive and affective domains. Adult education consciously includes both domains as affective components can impede or deter cognitive learning. Thus, assessment of psychomotor elements can be an indicator of cognitive and affective development resulting interactions between the two domains.

The psychomotor domain is included in constructivism. The review of Piaget’s works by Duckworth (1996) discuss the development of “sensorimotor intelligence” (p. 16). Sensorimotor intelligence is what was discussed earlier in regard to Piaget’s observations of children and conclusions that children performed behaviors at intellectual levels beyond what they could explain. As a result, the observation of actions or behaviors, or psychomotor elements, and the development of sensorimotor intelligence provides evidence of constructivist learning.

Food Safety Policy Issues

The United States government intends to protect food from causing foodborne illnesses. The FDA Food Code has a minimum requirement that managers demonstrate knowledge of foodborne illness prevention, Hazard Analysis Critical Control Point (HACCP) principles, systems based on HACCP principles, and requirements of the Food Code. One way for managers to demonstrate this knowledge is by completing and receiving certification from an accredited food safety training program (FDA, 2001). Though not required on the federal level, 17 states mandate that a certified food protection manager be on staff and an additional four states are working on similar legislation (Almanza & Nesmith, 2004). There is some evidence of effectiveness of the presence of a certified food protection manager during operating hours, which had a positive impact on compliance for four of nine foodservice facility types in a recent study (FDA, 2004).

Regulations

In 1993, the FDA issued the first version of the Food Code in its present format (FDA, 2001). Since then, a revised version was released every two years, until 2001. A supplement was published in 2003, with a revised edition released in 2005. As of March 2005, 86% of states and territories had adopted a food code similar to those released between 1993 and 2001 (FDA, 2005) covering 79% of the U.S. population.

The Food Code was intended to serve as a guide with recommendations based on science. “As in the past, this [2001] edition of the Food Code provides practical, science-based guidance and manageable, enforceable provisions for mitigating risk factors known to cause foodborne illness” (FDA, 2001).

The Iowa Food Code is based on the 1997 version of the FDA Food Code. Establishment inspection and Iowa Food Code enforcement are the responsibility of the Iowa Department of Inspections and Appeals (Iowa Department of Inspection and Appeals [IDIA], 2005). Only 15% of the inspections conducted within Iowa are performed by state inspectors (IDIA, 2005). The remaining inspections are conducted on behalf of the Department of Inspection and Appeals by inspectors employed by local health departments. Iowa foodservice establishments operating under the guidance of the Iowa Food Code are to be inspected at least once every six months (IDIA, 2004). The time between inspections may be lengthened if the following conditions are met.

The food establishment is fully operating under an approved and validated HACCP plan, is assigned a less frequent inspection frequency based on a written risk-based inspection schedule that is being uniformly applied throughout the jurisdiction, (or) the establishment's operation involves only coffee service and other unpackaged or prepackaged food that is not potentially hazardous. (IDIA, 2004, pp. 174-175)

Training

Training of foodservice employees regarding proper handling procedures has been a part of food safety education. A major player in food safety training is Cooperative Extension, which is an institution administered through the state's land-grant university system. Iowa Cooperative Extension "provides research-based learning experiences to improve quality of life in Iowa" (Iowa State University Extension [ISUE], 2005).

In cooperation with the Iowa Hospitality Association, ISUE Nutrition and Health field specialists offer and conduct ServSafe® training throughout the state. The staff performs lots of duties and began food service training only in 2000. The frequency with which each Extension field specialist offers training is dependent on demand within their respective areas and ranges from once or twice a year to monthly. In 2004, more than 600 restaurant and foodservice employees completed food safety training programs offered by ISUE personnel (ISUE, 2004).

The ServSafe® training offered by the Nutrition and Health field specialists is accredited by the American National Standards Institute (American National Standards Institute, 2005) and the Conference for Food Protection. The courses offered in Iowa consist of a one-day program that includes a certification exam. Most courses are offered in a one-day format, while a few are split between an afternoon and the following morning. All examination procedures are specified by the National Restaurant Association Educational Foundation in the *Examination Administration Handbook* (NRAEF, 2004) and are administered at each test site by the course instructor. The ServSafe® Instructor Kit is the primary source of training materials for ISUE field specialists. The Iowa State University Hotel, Restaurant, and Institution Management State Extension Specialist modifies the PowerPoint® presentations from the instructor kit to identify how the Iowa Food Code is different from the material in the generic presentations and on the certification exam, both of which are based on the 2001 Food Code with the 2003 Supplement.

Trends in Foodborne Illness

The prevalence of foodborne illnesses in the United States has most recently been measured through the Food Diseases Active Surveillance Network (FoodNet). FoodNet is part of the Center for Disease Control and Prevention's (CDC's) Emerging Infections Program (CDC, 2006). Trend data for illness prevalence has been collected annually by FoodNet since 1996. From 1996 to 2005, the prevalence of illnesses caused by *Yersinia*, *Shigella*, *Listeria*, *Campylobacter*, *Salmonella* and Shiga toxin-producing *E. coli* all decreased. The incidence of *Vibrio* increased and *Campylobacter* remained steady (CDC, 2006). While *Salmonella* decreased overall, four of five serotypes of *Salmonella* increased during the reporting time. Attributing illness causes with food prepared at home, at a restaurant, or other foodservice operation is challenging (Redmond & Griffith, 2003). Redmond and Griffith (2003) concluded that both home and foodservice contribute to foodborne illnesses. Estimates of illnesses caused by food from foodservice operations may be more accurate because of the sporadic nature of illnesses from food consumed at home and the typically small number of people affected by each situation (Redmond & Griffith, 2003).

Changing demographics and lifestyles also are impacting microbiological issues with respect to food (Knabel, 1995). The increased number of two-parent families that work, more children shopping and preparing food, and a greater percentage of elderly (identified as a higher-risk population) all contribute to a change in desired food features. The changes in desired features, which may include convenience, quicker preparation, minimal processing, and health-specific benefits or traits, impact a product's safety and thus, the chance for foodborne illness (Knabel, 1995). All of these elements impact the

safety of the food and can influence the role foodservice and in-home handling has in maintaining product safety and preventing foodborne illness. High quality training would seem even more important in the drive to minimize foodborne illnesses.

Conclusion

Science- and mathematics-oriented pedagogy can take many shapes, depending on the teacher's prior training and philosophical view of teaching and learning. A teacher's personal beliefs about teaching and learning will, in turn, shape the students' experiences in the classroom, whether the students are adults or children. Although youth and adults appear to learn differently, there are similarities that allow theories, models, and teaching techniques based on cognitive knowledge development in youth to be applied to adult education. An important overlaying concept is the influence of prior knowledge in learning. Learners enter into a learning situation with prior knowledge and conceptions, whether they are formed through informal inquiry and personal experience, formal education, or social interaction. Older learners have had more opportunities to build a repository of prior knowledge and for this knowledge to be structured and influenced by extrinsic elements such as societal norms, emotional experiences, and organizational culture. This complex set of knowledge areas, or conceptual ecologies as termed by Posner et al. (1982), in adults warrants greater understanding by adult educators.

Constructivism as used in formal science education for youth is focused on developing new knowledge through attentiveness to prior knowledge. Understanding a student's prior conceptions provides a frame on which instruction can be developed to maximize understanding at higher levels of learning per Bloom. Social interaction and

social knowledge can play different roles and may influence understanding differently. The preparation for and act of teaching for conceptual change requires careful planning, but must above all consider the learners' prior knowledge.

Strike and Posner (1982) note,

Perhaps what conceptual change theory requires is fewer teachers who emphasize calculating the right answer in their tests and instruction, and more teachers who emphasize the connections between physical conceptions, experimental evidence, and students' conceptual ecology. If conceptual change theory suggests anything about instruction, it is that the handles to effective instruction are to be found in persistent attention to the argument and in less attention to the right answers (p. 171).

CHAPTER 3. MATERIALS AND METHODS

As researchers and educators work to assess prior knowledge and to use it to inform teaching, the relationship between knowledge and prior experience and the structure of the prior knowledge must be accounted for to maximize the benefit to students and to achieve greater impact on learning. To this end, the research methods for the dissertation used were designed to provide data to examine adult learners' conceptual understanding of science aspects of food safety; specifically heat and thermal equilibrium. Research data provided evidence regarding how this conceptual knowledge, or lack thereof, influenced employees' decisions regarding proper food handling practices. Assessing canonical knowledge about food safety and food handling procedures, such as items on certification exams, elaborated foodservice employees' ability to retain nuggets of factual information, but routinely failed to identify how life experiences, attitudes, and beliefs inherent to adult learning impacted application of knowledge in work situations. As a result, methods widely used with conceptual research with children and in science education were employed to help answer questions about adult foodservice learners.

Selection of Research Focus: Temperature

Focusing the research on temperature and heat provided several methodological advantages. First, control of temperature is recognized as a main strategy for managing growth of organisms that cause foodborne illness across types of foodservice workplaces. Many of the microorganisms that cause foodborne illnesses thrive when foods stay at moderate temperatures, which are termed the Temperature Danger Zone and range

between 41 °F and 135 °F. Proper cooling and heating processes are essential to reducing the number of illnesses caused by foodborne pathogens.

Consequently, standardized food practices have always included processes for heating and cooling, length of time that foods can be kept at particular temperature ranges, and so forth. This makes temperature a well-understood focal point for foodservice workers, management, and food safety researchers. A focus on diseases was considered, but because of the complexity of the origins, causes, conditions for causing illness, uncertainty of illness cause, and the disconnect between practices and outcomes (due to the lag time growth phase of microorganisms), heat was selected. In addition, this dissertation research is new with respect to application of methodology and learning theory to food safety and adult learners, so a more conceptually basic topic was chosen.

Moreover, temperature has been studied in relation to food service practice, with interesting results. Olds (2004) tested six methods for cooling chili to determine which, if any, would meet the requirements of the Food Code. This dissertation research complemented the results of Olds (2004) by determining which practices were used to cool hot food and why foodservice employees used those techniques. Only three of the six techniques tested by Olds (2004) met the time and temperature requirements. All required the use of active cooling or technological interventions such as a blast chiller. This study showed that some practices do not conform.

In addition, food service institutions frequently fail to accomplish the goal of proper cooling (FDA, 2004). This conundrum informed the dissertation research such that it focused on temperature, and attempted to elicit unwanted behaviors and incomplete knowledge in sufficient quantity, making for a fruitful study of prior

knowledge of foodservice employees. The focus also made an important practical contribution due to the prevalence of errors in the workplace related to managing temperature (FDA, 2004).

This research assumed that foodservice employees could better meet goals of maintaining proper hot and cold holding temperatures if they knew more about the nature of temperature in protecting the safety of foods. This study aimed to describe the type and extent of conceptual understandings of scientific principles relevant to the prevention of foodborne illnesses. Because such work has not been completed with adults, the dissertation necessarily adapted existing methods and devised new ones to investigate this area. The research also determined conceptual understandings related to heat and thermal equilibrium that form the theoretical foundation for common food safety practices.

Heat and Thermal Dynamics

The research focused on the principles of heat and thermal dynamics as they related to cooling food products as understood and enacted by adults. This focus of applying science theory to adult learning and behaviors is a novel contribution to the field of constructivist science pedagogy. Knowledge of temperature and heat among youth in high school and college has been studied, but knowledge of adults in the applied context of foodservice employees has not.

K-12 and Post Secondary Studies

The investigation into and measurement of conceptual knowledge related to heat transfer and thermal dynamics has been conducted in relation to the physical world in a general sense. Jasien and Oberem (2002) investigated heat and temperature concepts by

undergraduate and post-baccalaureate students. The study focused on thermal equilibrium because this is a foundation necessary for comprehension of a more complex subject, thermal dynamics. A written questionnaire collected self-report demographic data and responses to a three-page multiple choice quiz about heat and temperature. Their findings indicated that regardless of the amount of science education the students had completed, knowledge of heat and temperature was incomplete and distorted by experiences in the real world in comparison to science. However, further analysis into why students answered questions wrong and why experiences with real-world ideas conflicted with or confused the science that had been taught was not examined. The relationship was only inferred by researchers through analysis of which incorrect answers were chosen and which groups of participants selected the incorrect answers.

Jasien and Oberem (2002) also studied knowledge of practicing physical sciences teachers with professional experience ranging from one to 30 years. When the data from the teachers were included in the analyses of correct responses, significant differences were existed between undergraduate, post-baccalaureate students, and practicing general physical sciences teachers. However, analysis of in-school only respondents resulted in no differences among the groups, regardless of science experience. This study identified sub par performance by physical sciences teachers on the quiz in regard to the basic concepts of heat, temperature, and heat transfer. The poor performance by teachers was projected to result in incorrect or inconsistent theories being taught in the classroom and could have perpetuated the problem of misconceptions and incomplete conceptual frames of students.

The methods used by Jones, Carter, and Rua (2000) enabled them to collect data about the way in which science concepts were associated in students' cognitive structures. This work, conducted with fifth-grade students, investigated students' understandings of heat, temperature, and convection. Jones et al.'s methods (2000) consisted of paired student work that was observed in a laboratory setting. Selected student pairs also were interviewed following the observation. The methods of Jones et al. are different from Jasien and Oberem (2002) because Jones et al. used paired learner interactions as the subject of observations, a move that included the element of social interaction in an investigation of knowledge development and conceptual change. Jones et al. (2000) concluded that an accurate conceptual ecology related to heat is complex; moreover, it interacts with other conceptual ecologies, such as evaporation and the water cycle. As a result, the researchers recommended that instruction intended to build upon students' prior knowledge of heat and convection must also include or address interactions with these other ecologies, as well as student experiences for successful learning.

The interviews of college students and instructors conducted by Posner et al. (1982) consisted of posing two problems to each interviewee. The think aloud technique was incorporated into the interview as the problems were solved, which meant that participants were asked to orally explain what they were doing and their reasons for doing it. Simon (1995) used a teaching experiment method to investigate conceptual understanding, which resulted in the mathematics teaching cycle and hypothetical learning trajectory discussed earlier. This method utilized the researcher as the teacher in a learning situation. Simon studied pre-service teachers of mathematics (1995). Data

sources from the experiment included transcripts from videotapes of teaching sessions, field notes recorded in a reflective journal following each session, and transcripts from audiotapes of researcher/teacher discussions with a second researcher.

Elicitation Techniques

A multitude of studies involving learners of various ages and a variety of content areas have used a cadre of data collection methods. These methods also can be used to elicit an understanding of learners' conceptual understanding as well as their processes for conceptual learning and change.

Methods novel to conceptual change research with youth included structured and unstructured interviews, observations, think-aloud protocols, and document reviews. Research by Trexler and colleagues (Trexler, 2000; Trexler & Heinze, 2001; Trexler & Meischem, 2002) used interviews with props to elicit conceptual understanding of pest-related and agricultural knowledge from children, elementary teachers, and pre-service elementary teachers. Conceptual change in adults also was examined by Price (2001) in a non-formal education setting through evaluation of two educational interventions designed to educate Philippine rice growers about proper pest management. Price used three methods of data collection to assess knowledge of the group and the individuals: free listing, triad sorting, and an interview process to orally administer a multiple choice test. The transition of one fifth grade teacher from an epistemology of "teacher as dispenser of knowledge" to "teacher as provider of situations and information" was studied with observations, interviews, and content analysis of journals by Etchberger and Shaw (1992, p. 411). Simon (1995) used teacher/researcher observations, reflection, and journal analysis from a classroom teaching experiment with pre-service mathematics

teachers, resulting in the development of the Mathematics Teaching Cycle and the Hypothetical Learning Trajectory (Simon, 1995, p. 135). Posner et al. (1982) utilized interviews of both college physics students and university physics instructors to collect data for their proposition of the original Conceptual Change Model. Multiple data collection methods have been applied in the assessment of conceptual knowledge and conceptual change in variety of age groups (Posner et al., 1982; Simon, 1995).

The method of elicitation can influence the type and form of knowledge that is assessed. Jones et al. (2000) used concept maps, card sorts, and interviews to assess fifth grade students' prior knowledge and conceptual ecologies related to heat and convection. Concept maps produce a visual representation of the ways in which elements are related or associated in the learners' conceptual framework by using a series of "propositions" (Novak & Gowin, 1984, p. 15). The proposition is composed of two concepts joined with a linking word or phrase to complete a thought. The card sort used 20 individual cards, each containing one term related to heat. Participants were provided the stack of cards and asked to arrange them into groups based on their perceived relationship of the terms (Jones et al., 2000). Interviews were conducted to investigate participants' reasons for the arrangement of their concept maps as well as their card sorts. The results from Jones et al. indicated that each of the methods yielded a different view of the students' prior knowledge and organization of that knowledge. For example, interviews about the card sort activity revealed specific word associations with experiences whereas the general interviews identified spontaneous use of analogies (Jones et al., 2000).

Interviews

Interviews also are commonly used to probe a person's understanding of a subject. The use of interviews can provide extensive data about a person's cognitive structure and how the concepts are organized within and among other ideas. Trexler and Heinze (2001) for example, used interviews with pre-service teacher education students to determine the extent to which their conceptual understandings of agriculture coincided with an accepted view developed by agricultural experts (Trexler & Heinze, 2001).

There are different types of interview formats. The structured interview encourages consistency of data collected across the sample (King, Morris & Fitz-Gibbon, 1987). A specific questioning guide, however, can limit data that are collected. The structured interview format provides little if any opportunity to investigate intriguing or unexpected data because of the predetermined format. Structured interviews work best when the research has a predetermined theory or idea of what is happening and the data used to corroborate this theory (King et al., 1987). Therefore, exploratory-type inquiries are best conducted with a technique other than the structured interview.

An unstructured interview encourages more naturalistic conversation between the researcher and one or more participants. The lack of rigidity permits the researcher to learn about unanticipated connections made between the subject matter and other phenomenon (King et al., 1987; Schensul, Schensul & LeCompte, 1999). Conducting unstructured interviews, however, requires a skilled interviewer who can ask open-ended questions and follow up with probes (Schensul et al., 1999). Unstructured interviews are the recommended interview technique when little is known about the subject or area of study and the purpose is to collect as much data from each respondent as possible. These

interviews are not bounded by a rigid interview guide but are directed with a small set of guiding questions and a series of probes (King et al., 1987).

Researchers also may employ special interview techniques in combination with either structured or unstructured interviews. For example, a Piagetian-type interview would be used to examine learners' conceptions about an idea (Duckworth, 1996). This type of interview includes the non-structured element of no predefined question guide, but typically includes a prop or model with which the learners can interact. Questioning surrounds learners' actions with the model or prop and is focused on identifying their notions about a concept rather than determining what they know (Duckworth, 1987). A think aloud protocol (Davison, Vogel, & Coffman, 1997) might be used to expand beyond the technique described earlier as a Piagetian-type interview. The think-aloud technique asks interviewees to verbalize the mental processes that are occurring while formulating ideas and conclusions. In short, "the think-aloud approach is viewed as particularly useful in understanding the products as well as the processes of cognition" (Davison, Vogel, & Coffman, 1997, p. 950).

Observation

Observation is another credible method of data collection. The researcher witnesses behaviors—sometimes in concert with interview data and sometimes without—and records data about the actual event, process, or behavior (King et al., 1987). The three types of data collection methods for observations include on-the-spot checklists, coded behavior records, and delayed report instruments (King et al., 1987). Each method has advantages and disadvantages depending on the situation being observed, the purpose of the observation, the question to be answered with the data, and the number and level of

observer skills. Schensul et al. (1999) warn, however, that observations are most accurate when based on a theoretical frame so observer bias is reduced. Moreover, like other qualitative techniques, the data collected is “always filtered through the researcher’s interpretive frames” (Schensul et al., 1999, p. 95).

Both interviews and observational studies may employ props or role playing situations in addition to being naturalistic. Photographs, props, tasks, the presence of other people, and objects may be used to focus or stimulate both behaviors and conversation. Typically, the prop or situation would be used across interviews. Prompts have been used to guide and focus personal interviews used to elicit data about conceptual understanding. Trexler (2000), Trexler and Heinze (2001), and Trexler and Meischen (2002) used a hamburger as an interview prompt with 5th grade students and prospective elementary teachers. The hamburger was used for multiple subjects, including understanding of pest-related science and agricultural education benchmarks. Though the interview topics were not about the hamburger specifically, the components of the hamburger were used to encourage discussion and elaboration of ideas by the participants.

The dissertation research employed a pot of chili as an interview and observational prop. Working with the chili and handling the equipment served as reminders to employees of what had been done in the past or of prior experiences. Chili worked because it is a nearly universal food item. Many cultures include some form of chili in their cuisine, which increases participant familiarity with the food item and reduces likelihood of introducing cultural bias into the research. In addition, chili is commonly associated with social gatherings and group meals, and is considered an easy

rather than difficult food to prepare and serve. The connection of chili with culture and camaraderie may have helped to put subjects at ease during the interviews.

Jones, Minogue, Tretter, Negishi, and Taylor (2005) utilized sensory feedback with different technological instruments to increase student engagement and understanding when studying nanoscience concepts such as viruses. Their study indicated that students were more engaged with the learning experience as ability to interact with the subject or topic increased. Using the interactive and multi-sensory interview prompt of the chili pot helped increase participant engagement with the interview and recall ability of thoughts, experiences, knowledge and other relevant data. The use of chili as a research prompt also had affective, social, and cultural components that made chili an ideal stimulus.

Data Collection from Adults

Data collection incorporated methods that examined life experiences and beliefs of the participant that shaped their present behaviors. Knowledge assessment was designed to investigate the extent to which participants knew what was right in regard to appropriate behaviors and the extent to which behaviors were correct. Prior experiences, family influence, operational procedures and policies, or cultural traditions were expected to outplay knowledge in regard to which behaviors should be performed. For example, a foodservice employee may have known that thawing meat in the refrigerator was the safest, recommended method, but his or her mom may have thawed meat on the counter. Nobody ever became sick and it was quicker. Therefore, thawing at room temperature might have been practiced at work regardless of the proper method.

There also was an expectation that a significant affective component influenced how adults learned and how they applied their knowledge to situations. Affective dimensions include personal beliefs, feelings, emotions, and confidence. The affective domain developed by Krathwohl et al. (1965) included the categories of receiving, responding, valuing, and organization. These categories go from a general level of awareness to a state of internalization where the learner uses them in judgments about behaviors. Together with cognitive knowledge, these characteristics influence the degree to which adults successfully changed or retained particular behaviors.

Data collection methods for adults in this research therefore allowed for elicitation of cognitive, conceptual knowledge as well as affective aspects that included beliefs, attitudes, and emotions associated with the concepts in order to draw conclusions about reasons for or barriers to desired behaviors. The methods examined conceptual understanding beyond the cognitive artifacts of factual knowledge to elaborate the origins and relations of these concepts. In a similar manner, the methods for examining learners' affective elements described such elements but also elaborated on why participants had these beliefs and what meaning they had for the learner. The work of Price (2001) is an exemplar of how methods to assess knowledge can be used to investigate learners' knowledge beyond the rote memorization and retention level. Through free listing (a brainstorming-type data collection technique), triad sorting (a variation of card sorting), and scheduled interviews, data were collected that allowed for group and individual knowledge assessments as well as the investigation of behavior change. The work by Price (2001) also indicated that even though adult learners (Filipino rice growers) did not understand the subject to the degree that they could utilize technical jargon (e.g., Latin

scientific insect names), they had a conceptual understanding of which insects were “friendly” and which ones were detrimental to rice. Importantly, they were able to apply this knowledge to behavior decisions of when to apply insecticides and how often after a constructivist educational program called “Farmer Field Schools”.

A distinguishing component of the research was its use of methodologies to go beyond how adults perform tasks or behaviors. The research investigated why food handlers made the decisions they did in regard to performance. A critical element was to know what the employees did in regard to steps for cooling food items. However, this study also investigated why they made these decisions, why they didn’t choose alternatives, and what they thought their decision had to do with cooling food items. The use of interviews during the observation component allowed for in-depth questioning into practices, why that practice was chosen, why specific equipment or techniques were used, what was happening to the heat, why the selected practice would help cool the food, and so forth. The combination of methods allowed participants to provide a verbal description along with a physical demonstration of practices.

Data Collection Instruments and Protocol

An interview guide with probing questions was developed to facilitate the interview and think-aloud aspects of data collection. The complete research protocol, including consent forms, data collection techniques, and the debriefing protocol were approved by the Iowa State University Institutional Review Board (IRB). The IRB application and approval letter are included as Appendix A.

The guide was specifically developed for this research and included questions related to prior experience with cooling foods, perceptions about which foods cool at

different speeds, a relative ranking of foods based on cooling speed, and an explanation of how this ranking was determined. The guide also included aspects about how and where the participants learned the procedures demonstrated during the chili component. The complete interview guide is included as Appendix B, the interview and observation notes form is in Appendix C, and the debriefing guide is in Appendix D.

Foodservice Employees

The study focused on adult hospital foodservice production and management employees whose job responsibilities were related to food preparation and handling. Professional standards and training applicable to these foodservice operations, such as ServSafe[®], helped these operations maintain compliance with all applicable laws, codes, and policies such as the Iowa Food Code (IDIA, 2005).

Sample

The sample for this research was sought from the foodservice employee pool at two health care-based foodservice facilities that were part of an urban health care system in the Midwest. The two facilities were under the same management; therefore, differed little in training, operating procedures, administrative practices, and menus. The primary pool of participants was chosen from one facility and additional participants were chosen from a second foodservice operation as part of cross checking for selection bias.

The research addressed knowledge of heat and thermal equilibrium in ways different from earlier work that focused on youth and on physical science concepts in general. The adults for this study varied in regard to age, gender, race and ethnicity. Data collection techniques and interview props were developed to avoid cultural biases that could have influenced the information provided by participants.

Selection criteria

Participants met minimal requirements: (a) worked at the food service operation for a minimum of four weeks, (b) job description must match by 90% to the actual foodservice responsibilities, and (c) job responsibilities must have included cooling foods. Selected personal data were collected, such as (a) extent of food safety training completed, (b) responsibilities within the operation, and (c) history in the foodservice industry.

Sample size

Data were collected from as many foodservice employees at one facility as necessary to achieve data saturation. Neuman (2003) explained that data saturation occurs when interviews are conducted but no new information is collected. After saturation at one facility, data were collected from participants at a second facility for comparison and as a check for biases associated with the first facility. Data from the second facility were no different than data from the first one, so only enough additional data were collected for validation of data from the first facility. Between 20 and 30 participants were expected to be needed in order to reach data saturation at the first facility and to conduct data validation at the second facility.

Foodservice Facilities

A hospital foodservice operation was chosen because of the multiple levels of employees within the personnel organizational system, each with different job responsibilities but all responsible for cooling food products. The importance of proper cooling techniques in a hospital is paramount given that the primary customers are

patients who often have suppressed immune systems and are more susceptible to contracting a foodborne illness.

This research differed from previous studies because it examined learners' understanding and knowledge of core science concepts—heat and thermal equilibrium—in an applied, naturalistic setting. The setting was the facility kitchen in which the participants worked. This was selected because it provided a degree of comfort since it was a familiar setting to the participant. Collecting data in the participant's workplace also allowed for assessment of what elements of the cooling process could be controlled by the participant and which ones were mandated or built into existing systems.

The facility's kitchen also was selected because it provided for an opportunity to assess what equipment and utensils were available for cooling food. The participants had access to these resources during the discussion and observation of practices for properly cooling food. The Food and Drug Administration Food Code (FDA, 2001), which serves as the basis for many jurisdictional food codes in the United States, includes rules about cooling foods to prevent the growth of foodborne-illness causing microorganisms. However, the Food Code specifies outcomes rather than systems or processes. The recommended processes for satisfying the Food Code requirements are most commonly included in food safety training programs provided by foodservice industry organizations, but may also be left to individual managers in institutions to develop locally.

Differentiation of techniques

Data collection methods were adapted in this study to determine how foodservice employees' conceptual knowledge and misconceptions about heat and thermal equilibrium influenced their behaviors. An element of the data collection process

included introducing an idea that is contradictory to the employees' current ideas, beliefs, and knowledge about food handling and heat. Data included employees' responses or reactions to the conflicting conception. Determining the content and extent of employees' conceptual ecologies about heat, thermal equilibrium, and their job responsibilities illuminated the employees' conceptual understanding of these concepts and how the employees applied them to specific tasks involved in cooling foods.

Science of Heat Transfer

The concepts of heat, temperature, thermal dynamics and thermal equilibrium have been studied extensively in children. The two concepts this research focused on were heat and thermal equilibrium. Arnold and Millar (1994) provided a clear and concise scientific explanation of heat, temperature, and thermal equilibrium when two objects are in direct contact with each other.

...if two objects at different temperatures are placed in thermal contact, heat will flow from the one at higher temperature to the one at lower temperature. For a given pair of objects, the bigger the temperature difference, the greater the rate of heat transfer. If (net) heat flows into an object, its temperature rises; if (net) heat flows out, its temperature falls. This means that, as heat is transferred from one object to another, the temperature of the hotter object falls, and that of the cooler object rises. After a time they both reach the same temperature. They are then said to be in *thermal equilibrium* with each other (Arnold & Millar, 1994, pp. 406-407, original emphasis).

This is the most simple of situations: the two objects in direct contact. Arnold and Millar (1994) further explain the situation becomes more complex due to the surroundings. A more complex situation that they explain and is representative of the idea of cooking and hot holding foods (and can be reversed to represent cooling and maintaining cold holding temperatures of foods) is “of an object being raised to, and then held at, a temperature higher than its surroundings by the continual transfer of heat from a neighbouring hotter object (a heater)” (Arnold & Millar, 1994, p. 407).

The temperature of the object initially rises, because heat is being transferred to it. As a result, its temperature becomes higher than that of its surroundings, and so it begins to transfer heat to its surroundings. The rate of this transfer increases as the object gets hotter, i.e., as the difference in temperature between it and the surroundings increases. Eventually the object reaches a temperature at which it loses heat to the surroundings at exactly the same rate as it is receiving heat from the neighbouring hotter object, i.e., it is losing heat to the general (and cooler) surroundings at the same rate as it is gaining heat from one specific (and hotter) part of its surroundings. The object is then in thermal equilibrium, in the sense that there is a balance between the heat input and output and its temperature is steady.

These explanations of two heat transfer situations were used for the basis of interview transcript analysis. Arnold and Millar (1994) acknowledged that students and adults could have a conceptual understanding of the relationship between heat and temperature without being able to explain it with scientifically accepted nomenclatures or

descriptions. Such realization was integral to the determination of whether participants “got it” in regard to these concepts.

Data Collection

This research examined the role foodservice employees’ knowledge about the concepts of heat transfer and thermal dynamics played in their decision making when confronted with a situation that required cooling food products as part of safe food handling practices. The data collection plan involved an interview that was mainly structured, but partially unstructured; naturalistic; scripted behavior observation; and use of a prop (a pot of chili).

The Chili Study

In order to elicit knowledge from food service employees, the investigation employed a scenario termed, “Handling the Pot of Chili”. Data were collected as participants were asked to demonstrate their procedures for cooling a large pot of chili. A large pot of chili was chosen as a research prompt for multiple reasons. First, it was a dense food item, making it cool slower than other liquid food items like a broth-based soup. Second, the chili was a liquid-based food item rather than a solid (such as a roast), which provided an opportunity for multiple cooling techniques to be used independently or in concert to reach proper end-point temperature requirements. Employees could have chosen from among several appropriate cooling techniques for liquid food items to achieve the goal specified in the food code. The range of options was intended to reduce the likelihood that respondents would provide a memorized but not internalized or practiced account of cooling procedures. Generally, there were two types of cooling for liquid foods from which they could have chosen:

1. Passive cooling could have been used by dividing the volume of chili into multiple small, shallow pans to increase surface area, which allowed for quicker heat dissipation.
2. Active cooling techniques of an ice water bath around the large pot and using a chilling stick in the pot also could have accelerated the cooling process. In addition, combining these techniques with mechanical techniques such as a blast chiller would have provided even faster cooling. A blast chiller is similar in concept to a convection oven except the moving air is used to rapidly remove heat from a product rather than to rapidly heat the product.
3. A combination of these and other techniques.

Findings were used to establish a benchmark of foodservice employees' concepts about heat transfer and thermal dynamics; identify the extent to which they applied this understanding to their responsibilities of cooling food; and to determine external, environmental or personal factors that might have influenced their knowledge or its application on the job. This was done through data collection methods that combined observational data of task performance with personal interviews.

Individual Interviews

Individual interviews with participants focused on the steps and reasons for cooling a large pot of hot chili. During the interview, references to alternative methods, recommended methods, or requirements associated with the Food Code by the researcher were minimal and used only as a prompt to encourage discourse between participant and researcher. The interview component was used to encourage participants to become familiar with and relaxed around the researcher. The interview also was used to collect

some demographic information, such as how long they had been working in food service and how long they had been working in their current position.

Document Review

Documentation is part and parcel of good service establishments and may include a Hazard Analysis and Critical Control Point (HACCP) program, a program based on HACCP principles, signage and instruction sheets created locally, memos, and other written agreements. When available, documents were reviewed for procedures, recommendations, and practices associated with food cooling include a HACCP plan, policy or operating manuals, management guidelines from contracted facility management, training and orientation materials, and other educational materials provided to employees. Other documentation included was a list of procedures for cooling foods or other signage posted in the facility. This analysis consisted of notation of the extent to which posted procedures were followed, but also adherence of posted procedures to standard research-based cooling practices.

Behavioral Observation

The research collected observation data in the kitchen of the foodservice establishment using the chili simulation to study the steps of how the participant actually proceeded with cooling a pot of chili. This component of data collection also examined and inventoried the available facilities and equipment.

In addition to direct observations of the employees, informal observations were conducted both in the kitchen and in the service area. Behaviors of employees were observed while touring the facility with the manager and while general facility observations were conducted. These informal observations were important because they

provided evidence that employee behaviors were not being modified during the formal, one-on-one observations.

Think-aloud Protocol

Data collection methods also used the think-aloud protocol in conjunction with the observational component. The think-aloud protocol has its intellectual roots in qualitative research related to cognition and the cognitive-behavioral relationship (Davison et al., 1997). In practical terms, a researcher employs a think-aloud protocol by asking participants to verbally articulate what they are thinking at the time that they perform a behavior or task (Davison et al., 1997).

The think aloud protocol was applied to the study at the point when participants began to demonstrate the chili cooling techniques. As they performed the steps, participants were asked to aurally elaborate the thoughts and cognitive processes they were performing. After the entire process of cooling the chili had been completed, the researcher went back to particular points of interest related to heat transfer and asked additional questions or asked for elaboration of responses.

Data Analysis

The data collection rubric consisted of two components, participants' knowledge related to heat and thermal equilibrium and the participants' procedures for cooling the chili. Each of the components included an open-ended data collection technique that was completed with data from the combined interview, observation, and think-aloud protocols.

Interview and Think-aloud Data

The interview and think-aloud data were recorded on a data collection sheet and on audio tape. This data included knowledge and behavioral components. The analysis utilized the open-coding technique described by Strauss and Corbin (1990) for developing grounded theory. Although this study was not designed to develop grounded theory from interview and observational data, the open-coding technique allowed for development of themes within the transcripts and interview notes. These initial themes then were further reviewed, refined, and re-applied to a final detailed review of transcripts to identify evidential statements that typified or illuminated the themes. The initial step of open coding was to break the data down and label concepts. After concepts had been identified in the data, they were reviewed and grouped into categories, which were given a new label that was more general and described all included concepts (Strauss & Corbin, 1990). The categories were then defined and described, or given characteristics. These characteristics were considered dimensions, which have a range. The ranges allowed concepts to be spatially located within the category (Strauss & Corbin, 1990).

Observation Data

Behavioral data analysis was similar to the interview and think-aloud data. Observation notes were analyzed using the open coding method to identify concepts, categories, and dimensions. In addition to looking for patterns within each interview and across interviews, data also were analyzed for each of the relevant behaviors that have been identified as appropriate for cooling hot foods.

Document Review

Signage and other visual procedural reminders were analyzed during a review of photographs that outline the facility. This analysis included three components, (1) the presence or absence of signs; (2) the location of signage in relation to work areas where food products were prepared for storage and were stored; and (3) the extent to which posted procedures or reminders adhered to practices included in the accredited food safety training curricula.

Summative Analysis

Analysis of the documents, interview and think-aloud transcripts, observational notes, and other visual products from the facilities followed a procedure adapted from Merriam and Simpson (1984). The diversity of the multiple data formats permitted the analysis to be similar to what is suggested for case study analysis. This research had similarity to case study research because multiple interviews were conducted at two facilities and an observational component was included in data collection. The research also included some ethnographic characteristics, including the data collection within participants' natural work environment of the kitchen.

As prescribed in Merriam and Simpson (1984), data from the three data collection practices were aggregated, which was “a process of abstracting generalities from particulars, of looking for patterns characteristic of most of the pieces of the data (Merriam & Simpson, 1984, p. 97). Categories from the data were developed by sorting the data components into “manageable units” (p.97). Each unit was reviewed for internal consistency and diversity from other units. The units were then labeled and summarized

in a narrative description using pertinent data elements to support, elaborate, or depict the unit's central organizing theme.

The types of data collected were conducive to reporting both through narrative and visual representation. One outcome was developing a concept map using participants' aggregated knowledge of heat, thermal equilibrium, and cooling practices. This concept map illustrates the extent to which the participants as a group understood how heat and thermal equilibrium were related to cooling. The map also shows the relationship between participants' behaviors, preferred cooling practices, and elements that created a difference between these two sets of procedures.

A second outcome was developing a continuum of factors the employees describe as having variable degrees of control, ranging from no control to complete control. Elements of the operation, such as changes to the menu, modifications to recipes, and procedures used for cooling products, were placed on the continuum in the aggregate to depict the perceived degree of control.

CHAPTER 4. RESULTS AND DISCUSSION

The qualitative-based, mixed methods approach to data collection resulted in 18 data-rich interviews that were transcribed into 17 full-text transcripts. One interview was not transcribed or included in the analysis because technical issues occurred that ruined the audio tape. Analyzing these 17 transcripts resulted in findings that were consistent with some expectations developed prior to data collection but also generated some new and robust concepts and themes. These findings will be reported and discussed later in this chapter. To better understand the context of the discussion to come, a summary description of the participants, the interviews, and the resulting transcripts are provided. The descriptive data about the participants and transcripts are reported in Table 4.1.

Table 4.1. Characteristics of participants and number of interviews.

Number of interviews	18
Number of interviews transcribed	17
Average number of lines per transcript	773
Average number of pages per transcript	24
Gender	8 Males, 10 Females
Number of participants from each facility	Facility A: 6 Facility B: 12
Dates of interviews	Facility A: June 20-23, 2006 Facility B: June 27-30, 2006

The interviews captured on audio tape were transcribed by an individual on contract. To facilitate data analysis, specific instructions about the transcription process were provided to the transcriber, including cleaning up the interviews by removing redundant phrases, “ums,” etc., as long as these corrections did not alter the meaning or context of the spoken word. The transcriber consistently labeled discussion from the researcher as being “Jason” and marked participant comments with an abbreviation of their first name. Pseudonyms were generated for analysis and reporting to maintain participant anonymity and confidentiality.

The electronic transcripts were maintained in their original format from the transcriber on the computer of the researcher and only have been placed on a DVD electronic storage device outside of the computer’s hard drive for transfer from an old computer to a replacement computer. The DVD has since been destroyed. All original transcripts, as received from the transcriber, were labeled as “archive copy”, printed, and stored in the researcher’s locked office. A second set of transcripts was printed for use in data analysis. The set of “working copies” remain locked in the researcher’s office. Audio tapes are being kept until data analysis and reporting are complete, at which time they will be destroyed per protocol of the Iowa State University Institutional Review Board.

All 17 transcripts were included in the data analysis process. Select elements from five of the 17 have been included in this chapter to emphasize key points of the discussion. The use of participant quotations presents comments that are expressive of respondents’ themes, beliefs, perspectives, and knowledge.

Four themes were consistently represented in participants' responses and actions. These four themes are categorized as Identity; Differentials of Knowledge; Institutional Rules; and Climate Change. Their implications for food safety training and adult education are elaborated in later chapters.

Identity

"I've cooked all my life. That's all I know is cooking." *Judy, tray line cook.*

A key theme from the interviews concerned identity. Identity is a set of characteristics that make something unique, separate from the rest (Erikson, 1980). Identity is a construct that is considered key to adult learning. The adult learners' life experiences are important to them and are a strong basis for their personal beliefs, definition of self, knowledge base on which new experiences and knowledge are built, and from which their perspectives about life's events that include such elements as work, society, family, and self existence are generated.

The primary identity for the majority of respondents was a "cook". A cook is engaged in food preparation for most of their lives with intentions to earn a living from it. However, a cook is also a position of stature and respect. To be a cook was to have a position of responsibility. Cooks are integral to the foodservice operations. They feed patients, visitors, and staff 24 hours a day, 7 days a week, and 365 days a year. Crucial to the research, the identity of a cook is focused foremost on preparation. As per the research, cooks did not focus on post-preparation; specifically, cooling. In this instance identity underscored the personal allegiance of the participants toward the fundamental role of their job, which was to prepare and cook foods.

To outsiders, identity as cook was known and accepted. There was no external name or identity, however, associated with responsibilities for cooling foods. A person responsible for using proper techniques to efficiently and adequately cool hot food products to maintain product safety and quality did not have a title but possibly should be named—perhaps a "cooler." However, this title or position does not afford the stature of a cook. Consider the dialogue that occurred between the researcher (Jason) and "Judy" (pseudonym). Judy was a tray line cook who had 20 years of experience in vocational rehabilitation training clients how to read recipes, cook, bake cookies, and so forth. Her tray line cook duties included "cooking the food, putting it on the tray line, on the steam tables, making sure there enough food prepared, and making sure that it was hot when it was put on the line." A tray line cook prepares food to go onto the service line where patient trays are readied for service to the patients in their rooms. She started in the hospital foodservice operation approximately six years ago as a relief cook who covered positions when the regular staff were absent. Judy transitioned from relief cook and started her responsibilities of tray line cook about four and a half years ago. This conversation occurred on June 20, 2006, in an office and continued into the facility kitchen.

Interview 3, line 581

Jason: From whom or where or how did you learn that process or that procedure for cooling any of the foods?

Judy: We went to a training and then just learning myself when I started working for the state, you know, start learning the cooling. I've cooked all my life. That's all I know is cooking.

The identity of cook is separate from that of a “cooler” and is emphasized by “Sue” in a different way. Sue was a weekend supervisor responsible for foodservice operations during the weekend shifts. In addition to supervisory responsibilities, Sue also assisted with production on Fridays and the weekend. Foodservice for Sue dated back to 1985 and included a variety of positions and education, including a culinary arts degree from a community college. She discussed cooking special sauces as a way of addressing a question about the effectiveness of a cooling. Note the absence of focus on cooling and the shift to cooking in the second line according to a process that Sue termed, “re-thermalating.”

Interview 8, line 334

Jason: Has there ever been a time when a technique failed to cool the product the way you wanted it to?

Sue: No. But to re-thermalate it might have other things to do with the product. Like a seafood bisque. You might bring the product temperature down but the process of re-thermalating it again usually causes the product, because of its nature, to break. The fat separates and you have this curdled cream sauce. Because you’re trying to re-thermalate it either by the steamer method, which isn’t the best, or throwing it back in a steam-jacketed kettle, you have a cream-based product that is hard to reuse.

As interviewer, I was unable to prompt Sue to discuss cooling in any more detail. Inquiries into specifics about cooling reverted to a discussion about how products responded during cooking, reinforcing the concept of identity as cook.

Education and Training

The identity of being a cook (and not a cooler or food safety officer) was developed through and reinforced by multiple elements that included participants' education and training; job title responsibilities and pressures; and their beliefs about what was important in their service role. Employees learned about food service from numerous sources, including community college culinary arts programs, military training, industry training, and professional development programs—including on site. These learning opportunities emphasized the aspect of cooking or producing foods, the art and science of combining ingredients that produced a quality item. The affective components of enthusiasm, dedication, and pride were directed toward the foods produced by the cooks. These food items had personal and social significance in that the cook's skills could be judged by those eating the food. This personal investment of time, care, and creativity in producing the foods was tightly bound with cooking abilities—such that they became cooks rather than food service employees. For example, I did not observe any reference to the personnel as “foodservice employees”, but the literature calls them this and presumes food safety is a component of the responsibilities associated with this role or title.

The pride as a cook also was exemplified by “Beth”, an entrée cook. As an entrée cook, Beth was responsible for preparing main dishes that were featured in the café rather than served to patients. Beth's training included attending a culinary arts program at a community college before leaving the foodservice profession to start her own business outside of food service. She returned to food service five years ago when she was hired at the hospital as a relief cook. Beth has been an entrée cook the past four years.

Interview 5, line 223

Beth: One of the nice things that has happened since our new chef was hired is that she brought in a lot of gourmet entrées. It's been really nice to learn to cook those whereas before it was pretty institutional. Now it's a lot different stuff and it's nice. I think people are really appreciating the change.

Job Title and Responsibilities

With the exception of some upper management personnel that had titles of managers or directors, all participants had the word cook in their titles or titles that emphasized the creation of food items with heat, such as baker. Relief cooks, tray line cooks, shift cooks, weekend or night cooks; all of these titles reinforce the image and expectation of producing food products. Employee responsibilities, whether explicitly defined by a job description or implicitly assumed by employees' understanding of their jobs, focused on an end goal of having food ready to serve on the patient tray line, the room service system, or in the cafeteria for hospital employees and visitors.

Interview 3, line 148

Sue: I'm responsible for cooking the food, putting it on the tray line, on the steam table, making sure that I have enough food, and making sure that it's hot when I put it on the line.

Further questioning about position responsibilities was required before participants discussed or acknowledged that their position also involved cooling food or otherwise preparing food for storage. This was frequently the case even after the initial questions directly asked participants to explain the responsibilities of their position. The initial questioning about position responsibilities resulted only in an immediate summary

of cooking responsibilities. Not until additional probing into who handled "leftovers" did many of the participants acknowledge that cooling was one of their responsibilities.

Interview 3 line 181

Jason: So as a cook, you also cool or take care of leftovers after the tray line is finished?

Judy: Yes. At 1:30 I tear down the steam table and then if there's food left over, then I cover it, put it in another pan, and put it in the walk-in cooler.

Importance

To some participants, there was a persona to the food they prepared. Food was not just a product of their job, like making widgets; but rather there was a distinct purpose and role fulfilled by the food they prepared. This persona of food and personal connection with the importance of producing quality, appreciated food for the foodservice customers is summarized in the conversation with Beth, the entrée cook who took a 20-year break from working in food service.

Interview 5, line 349

Jason: What would be something that you'd probably cool down every day?

Beth: Well, probably the biggest would be soup, because it just seems like they're not eating a heck of a lot of soup in the summertime.

Jason: Is it seasonal?

Beth: Yes. In the wintertime there's a lot of soup being eaten, a lot. We have what we call a spring/summer menu and then we have a fall/winter menu.

Jason: Seasonal preference?

Beth: Comfort food. There's comfort food in the spring and the summer and the same with the winter.

Jason: Usually it's not soup?

Beth: Yeah. Yeah. When it gets cold and rainy outside, even in the spring people turn to comfort food. They like the mashed potatoes and gravy and something that's going to stick.

The role of cook was consistently linked to the tasks of cooking foods, getting foods hot, maintaining foods at a hot temperature in order to safeguard flavor and texture, and to please customers. With few exceptions, the food safety aspects of participants' jobs were restricted to getting foods hot and keeping them hot. Properly cooling foods was not commonly mentioned, much less given the level of food safety importance as was provided to heating or maintaining hot temperatures.

Participants frequently used heating and cooking as a reference point when questioned about cooling. Reasoning for why steps in the cooling processes were conducted; justification for labeling foods as quick cooling or slow cooling; and the necessity to monitor cooling as closely as cooking were but a few of the situations when cooking was used as the default frame of reference.

Differentials of Knowledge

"Differentials of knowledge" is an element that is based on participants' knowledge through application of Bloom's taxonomy of the cognitive domain (Huitt, 2004). The taxonomy consists of six levels and as learners' knowledge advances higher on the taxonomy, behaviors are more complex. The differentiation made here is between rules-based knowledge and principles-based knowledge. Rules-based knowledge, in

regards to the data, is situated in the first three levels of Bloom's taxonomy: knowledge, comprehension, and application. These levels are defined by a learner's ability to recall information; to translate or interpret information; and to select and use information for problem solving, respectively. Rules-based knowledge is when a learner can remember and follow rules or procedures. Learners using rules-based knowledge remember the information taught and directly use it, without modification or adaptation, to solve problems; which are the characteristics of knowledge, comprehension, and application.

Principles-based knowledge, as used in this discussion, is situated in the top three levels of the taxonomy: analysis, synthesis, and evaluation. These three levels include a learner's ability to distinguish, classify, and relate information; to originate and combine ideas into a new plan; and to appraise or critique using standards, respectively (Huitt, 2004). Principles-based knowledge is a more conceptual form of knowledge that can be applied to various situations by the learner and can be adapted to generate a new solution to a problem when the existing knowledge is insufficient. This flexibility and adaptability of concepts is the essence of how Huitt (2004) explains analysis, synthesis, and evaluation.

Participant behaviors and responses related to cooling food followed the distinction made between rules-based and principles-based knowledge. When discussing cooling practices participants focused on the procedures learned during training; a rules-based approach. Even though off-site training included additional practices that might have improved the cooling process, participants maintained that the steps learned were sufficient for cooling.

Cooking, however, was much different. Participants frequently discussed adding a personal touch to recipes. Adding ingredients not on the original recipe; adjusting spices to modify flavor profiles; using different cooking equipment; and monitoring cooking progress and adjusting cooking time to maximize product quality are a few examples cited by participants that used principles-based knowledge. Participants analyzed the situation and their culinary knowledge; synthesized a method or process different than what was known (the recipe or instructions); and evaluated the outcome of this new plan with the criteria of final product quality.

Principles-based knowledge application to cooling was seldom observed or identified through the interviews. Examples of how principles-based knowledge could have been applied to cooling include reducing portion sizes prior to use of the blast chiller or storage in the cooler; using an ice bath at times other than when necessary because the blast chiller was inoperable; and monitoring and stirring liquid products in the cooler.

Rules-based *versus* principles-based knowledge is a critical distinction between participants' disposition toward cooling compared to cooking. The use of rules-based knowledge was prominent in participants' explanations and actions related to cooling food.

Out of Sight, Out of Mind

"Out of sight, out of mind" summarizes the cooks' attitudes about foods once they have completed cooling procedures such as putting foods in the refrigerator. Procedures used in the facilities to cool products for storage were taught mainly through on-the-job training at the facilities. Some participants discussed learning practices at previous jobs,

in training, or in formal education. Despite all this, the data revealed no procedures-based cooling on the job; the specific process as described during the chili demonstration component was specific to the respective facilities. Little, if anything, was used in practice by the cooks with the chili except what they had been told to do—despite training.

As a result of being taught a specific procedure, participants took a high level of the effectiveness of the procedures for granted. There were frequently two processes described, one was the preferred method and the other was the typical method (see also Figure 4.1). For the chili, the typical method involved transferring the chili from a gallon container into a large, shallow pan, placing the pan in a blast chiller until the desired end-point temperature was reached, covering the pan, date labeling it, and placing it in the walk-in cooler for storage. Many variations of such procedure were actually described, but the one described by many as typical often skipped the step of the blast chiller. When asked if any follow-up was done with the products to ensure they were cooling properly, none of the participants indicated they did anything with the food after it was placed in the walk-in cooler. There was a reliance on the procedure they were taught or were using and on others taking responsibility.

“Kevin” had worked at the hospital for four years as a relief cook. Prior to joining the hospital staff, he was on active duty in the Navy where he received formal food preparation and safety training. As a relief cook, Kevin frequently experienced the variety of roles and responsibilities associated with the foodservice cook positions.

Interview 16, line 286

Jason: What has prevented food from going through the blast chiller, other than it being broken?

Kevin: Some of the times it depends on the hours. We're on our set schedules and we can't stay behind and make sure it's all done. Sometimes they keep the cafeteria open later than normal hours, which causes them to keep the food out there. Well the cooks are gone. Who's going to blast-chill the food? So as far as I know, most of that what's left out there is supposed to be thrown away, but I'm not sure if it's always being done. Like I said, I don't really pay attention that much.

The differentials of knowledge frame also is implicated in the cook's practices toward modifying the procedures taught for the facility with knowledge gained from off-site food safety training. Multiple cooling techniques beyond those described in the preferred or typical methods earlier were cited by participants, but were not used because they appeared to take too much time. As a result, participants relied on facility-specific procedures for cooling foods.

Institutional Rules

The theme of "institutional rules" surfaced from the interviews in many forms, but all referred to the concept of working within a set of rules, restrictions, or guidelines. Institutional rules are a form of control over systems, whether political, social, economic, or organizational, established by some person or group with actual or perceived authority or control. The evidence in this study supports the claim that institutional rules were in play or, at a minimum, were shaped by employees' conscious consideration of authority

figures. These authority figures were not singled out by participants but through the discourse and analysis took two forms, the first being proper behaviors taught during food safety training and the second was an ambiguous form of jurisdictional rules. The following citation from Beth, the entrée cook, is an example of where these ambiguous jurisdictional rules influenced her perceptions of right and wrong. She did not specify who established or would enforce such consequences, but made it evident through her remarks that she did not want to break these rules and receive the anticipated punishment.

Interview 5, line 922

Jason: Is there anything you can do to help speed up the cooling process?

Beth: The freezer, or the cooler. Just so it's not sitting out in room temperature....

That's the no-no.

The consequences of improper cooling practices also were explicitly described by “Nate,” a patient cook. As a patient cook, Nate worked with preparing and cooking food for patients. Patients were the “most protected” of customers for the foodservice operation’s unit because patients' ailments typically made them more susceptible to contracting a foodborne illness.

Jason: I was just wondering if there was something that went wrong during a time when a product did not cool as you expected it to.

Nate: I've never made anybody sick so I would say no, at least not yet in my life.

The practice of leaving food items at room temperature or “just sitting out” was referred to in multiple interviews. The reference, though, was in two different manners. Some participants included setting food out at room temperature as an integral component of their typical cooling method. In contrast, other participants acknowledged

such a practice was against the rules and if caught would result in getting into trouble. In standard food safety training, leaving food at room temperature is not recommended as a good practice.

Interview 16, line 228

Jason: Is there ever a time that you wouldn't or haven't used the blast chiller to cool down product?

Kevin: In the past we had problems with the Freon running out and of course it just turned to an oven.

Jason: So then what did you have to do?

Kevin: Pretty much just cover the product up and make sure no air get in and just let it...push it in the back of the cooler or let it sit out so it kind of gets down to room temperature, and then push it in the back of the cooler.

The institutional rules element of an unknown or unidentified set of rules regarding handling practices was recalled by participants in various forms. For some, the practice of leaving food out was just a “no-no” that did not have any perceived ramifications. For others, cooling foods at room temperatures would yield consequences, or that they “would get in trouble”. Some participants’ responses also acknowledged a form of formal governance that varied in degree of importance or significance to the participants. A common example from the data is based on responses about the facilities having a formal policy manual or set of operating procedures for cooling. Knowledge of such a manual ranged from “one does not exist” to “there’s a manual around here somewhere.” The identified form of such manual was as varied as its existence. Some participants referred to materials received in a new employee orientation packet. Others

referenced a food safety training book used for an off-facility, day-long training program. One referenced the operating manual for the commercial blast chiller.

Interview 10, line 316

Jason: Is there any procedural manuals that talk about recommended ways of doing cooling?

Nate: Yeah, there's a manual around here somewhere but I'm not really sure where it is at. I have seen it. I can't remember. Well, yeah, I had my manual when I came back from ServSafe class but I don't know where it's at. (whisper) Probably at home in the closet.

Jason: I have one of those.

Nate: (restates with emphasis) I think mine's at home *in the closet*.

Regardless of the form of the manual in question, its importance in stimulating safe food practices was minimized. Of all the participants, some stated that no such manual existed or if it did, they could not recall ever seeing it. The range of perceptions of presence and form of a "policy manual" among the participants, in conjunction with the frequency of on-the-job training and job shadowing as a training technique, suggests written practices and formal training are not frequently used or pleasantly received.

Climate Change

The aspect of climate change is oriented around the sensory or tactile element of the work environment. The majority of a cook's time is spent cooking. This puts cooks in frequent and close proximity to equipment that requires heat to function. In addition, the physical layout of the facilities groups cooking equipment in a single area to improve efficiency of cooks' time by multi-tasking and to simplify facility development by putting

necessary utilities and ventilation in one location. In short, the work environment is hot. As workers cook and then cool, they experience drastic sensory changes; for example, going from the 80° F cooking area to the 40° F cooler to get ingredients or to store leftovers. This drastic change of climate forces employees to experience “hot” and “cold” on a personal sensory and tactile level.

When considering climate change in regard to hot and cold, one must recognize that the participants’ reactions to these environmental changes can be explained as occurring within the psychomotor domain.

Unique Chilling Technology

One aspect of climate change is the use of a blast chiller to help cool products. A blast chiller works in reverse of a convection oven to quickly remove heat from food products. The blast chiller circulates fast-moving, cold air around the food items, increasing the temperature difference between the hot food and the air around it so heat will more rapidly move from the food to the air. Frequently participants noted their current employment was the first time they had seen or used a blast chiller.

The environmental change was not always a literal change created inside the blast chiller, but also a figurative one created by the employees’ perspectives and the facilities’ environments. Employees’ prior work experience rarely included the use of a blast chiller so the technology was new and unfamiliar. Relying on this technology to perform the task of cooling was similar to employees’ allegiance to the learned procedures for cooling foods. The blast chiller seemed to acquire an identity of “the cooling black box” in that the participants did not know how it worked, but knew what it did to the food products.

In the following conversation, Nate describes the blast chiller operation. Nate's description of how the blast chiller operated was animated.

Interview 10, line 128

Jason: If you did have some food that you were going to chill and put into storage for the next day's use, what would be the process you would go through to do that?

Nate: You put them in a 4-inch pan.

Jason: The big long ones?

Nate: Yes, it's a big thing. You have stuff and you put it in there and you put it in the little blast chiller and put your little thermometer in there and chchchchch (faux shivering).

Respondents illustrated climate change in two fundamental parts. The first was that their experience in the kitchen of hot and cold was palpable. The noises, arm motions, and Nate's description of the blast chiller; the components fundamental to it working, such as the food and the built-in thermometer probes; and the actual operation of the blast chiller operating were representative of how respondents described this unfamiliar (and expensive) piece of equipment. Respondents knew food went into the blast chiller hot, it operated, and the food came out cold. A few participants recalled incidents of extremes. One described how she forgot about food in the blast chiller and the food was frozen when she pulled it out. Others explained that sometimes the blast chiller would malfunction (most commonly described as problems with Freon) and the blast chiller would seemingly cook the food more.

There also was uncertainty regarding the dependability of the blast chiller. Like the cooling procedures, some expected the blast chiller to cool the product to the desired end temperature within a given time, regardless of the product type or volume. Others used the blast chiller's thermometer probes to provide product temperatures but they monitored the cooling progress manually by periodically reading the thermometer displays. Still others used the thermometer probes and set the blast chiller to cool to a designated temperature and hold the product. The various blast chiller procedures used by participants varied for multiple reasons, including unfamiliarity with the chiller's features; lacking confidence with the chiller; uncertainty about the principles behind how the chiller works; or prior experiences with the chiller (both positive and negative).

Interview 8, line 405

Sue: The blast chiller is pretty much idiot proof if you just go back and read it.

It's going to tell you when it's down to a safe zone to put it back into the cooler to do the final process.

The Science of Climate Change

Another aspect of climate change includes a tie between heat and the physical states of water (ice, liquid water, and steam). As the literature described, students of various ages struggle to discuss heat without an association to another science concept, such as temperature or the water cycle. Although heat is a concept of its own, it is often referred to in tandem with temperature or in its effects on water. Data from this research showed nothing different. Routinely, participants referred to heat in conjunction with other concepts. A common response from participants was providing images or descriptions that gave heat a physical, visual presence.

Interview 3, line 782

Jason: How does ice drop the temperature of a product?

Judy: Because it's cold. The ice and water are cold. When you're putting something hot in the ice then it like de-vaporates. The heat drops.

Another common response regarding cooling procedures that blended or blurred the line between heat and other concepts was leaving coverings on pans open when placed in the cooler so the heat could “escape.” Respondents frequently included covering food pans before placing them in the cooler to keep them from splashing during transport or to keep “things” from getting in the food, but they also commonly left one end of the plastic wrap folded back to speed cooling by letting the heat out. Rarely did participants acknowledge that heat could be transmitted out through the pan. Only when comparing the ease of keeping foods hot in metal pans compared to plastic pans, which was seldom, did participants consider the pans had a role in temperature regulation.

Mapping Foodservice Employee Knowledge

The fundamental tenants of constructivism are formulated around the idea that knowledge is unique to the individual learners. However, there is a desire in the field of education to aggregate individual learners' knowledge to inform and structure curriculum and instruction. This desire is based on political economy. The data were collected from individuals and represent each individual's knowledge, beliefs, opinions, and feelings, which from a constructivist view of learning is better information for shaping instruction.

The interviews and observations examined each participant's knowledge of heat, thermal equilibrium, cooling, handling practices, and so forth. For representation and discussion that will better inform instructional decisions that occur in an economy model,

the individual data are aggregated into one concept map that illustrates the group's knowledge about the concepts of interest (see Figure 4.1). This concept map is a compilation of responses, discussion, and explanations from all of the participants. While some views differed in respect to specific elements included in the concept map, the overall structure is a generalized representation of the participants' collective knowledge.

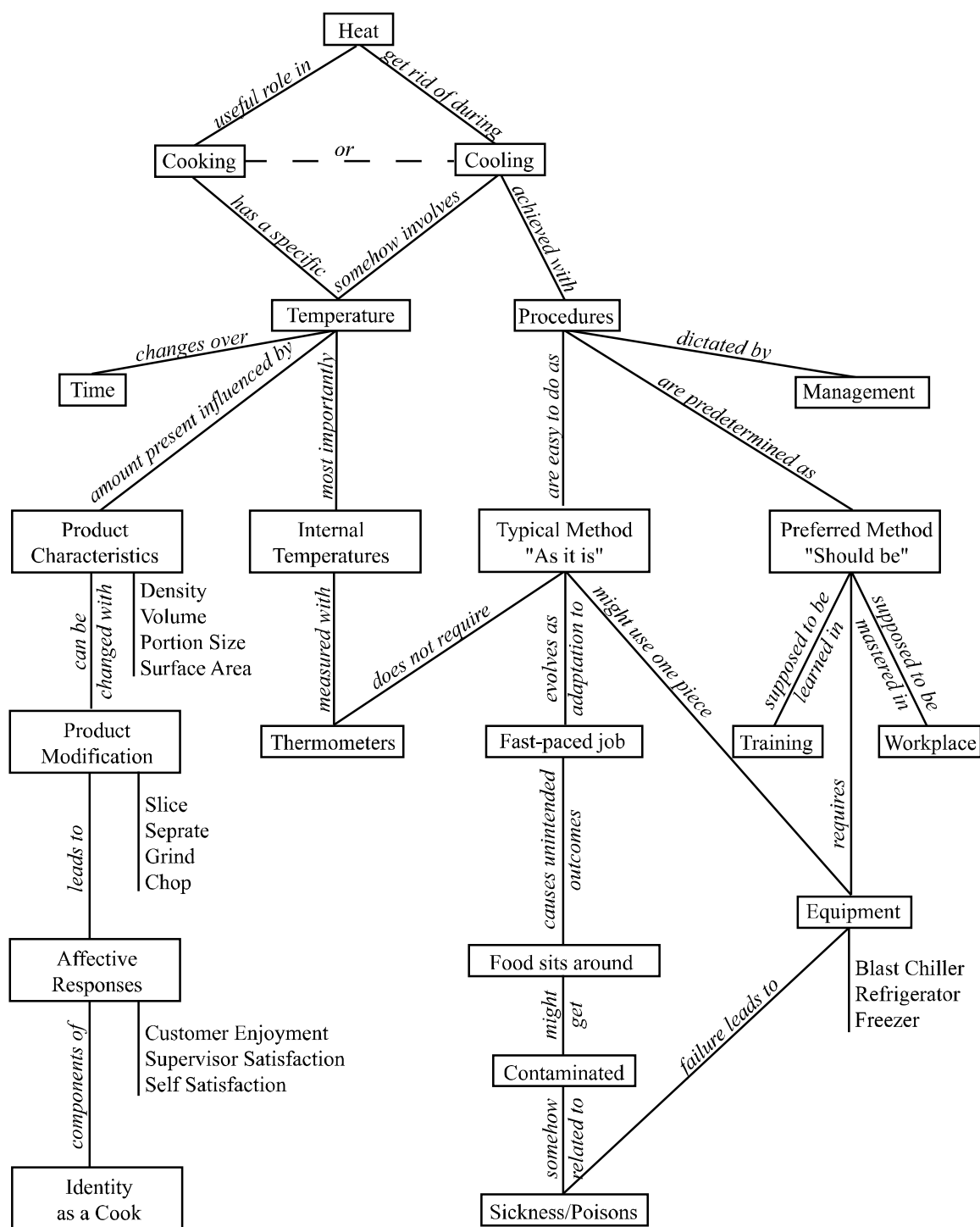


Figure 4.1. Aggregated concept map of foodservice employees' content knowledge related to heat, thermal equilibrium, and cooling.

Presenting individual data in an aggregated form such as Figure 4.1 limits the ability to recognize and address unique perceptions, understanding, misconceptions, and beliefs of specific participants. However, this concept map simplifies the commonalities so that we can step back and look at the common threads when considering curriculum changes.

A fundamental element of Figure 4.1 is the lack of specificity regarding why the procedures, whether “preferred” or “typical”, existed. Objective 1 was to determine the extent to which employees’ conceptual understandings of heat and thermal equilibrium mapped onto a science-base explanation of the concepts. To this end, the interviews and think-aloud elements of data collection focused on why behaviors were thought to be performed (in the case of “typical” procedures) or required (in the case of “preferred” procedures) in relation to what was occurring during the cooling procedures. Participants were able to identify the examples listed under “product characteristics” and “product modification” as being important to cooling but could not explain how these would influence the rate of heat transfer to reach the idea of thermal equilibrium. Heat and heat transfer were better comprehended when discussed in terms of cooking, but participants lacked the ability to use this concept, but in reverse, when asked about cooling.

Summary

The interviews with the hospital foodservice employees provided data that went beyond an assessment of cognitive knowledge about food handling practices and food safety rules. The employees have a strong personal interest in their jobs as cooks. However, the job responsibilities related to cooling are identified as separate from cooking and do not mesh with their identity as cooks. Participants characterized the

foodservice operation as being driven by their abilities to prepare, cook, and serve quality food. Though safety was included as a small component of handling techniques, participants near equally referred to quality and convenience as reasons for cooking foods.

The four elements of Identity; Differentials of Knowledge; Institutional Rules; and Climate Change serve as fundamental blocks of meaning from which recommendations for curricular changes will be built. These recommendations range in scope from site-specific proposals like changing participating facility protocols, to system-wide suggestions that include restructuring the pedagogical framework used for food safety training. These findings also suggest that after further investigation with additional foodservice segments, consideration should be made regarding the purpose of providing food safety training to adults. Specific recommendations based on the data presented in this chapter are elaborated in the following chapter.

CHAPTER 5. CONCLUSIONS AND IMPLICATIONS

The intent of the research was to prepare evidence-based conclusions related to the shape or status of knowledge of foodservice workers regarding crucial concepts in food safety. Such information is essential to the design and implementation of food safety curricula that satisfy the three tenets of constructivist science education as they apply to adults: (a) learning is inextricably intertwined with prior knowledge of the learner; (b) in a teaching setting, bringing prior knowledge closer to standard scientific knowledge requires the active engagement of the learner (Posner et al., 1982); and (c) engagement of the adult learner is more likely to occur when prior knowledge is elicited, respected, and permitted to remain under the control of the adult (Mezirow, 1990).

Review of Methods

A component of this dissertation research was to use methods from conceptual research of children and in science education of address questions about adult foodservice learners. The interviews flowed well through using the interview guide. Questioning order was modified based on interview responses, but all elements of the guide were included in each interview. Observing participants' nonverbal cues during the interviews allowed for gauging of the intensity of nervousness, confusion, or misunderstanding and provided opportunities for clarification and follow-up questioning. Thinking through the reasoning for their behaviors was difficult for respondents and they were nervous or afraid they would give the wrong answers. As the interviewer, I did not reveal that I was a certified ServSafe® or that I was a meat scientist.

The observational studies seemed to work well with regard to participant honesty. The use of a naturalistic environment and real equipment allowed me to double-check what other employees were doing for comparison with the participant being observed. The short timeframe for conducting the data collection was a concern in regard to employee conversations biasing responses and behaviors of later participants. The informal observations of employees outside of the select observation period confirmed that behaviors of employees were consistent throughout the time of data collection.

The order of data collection techniques might be revised for future research. This dissertation research had interviews first, then the observations in-facility, followed by a concluding interview. Conducting the observation component first would eliminate the likelihood that interview questions would influence behaviors during the observational data collection. Again, informal observations during walk-through reviews of the facility confirmed that minimal, if any, modifications to behaviors were made by employees during the data collection process.

Prior Knowledge and Heat

The research elicited prior knowledge related to heat concepts of food safety. Science concepts related to heat are fundamental to understanding ways to limit growth of organisms that cause foodborne illnesses. There are, of course, many more science-based dimensions to controlling foodborne illnesses in foodservice operations. Heat—and its context-driven set of procedures for cooling foods—is anticipated to substitute for other processes in the lessons learned from the research about reforming food safety education.

The basis for conclusions elaborated in the first section of this chapter is provided in Figures 5.1 and 5.2. These figures include an enhanced version of the concept map presented and discussed in Chapter 4 and an aggregated assessment of participant's perceived level of control within the operation, respectively. Conclusions are constructed around these two figures because application of research results to design and instruction of food safety curriculum related to cooling can not occur without an understanding of participants' prior knowledge regarding food handling procedures and the level of control they believe they possess in respect to practices they perform at work.

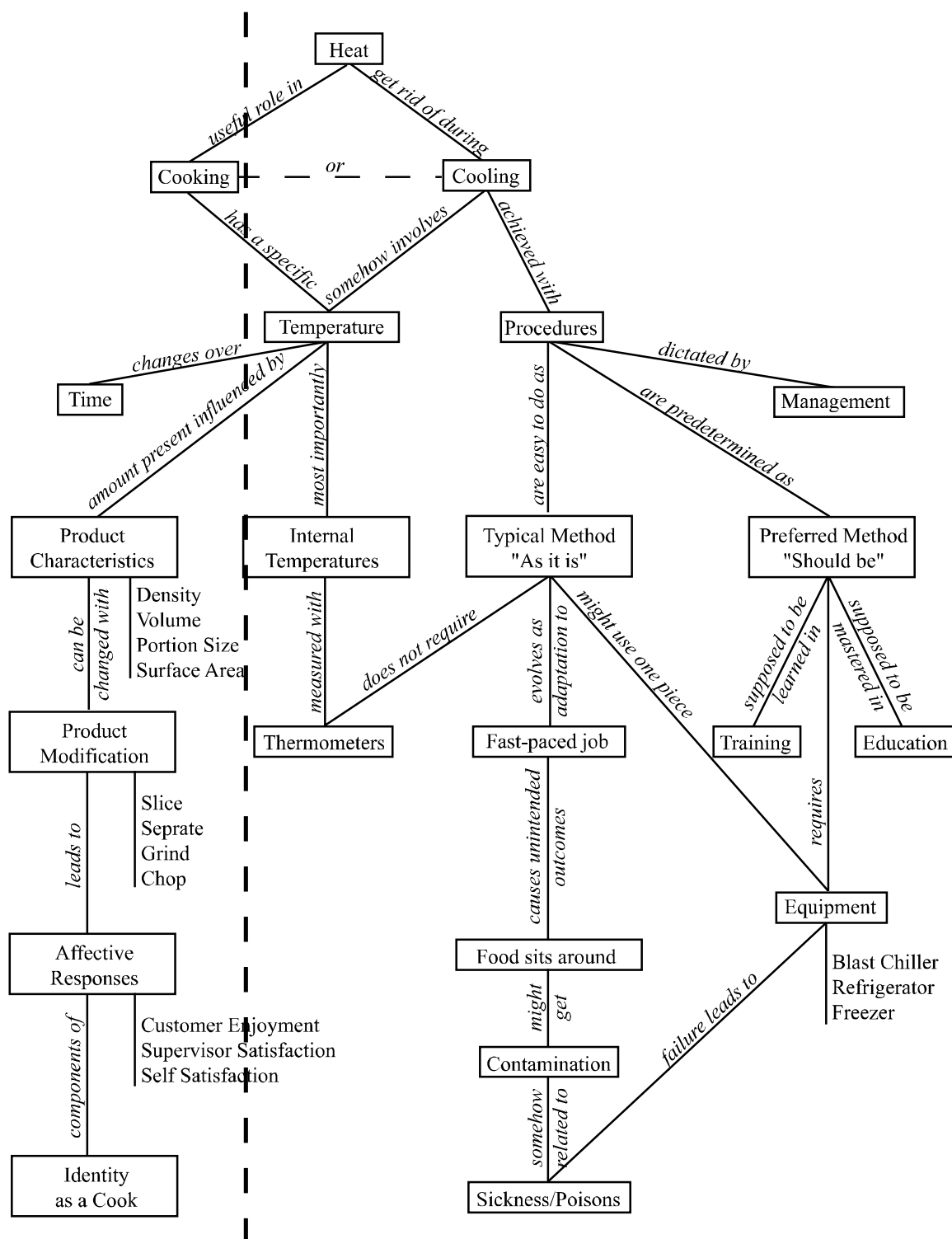


Figure 5.1. Aggregated concept map of foodservice employees' content knowledge: principles-based versus rules-based elements of cooling.

The aggregated knowledge of participants represented in Figure 5.1 is a starting point for curriculum and/or instructional revisions to improve training participants' understanding of science concepts. In turn, revised instruction will provide for more independent learners who are able to apply conceptual knowledge beyond the situation in which it was learned. The concept map identifies areas where clarity and richness of concepts diminish as the participants moved from *heat associated with cooking* to *heat associated with cooling*. For example, disconnected, dichotomous view exists between cooking and cooling, although they are based on the same scientific principles of heat transfer and thermal equilibrium.

The dichotomy is illustrated in Figure 5.1 with a vertical line dividing the map. The left half of the map is generated from the principles-based knowledge discussed in Chapter 4. Participants' abilities to synthesize new practices, techniques, or procedures for cooking to maximize the affective components in the lower portion of this half use knowledge that is situated higher in Bloom's taxonomy (Bloom et al., 1956) of cognitive domain. In addition, the interaction between the cognitive, culinary knowledge and the desired affective knowledge (identified in Figure 5.1) results in a psychomotor response of food preparation techniques that require little, if any conscious thought.

In contrast, the right half of Figure 5.1 is rules-based and related to cooling. Participants' conceptual knowledge for cooling is not as developed as for cooking. The knowledge diagrammed in this half is associated with the cooling procedures, whether preferred or typical, is concrete in regard to knowing and applying the procedures. Though possibly existent on a select, individual basis, the ability or perceived need to understand cooling beyond the application level of the cognitive domain is absent.

Value of Understanding the Lack of Transfer

In the science education literature, it is not uncommon for youth to understand and apply a science concept, for example gravity, to one situation (balls falling from a tower). Often, the same youth fail to understand how gravity works in a novel situation (balls falling from a tower on the moon). From a teaching perspective, the situation is under control as long as the teacher understands this constraint of application and attempts to teach across contexts. Moreover, in formal K-12 education, less emphasis is required for correct application of scientific concepts across diverse contexts since children are still learning.

However, with adult education, instructional needs are different. For food safety education, it has long been the consensus that heating and cooling are not only guided by the same scientific principles (which is correct), but are considered in the same manner by learners. This research shows that this assumption is incorrect. Heat is not uniformly understood in regard to its role in food service and food safety when applied to the concepts of cooking and cooling. This divergence may be in part due a multitude of influences, such as a potential disregard of foodservice workers as people who care about their jobs; an oversight of distinct identities brought to the workplace by individuals; an assumption that only formula-based, or rules-based, is sufficient; or that foodservice employees are not able to process and apply knowledge beyond a rules-based capacity, and so forth. Price (2001) showed that similar assumptions about training programs for Filipino rice growers were incorrect and that the growers were in fact capable of processing information and learning at a level much greater than previously allowed or anticipated.

With such simplistic assumptions about foodservice employees' interests and abilities, little wonder exists as to why minimal headway has been made to improve food safety practices in foodservice operations. However, now that we know more about one segment of employees who attended training and were charged with maintaining food safety, we can do something about it, given the responsiveness of constructivist education to the learner's conceptual frameworks.

Knowing, on a general level, participants can not demonstrate that they comprehend the relationship between cooking and cooling can serve as an entry point for instruction in a training program. Instructors can develop training instruction and activities to address this disconnection through a focus on the primary concept of heat transfer, which helps simplify later instruction that may be more focused on specific handling practices. This is what Simon (1995) referred to as a hypothetical learning trajectory (HLT).

Food safety education needs to respect, draw upon, and even reinforce what learners know about heat through education first focusing on heating concepts for **cooking**. Heat for cooking might be where to begin a program because it reinforces correct, existing knowledge; surfaces partial knowledge; and reinforces the preferred identity of a cook. Then, one could move to cooling processes in cooling with regard to producing food, perhaps by talking about cooling processes used to make custards or puddings. This step creates a connection between the comfortable and familiar—cooking—and a not-so-familiar concept of cooling. At this point, then instruction might move to cooling processes for cooling and their implications for food safety.

The aggregated knowledge structure in Figure 5.1 is a starting point, allowing instructors to customize for the group. Research and instructional modifications may want to move to the level of *individual knowledge*, which is not represented by this concept map. Working at aggregate level may be sufficient to engage a majority of learners. For those who do not become involved, progressing from the aggregate to the individual level will provide additional resources and opportunities for generating interest in learning. Studying at the individual level allows for understanding of specific misconceptions, realization of past experiences that shape present perceptions, explanation of incomplete cognitive structures, and elaboration of personal meanings that influence a learner's receptivity to new instruction. Working on the individual level helps inform instruction to address individual, significant barriers to learning.

The concept map in Figure 5.1 echoes the conceptual ecology of participants in regard to which conceptual aspects of heat transfer, thermal equilibrium, and cooling practices were stronger and which ones were weaker. Participants had a richer understanding of how food product responded during cooking and therefore provide more details about how to manipulate the product and its characteristics to achieve cooking. This was not as thorough when initial phases of the conversation focused on how to increase the speed at which a product cooled. Understanding the depth and breadth of learners' conceptual ecologies for **preparation of food** can inform instructional planning because as Posner et al. (1982) state, the conceptual ecology is what "will influence the selection of a new central concept" (p. 214). Having an indication as to what will influence whether or not learners will accept or learn new concepts allows instructors to

develop activities that create dissatisfaction with existing knowledge or will result in a disorienting dilemma that is contradictory to prior experiences and existing beliefs.

Food Handling Practices

Employees' food handling practices when cooling foods were neither strongly nor consistently associated with their established concepts about heat and thermal equilibrium. Cooling behaviors of participants were driven by procedures learned in training rather than a conceptual understanding of how to get foods cooled quickly. Even after having completed a rules-based training program the behaviors should have been driven by the time/temperature requirements stipulated in the governing jurisdiction's Food Code, which are intended to minimize the time foods are at a temperature that supports microbial growth. However, the time and temperature requirements were not articulated by participants and were not monitored, as demonstrated by the lack of thermometer use. Monitoring times and temperatures are significant for two reasons. First, the rules-based aspect of food safety states that foods must be cooled to a specific temperature within a given time. The fundamental reason is that the temperature range between "hot" and "cold" is ideal for microorganism growth, some of which might cause illness. By limiting the time food temperatures are within this range, the likelihood for microorganism growth also is limited.

Regardless of whether the facility cooling protocols taught during employee training included the required time/temperature combination to meet applicable regulations, all participants had completed, and passed, one of the three accredited food safety training programs. A component of this training and certification program included cooling times and target temperatures. The infrequent use of practices

associated with accelerated cooling of products, whether included in in-house employee training or in the accredited training program completed by all participants, suggests participants were unfamiliar with heat transfer and thermal equilibrium in relation to cooling.

Proposed Hypothetical Learning Trajectories (HLTs)

A third goal was to produce hypothetical learning trajectories based on the research that would inform instruction using current curricula. The hypothetical learning trajectory (HLT) consists of three components: the teacher's learning goal, the teacher's plan for learning activities, and the teacher's hypothesis of the learning process. Based on the participants' existing knowledge about heat, thermal equilibrium, and cooling procedures, the following HLT has been developed to demonstrate how personal identity, existing knowledge, and the dual role of heat in cooks' vernacular can be incorporated into an instructional plan. The HLT builds on learners' knowledge of cooking in order to introduce the basic concepts of cooling, which are not specifically associated with food safety. This HLT uses prior cognitive and affective knowledge as a starting point for teaching about weak or misunderstood concepts that had little perceived significance for employees.

HLT about Cooling

Physics provides an explanation that heating and cooling are not separate topics that warrant separate discussions, but rather they are inverse operations of the adjustment of the level of heat within a substance. To heat something is the process through which energy is added and a measurement of successful heating is a rise in the object's temperature. Cooling is the same process except the flow of energy is reversed. In the

case of cooling foods, the flow of energy to reach thermal equilibrium is from the hot food to the cooler environment around it.

Specific practices included in food safety training focus on either heating or cooling but ignore the fact that heating and cooling are the same process from the point of view of science. Understanding how these two concepts are the same might help foodservice employees relate what they know about how foods cook to how foods cool. This transfer of knowledge might help alleviate some of the ambiguity of cooling demonstrated by employees during the interviews and observational components. The fundamental difference between cooking (heating) and cooling is the direction of the energy flow when attempting to reach a thermal equilibrium between the object of interest, in this case the food item, and its environment. Training for knowledge retention and transfer could utilize the central concepts of heat, temperature, and thermal dynamics (on the basic level of heat transfer and thermal equilibrium) as an organizing concept around which cooking practices, methods of maintaining food temperatures (whether hot or cold) and techniques for cooling foods can be developed in the training.

As evident by this research, cooks and other foodservice employees are oriented toward the understanding of heat. They are focused on using heat to cook foods and to maintain hot foods as part of their daily job responsibilities. Building on this interest, familiarity, and self-definition with heat and heating, food safety training can teach the idea of heat in terms of cooking. Foodservice employees have provided evidence that they understand heat when described in cooking (defined as the process of getting foods hot) terms. Using this familiarity as a starting point, a disorienting dilemma (Mezirow, 1995) can be introduced that challenges training participants by demonstrating heating

and cooling are the same thing. The constructivist frame enters into such a situation when the participants are provided this problem, materials, and asked to prove otherwise. The Piagetian-based work of Duckworth (1996) discusses a similar method where the focus is not on the level of knowledge possessed by the students, or in this case the training participants, but rather the process through which knowledge or understanding is developed.

Teacher's learning goal

Training participants will be provided with an opportunity to learn about the concept of heat.

Teacher's plan for learning activities

Cooking: Participants first are going to generate a plan for cooking a food item of their choice. The focus of the plan will be to show how heat is used through their chosen process to produce a final, high-quality food item.

Cooling: After cooking a food item of their choice, participants will be asked to prepare a pre-selected food item: custard. Unless they have a dairy allergy, custard should appeal to most participants if they make a quality product, they will be able to enjoy it as a dessert. Custard was chosen because part of the process to get quality custard requires quick cooling after cooking. At this point, the concept of cooling is introduced but still in relation to cooking and producing a quality product.

Teacher's hypothesis of the learning process

Participants will use their cooking experience and association as a cook to advance by developing a cooking plan. This first step begins to move the learners to analyzing what they are doing while maintaining familiarity through the work with

cooking. The custard element is not intended to be taught much as it is to introduce cooling into the cooking (preparing food) process. At this point, discussion will incorporate the interaction between cooking and cooling for this one product with regard to quality. From here, instruction will then shift toward cooling, its integration with cooking. A second HLT will then build from this cooking/cooling discussion into cooling and food safety.

Perceived Control

Control in this situation refers to the degree of flexibility an individual employee (or the employees as a group) perceives to have in regard to making changes that might differ from what he or she learned in training or from what is specified by an authority figure such as the facility management company or management personnel. The concept of perceived control is similar to a misconception or prior life experience in that it must be identified and addressed through instruction and appropriate learning activities. When designing curricula revisions or addressing these issues in training, perceived control is an important consideration. If training participants do not believe they have permission to make changes, then alternatives differing from current practices are less likely to be considered than alternatives for elements over which the participants have greater control.

The research indicated that participants had a perceived adequate level of control regarding various aspects within the foodservice operation. Based on the interview responses and observational notes, Figure 5.2 was developed as an approximated relative degree of control for eight elements within the operation. These eight elements were identified in the transcripts.

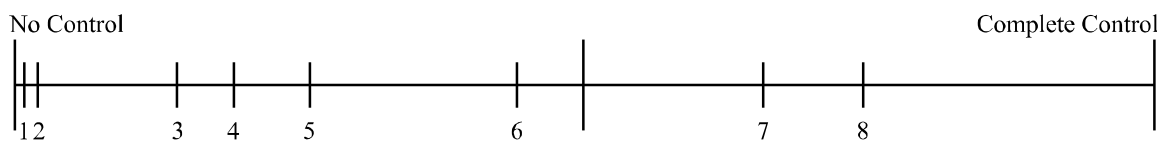


Figure 5.2. Estimation of aggregated level of foodservice employees’ perceived level of control. Employees’ perceived control to change 1 = menus (cafeteria and patients), 2 = patient recipes, 3 = equipment for cooling, 4 = cooling protocol, 5 = pans for cold leftover storage, 6 = pans for hot food holding, 7 = cafeteria recipes, and 8 = equipment for cooking.

Participants referred to the eight elements in Figure 5.2 in the course of the interviews. They were not discussed in direct regard to degrees of control, but ideas about control were gleaned from the context of conversation as being flexible or rigid, generating consequences if not followed, having “culinary license” to make changes, etc. The importance of Figure 5.2 is that it illustrates what participants believe is their level of control over these various elements. This relational diagram of perceived control levels can inform instructors’ decisions when developing HLTs related to cooling practices, equipment use, etc. Figure 5.2 provides perspective on which of these eight areas will be more likely to serve as barriers to learning because of learners’ understood degree of freedom to change what might be considered unchangeable.

Implications for Practice

Building upon the results and discussion from Chapter 4, an elaboration of a set of conclusions that serve as implications of this research beyond the teaching of or training about cooling as it relates to food safety has been provided. The gist of each implication

is introduced as a question for which the answer forms the justification for the respective implications.

Would making the rules taught in training more specific simply solve the problem?

Making the rules more specific might be appropriate for the specific instances where those rules apply, but this is not consistent with constructivist learning or transformational learning, nor does it facilitate the transformation of knowledge that results from these forms of learning. Having a greater amount of more specific rules provides a situation where learners are challenged to remember when and where to apply each rule while still being without a general context of conceptual understanding in which to apply them. Specificity does not result in greater learning. Both constructivist and transformational learning posit that learning is best achieved through building connections between new knowledge and prior knowledge. Increasing the specificity does not help develop these linkages and may even hinder retention and application because the specificity might limit how the new rules are assimilated into existing knowledge structures.

Can cooling techniques be taught in the context of cooking instead of food safety?

Science may consider heat a single concept regardless of its use, but this research provides evidence that heat is not a unitary concept between the conceptual frame of cooking and the conceptual frame of cooling. Participants' knowledge of heat in respect to cooking was on a different level within the cognitive domain than was their knowledge of heat when applied to cooling. This research illustrates an instructional opportunity for improving the conceptual understanding of cooling. The conceptual knowledge of heat for cooking, combined with the affective elements or cooks' personal self-interest in

cooking, is an avenue through which the theory of transformational learning (Mezirow, 1990) and the conceptual change model (Posner et al., 1982) can be applied to cooling training.

This dichotomous view of cooking and cooling also was made evident in interviews in that during culinary training, cooks are taught about the importance of cooling, but the focus is on food preparation. For some food items, such as custards and milk-based soups, quality can be compromised if the product is not handled in the proper manner. The image identified in Chapter 4 is related to personal image as a good cook based on the quality of food items. This personal interest in product quality could serve as the affective element that helps develop interest of foodservice employees to build upon proper cooling techniques.

The two themes—differentials of knowledge and institutional rules—also are integrated with the identity theme and cooks' attention to quality element when investigating how to reframe cooling techniques in food safety training. The goal is to elevate the level of importance cooling procedures take among all of the responsibilities and tasks of foodservice employees. When training programs begin to focus on cooling, this study helps to identify why session attendees may not place cooling practices high on the list. Either rules or standards are already in place and can, or should, not be deviated (stemming from the institutional rules theme) or cooling isn't important and can be delegated or become somebody else's responsibility (differentials of knowledge).

A shift in pedagogy regarding how and where cooling is included in training draws upon the adult learning theory of Mezirow (1990, 1995) that uses personal meaning making and the critical incident to establish learner interest and willingness to

learn. Teaching practices associated with cooling products should be focused around how cooling can influence quality, which based on the available data would build upon personal meaning, and be discussed in light of current procedures they are performing. This misconnection between how to cool for quality and how cooling is being presently being done, if orchestrated properly, serves as the critical incident to open learners to new practices or information that may be in conflict with existing knowledge. At this point proper techniques can be presented, all still under the quality frame. A mechanism for demonstrating the relationship between cooling and quality and safety is the necessity to keep raw ingredients cool. The tie between cooling and product safety can be included through a different avenue that is focused on product safety.

Are teaching methods appropriate for the subject?

This research illuminated two elements that lend themselves to using individual experimentation related to heat, temperature, and cooling techniques. The first is the sensory or tactile aspects of heat, hot versus cold, and changes in temperature. Incorporating senses beyond vision and hearing, such as smell and touch, into the learning environment strengthens the learner's ability to become involved in the content and generates additional channels through which reflection and synthesis of material can occur. Senses help develop a cognitive recollection mechanism so by including more senses in the learning process the mental connections of the content to the practices are reinforced.

Including additional tactile involvement in learning with individual experimentation allows training participants to utilize sensory responses as ad hoc data collection instruments, which builds on the personal meaning making that is an integral

component of transformational learning. The combination of touch or feel associated hot and cold foods with visual aspects of physical product changes during cooling and the representation of heat and cooling changes using a thermometer helps training participants quantify the abstract and invisible concept of heat. To some degree, including these sensory aspects through experimentation allows participants to personify heat, cooling, and temperature.

Experimentation also allows for addressing what could be labeled as the logical aspect of cooling. In this regard, the logical aspects of heating and cooling relate to generalized statements about the meaning behind specific practices. For example, one element of cooling procedures that some participants reported was removing a container of food, such as a pot of soup, from hot storage and leaving it out for a short period of time (usually between five and 15 minutes) so it can cool to room temperature before continuing with the cooling techniques. Experimentation can be used as a method of having training participants prove how leaving the product out for a short period of time cools it quickly.

Being a cook involves sensory involvement and experimentation in the kitchen. Cooks sample the foods they prepare to make sure they taste right and if not, they modify their initial procedure (e.g., the recipe's specifications) with their intuition and experiential knowledge of cooking to make the food better. Building on this existing familiarity with experimentation in training programs 1) allows participants to utilize learning techniques familiar to them and 2) provides for opportunities of creating disorienting dilemmas that can begin the process of transformational learning that leads to behavioral changes.

Should teaching be designed for a certification exam or to create food professionals?

The identity theme developed from the research data contradicts the stereotype that foodservice employees are under-paid, over-worked working-class people employed in foodservice for the simple fact that they need a job. In contrast, the aspect of personal identity the participants have regarding their job performance and output shows that they care about what they are doing and consider themselves to be professionals. In this instance 'professional' is defined as a person being involved in a learned profession and possessing skills to the degree of being able to train understudies or apprentices. The skills of the participants were acquired through various means that included formal education schooling, on-the-job training, observation, and development sessions such as ServSafe® for food safety expertise.

Conducting training programs for the short-term goal of passing a certification exam does not help develop professionals. A training program that focuses on learning, personal and occupational development, and long-term impacts through improved behaviors and changed mindsets emphasizes the importance of professionalism in the workplace. This research indicates that experienced, dedicated foodservice employees with cooking and cooling responsibilities are concerned with what they do, whether it is producing a quality food or preventing consumers of their food from becoming sick. Though often overrun on the job with issues and other “emergencies”, these employees do what it takes to fulfill their cooking responsibilities to the fullest—a demonstration of professionalism. Channeling the desire for professionalism in preparing food into all aspects of food handling should become a goal of training. Professionalism of food handling, not just food preparation and cooking, would indicate a personal interest in

such responsibilities and as this research has indicated, personal interest can result in higher attention to detail, greater cognitive awareness of influencing factors, and more perceived control that allows for manipulating standard procedures to improve performance.

What are the contributions of this research in regard to theoretical application by its combination of constructivism from youth and young adults and transformational learning from adult education?

Each of the theories brings unique features to this research. Constructivism provides the focus on cognitive learning and the work of Piaget in regard to using behaviors as indicators of intelligence and learning. The conceptual change model that is based on constructivism helps guide instructional development in a manner that builds on prior knowledge for greater understanding, more complex learning, and facilitating transfer of knowledge.

Transformational learning best informs this research from the focus on affective influences on adult learning. The life experience of adult learners, which is part of the prior knowledge used with conceptual change, is more rooted in personal meaning generated from attitudes, beliefs, perceptions, and emotions. This research demonstrates that theories from separate disciplines can assist in answering questions. This duality of a theoretical base underscores the importance of looking beyond traditional fields of study for theories pertinent to addressing seemingly isolated problems.

APPENDIX A. IOWA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD DOCUMENTATION

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office of Research Assurances
Vice Provost for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

DATE: May 25, 2006

TO: Jason Ellis
CC: Dr. Nancy Grudens-Schuck

FROM: Institutional Review Board
Office of Research Assurances

SUBJECT: IRB ID Number: 06-254

Study Review Date: May 24, 2006

The Institutional Review Board (IRB) Chair has reviewed the project, "Assessing food service employees' application of scientific knowledge in the workplace," and declared the study exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) (1) and (2). The applicable exemption category is provided below for your information. Please note that you must submit all research involving human participants for review by the IRB. Only the IRB may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.


The IRB determination of exemption means that this project does not need to meet the requirements from the Department of Health and Human Service (DHHS) regulations for the protection of human subjects, unless required by the IRB. We do, however, urge you to protect the rights of your participants in the same ways that you would if the project was required to follow the regulations. This includes providing relevant information about the research to the participants.

Because your project is exempt, you do not need to submit an application for continuing review. However, you must carry out the research as proposed in the IRB application, including obtaining and documenting (signed) informed consent if you have stated in your application that you will do so or if required by the IRB.

Any modification of this research should be submitted to the IRB on a Continuation and/or Modification form, prior to making any changes, to determine if the project still meets the Federal criteria for exemption. If it is determined that exemption is no longer warranted, then an IRB proposal will need to be submitted and approved before proceeding with data collection.

Exempt Categories

- (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

	Review Date: _____	IRB ID: <u>06-254</u>
	Approval Date: _____	Length of Approval: _____
	Approval Expiration Date: _____	FULL Committee Review: _____
	EXEMPT per 45 CFR 46.101(b): <u>1,2</u> Date: <u>9/24/06</u>	Minimal Risk: <u>AS</u>
	EXPEDITED per 45 CFR 46.110(b) _____	More than Minimal Risk: _____
	Category _____, Letter _____	Project Closed Date: _____

IRB

ISU NEW HUMAN SUBJECTS REVIEW FORM

MAY 09 2006

SECTION I: GENERAL INFORMATION

Principal Investigator (PI): Jason Ellis		Phone: 4-7549	Fax: 4-6364
Degrees: BS, MS	Correspondence Address: 7W MacKay Hall		
Department: AgEdS	Email Address: jdellis@iastate.edu		
Center/Institute:	College: Agriculture		
PI Level: <input type="checkbox"/> Faculty <input type="checkbox"/> Staff <input type="checkbox"/> Postdoctoral <input checked="" type="checkbox"/> Graduate Student <input type="checkbox"/> Undergraduate Student			

Title of Project: Assessing foodservice employees' application of scientific knowledge in the workplace
Project Period (Include Start and End Date): [mm/dd/yy][05/01/06] to [mm/yy/dd][12/15/06]

FOR STUDENT PROJECTS	
Name of Major Professor/Supervising Faculty: Nancy Grudens-Schuck	x Signature of Major Professor/Supervising Faculty: <i>N. Grudens-Schuck</i>
Phone: 4-0894	Campus Address: 217D Curtiss Hall
Department: AgEdS	Email Address: ngs@iastate.edu
Type of Project: (check all that apply)	
<input type="checkbox"/> Research <input type="checkbox"/> Thesis <input checked="" type="checkbox"/> Dissertation <input type="checkbox"/> Class project	
<input type="checkbox"/> Independent Study (490, 590, Honors project) <input type="checkbox"/> Other. Please specify: _____	

KEY PERSONNEL

List all members and relevant experience of the project personnel. This information is intended to inform the committee of the training and background related to the specific procedures that the each person will perform on the project.

NAME & DEGREE(S)	SPECIFIC DUTIES ON PROJECT	TRAINING & EXPERIENCE RELATED TO PROCEDURES PERFORMED, DATE OF TRAINING
Jason Ellis, MS	Principal investigator, protocol development, data collection	1/16/2002
Nancy Grudens-Schuck, MS, PhD	Major professor, protocol development	June 20, 2000 certification training. Teaches social science methods.

Add New Row

FUNDING INFORMATION

Internally funded, please provide account number: NA
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Research Assurances 12/01/2005

Externally funded, please provide funding source and account number: Partially - Food Safety Consortium: 416-41-76
Funding is pending please provide OSPA Record ID on GoldSheet:
Title on GoldSheet if Different Than Above:
Other: <i>e.g., funding will be applied for later.</i>

SCIENTIFIC REVIEW

Although the assurance committees are not intended to conduct peer review of research proposals, the federal regulations include language such as “consistent with sound research design,” “rationale for involving animals or humans” and “scientifically valuable research,” which requires that the committees consider in their review the general scientific relevance of a research study. Proposals that do not meet these basic tests are not justifiable and cannot be approved. If an assurance review committee(s) has concerns about the scientific merit of a project and the project was not competitively funded by peer review or was funded by corporate sponsors, the project may be referred to a scientific review committee. The scientific review committee will be ad hoc and will consist of your ISU peers and outside experts as needed. If this situation arises, the PI will be contacted and given the option of agreeing that a consultant may be contacted or withdrawing the proposal from consideration.

☒ Yes ☐ No Has or will this project receive peer review?

If the answer is “yes,” please indicate who did or will conduct the review: Doctoral committee

If a review was conducted, please indicate the outcome of the review: Approved as relevant and useful

NOTE: RESPONSE CELLS WILL EXPAND AS YOU TYPE AND PROVIDE SUFFICIENT SPACE FOR YOUR RESPONSE.

COLLECTION OR RECEIPT OF SAMPLES

Will you be: (Please check all the apply.)

☐ Yes ☒ No Receiving samples from outside of ISU? See examples below.
☐ Yes ☒ No Sending samples outside of ISU? See examples below.

Examples include: genetically modified organisms, body fluids, tissue samples, blood samples, pathogens.

If you will be receiving samples from or sending samples outside of ISU, please identify the name of the outside organization(s) and the identity of the samples you will be sending or receiving outside of ISU:

Please note that some samples may require a USDA Animal Plant Health Inspection Service (APHIS) permit, a USPHS Centers for Disease Control and Prevention (CDC) Import Permit for Etiologic Agents, a Registration for Select Agents, High Consequence Livestock Pathogens and Toxins or Listed Plant Pathogens, or a Material Transfer Agreement (MTA) (<http://www.ehs.iastate.edu/bs/shipping.htm>).

SECTION II: APPLICATION FOR INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

☒ Yes ☐ No Does this project involve human research participants? If the answer “no” is checked, you will automatically moves to a question regarding the involvement of radiation producing devices in your project.

SECTION III: ENVIRONMENTAL HEALTH AND SAFETY INFORMATION (EH&S)

- ☐ Yes ☒ No Does this project involve laboratory chemicals, human cell lines or tissue culture (primary OR immortalized), or human blood components, body fluid or tissues? If the answer is "no" is checked you will automatically move to a question regarding the involvement of human research participants in your project.

ASSURANCE

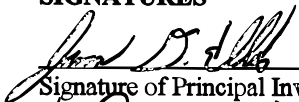
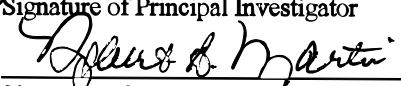
- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subject or welfare of animal subjects are protected. I will report any problems to the appropriate assurance review committee(s).
- I agree that I will not begin this project until receipt of official approval from all appropriate committee(s).
- I agree that modifications to the originally approved project will not take place without prior review and approval by the appropriate committee(s), and that all activities will be performed in accordance with all applicable federal, state, local and Iowa State University policies.

CONFLICT OF INTEREST

A conflict of interest can be defined as a set of conditions in which an investigator's or key personnel's judgment regarding a project (including human or animal subject welfare, integrity of the research) may be influenced by a secondary interest (e.g., the proposed project and/or a relationship with the sponsor). ISU's Conflict of Interest Policy requires that investigators and key personnel disclose any significant financial interests or relationships that may present an actual or potential conflict of interest. By signing this form below, you are certifying that all members of the research team, including yourself, have read and understand ISU's Conflict of Interest policy as addressed by the ISU Faculty Handbook (<http://www.provost.iastate.edu/faculty> .) and have made all required disclosures.

- ☐ Yes ☒ No Do you or any member of your research team have an actual or potential conflict of interest?
☐ Yes ☐ No If yes, have the appropriate disclosure form(s) been completed?

SIGNATURES

	<u>5-9-06</u>
Signature of Principal Investigator	Date
	<u>5-9-06</u>
Signature of Department Chair	Date

PLEASE NOTE: Any changes to an approved protocol must be submitted to the appropriate committee(s) before the changes may be implemented.

Please proceed to **SECTION II**.

SECTION II: IRB SECTION - STUDY SPECIFIC INFORMATION**STUDY OBJECTIVES**

Briefly explain in **language understandable to a layperson** the specific aim(s) of the study.

This study assesses foodservice employees' understanding of basic science concepts that underlie behaviors that are part of their job responsibilities.

BENEFIT

Explain in **language understandable to a layperson** how the information gained in this study will benefit participants or the advancement of knowledge, and/or serve the good of society.

The information from this study will explain how the level of knowledge of foodservice employees affects their ability to keep food safe, which decreases the chances that customers or themselves will get sick from foodborne illnesses. The results will be used to improve food safety training programs.

PART A: PROJECT INVOLVEMENT

- 1) ☐ Yes ☒ No Is this project part of a Training, Center, Program Project Grant?
Director Name: Overall IRB ID:
- 2) ☒ Yes ☐ No Is the purpose of this project to develop survey instruments?
- 3) ☐ Yes ☒ No Does this project involve an investigational new drug (IND)? Number:
- 4) ☐ Yes ☒ No Does this project involve an investigational device exemption (IDE)? Number:
- 5) ☐ Yes ☒ No Does this project involve existing data or records?
- 6) ☐ Yes ☒ No Does this project involve secondary analysis?
- 7) ☐ Yes ☒ No Does this project involve pathology or diagnostic specimens?
- 8) ☐ Yes ☒ No Does this project require approval from another institution? Please attach letters of approval.
- 9) ☐ Yes ☒ No Does this project involve DEXA/CT scans or X-rays?

PART B: MEDICAL HEALTH INFORMATION OR RECORDS

- 1) ☐ Yes ☒ No Does your project require the use of a health care provider's records concerning past, present, or future physical, dental, or mental health information about a subject? The Health Insurance Portability and Accountability Act established the conditions under which protected health information may be used or disclosed for research purposes. If your project will involve the use of any past or present clinical information about someone, or if you will add clinical information to someone's treatment record (electronic or paper) during the study you must complete and submit the Application for Use of Protected Health Information.

PART C: ANTICIPATED ENROLLMENT

Estimated number of subjects contacted to reach required enrollment: 40		
Number of subjects to be enrolled in the study Total: 25 Males: 5 Females: 20		
Check if any enrolled subjects are:	Check below if this project involves either:	

<input type="checkbox"/> Minors (Under 18) Age Range of Minors: <input type="checkbox"/> Pregnant Women/Fetuses <input type="checkbox"/> Cognitively Impaired <input type="checkbox"/> Prisoners	<input checked="" type="checkbox"/> Adults, non-students <input type="checkbox"/> Minor ISU students <input type="checkbox"/> ISU students 18 and older <input type="checkbox"/> Other (explain)
List estimated percent of the anticipated enrollment that will be minorities if known:	
American Indian:	Alaskan Native:
Asian or Pacific Islander:	Black or African American:
Latino or Hispanic: 15%	

PART D: SUBJECT SELECTION

Please use additional space as necessary to adequately answer each question.

11. Explain the procedures for selecting subjects including any inclusion/exclusion criteria (i.e., *Where will the names come from? Will a sample be purchased, will ads, fliers, word of mouth, email list, etc. be used?*).

Prospective foodservice operations will be identified through contacts with university faculty and staff familiar with food safety and the Iowa foodservice industry. Facility directors will be contacted about facility participation. Individual subjects at each participating facility will be informed about the project, its intent and then asked about willingness to participate.

12. Attach a copy of any recruitment telephone scripts or materials such as ad, fliers, e-mail messages, etc. Recruitment material must include a statement of the voluntary and confidential nature of the research. Do not include the amount of compensation, (e.g., compensation available).

Note: Please answer each question. If the question does not pertain to this study, please type not applicable (N/A).

PART E: RESEARCH PLAN

Include sufficient detail for IRB review of this project independent of the grant, protocol, or other documents.

13. Describe the flow of events used in this research protocol. Include information from the first contact with the volunteers to the end of the study. Use a diagram or flow chart if appropriate. Also, include a description of the study procedures or tasks that participants will be exposed to or asked to complete. This information is intended to inform the committee of the procedures used in the study and their potential risk. Please do not respond with "see attached" or "not applicable."

Initial contact for facility participation will be made with the foodservice director via telephone. If the facility is willing to participate, then the project will be explained at a staff meeting. This explanation will include a summary of participants' rights as human subjects. Telephone or e-mail will be used to confirm interview times and dates with participants. Data will be collected one participant at a time through one-to-one interviews (see following paragraph for interview procedures). At the end of the interview, participants will be debriefed as to how this information will be used. All participants completing the interview process will be mailed a thank you that includes their compensation. A final, summary report will be provided to all directors for distribution to their employees.

Data will be collected using one-to-one interview, observation, and think-aloud protocols. First, participants will explain how they would proceed with cooking the large pot of chili. This component is to get an initial benchmark of their routine behaviors. Then, the participants will be asked to demonstrate what they would do with the actual equipment, utensils, etc. If time and logistics allow, an actual pot of chili will be available for them to use. The speak-aloud protocol will be used to have the participants explain why they are doing the activities and how they

believe that helps the cooling process.

14. For studies involving pathology/diagnostic specimens, indicate whether specimens will be collected prospectively and/or already exist "on the shelf" at the time of submission of this review form. If prospective, describe specimen procurement procedures; indicate whether any additional medical information about the subject is being gathered, and whether specimens are linked at any time by code number to the subject's identity. If this question is not applicable, please type N/A in the response cell.

N/A

15. For studies involving deception, please justify the deception and indicate the debriefing procedure, including the timing and information to be presented to subjects. If this question is not applicable, please type N/A in the response cell.

The only deception of this project will be withholding the full intent of the questioning: assessing their knowledge about heat transfer and thermal dynamics and how they apply this knowledge to the given task. At the initial meeting, the project will be explained as a study to improve training by learning what they do and why they do it. This information will be withheld until the debriefing that immediately follows each data collection interview. This deception will be used to minimize influencing respondent answers to questions and changes to behaviors. If participants know the interview and behavioral assessment is about them and not the practices, then there is the risk of inaccurate data because of respondents wanting to provide the researcher with the "right" answer instead of their answer, if different. Also, respondents may change their behaviors if they know what they do is not necessarily right but what they routinely do on the job.

PART F: CONSENT PROCESS

16. Describe the consent process for participants who are age 18 and older. *If the consent process does not include documented consent, a waiver of documentation of consent must be requested.*

All potential participants will be verbally informed of their rights as participants during the initial introductory presentation at the staff meeting. Willing participants will be provided a written consent form explaining their rights prior to their interviews, which will ask for a signature. They also will be provided a verbal explanation at the same time.

17. If your study involves minors, please explain how parental consent will be obtained prior to enrollment of the minor(s).

NA

18. Please explain how assent will be obtained from minors (younger than 18 years of age), prior to their enrollment. Also, please explain if the assent process will be documented (e.g., a *simplified version of the consent form, combined with the parental informed consent document*). According to the federal regulations assent "...means a child's affirmative agreement to participate in research. Mere failure to object should not, absent affirmative agreement, be construed as assent."

NA

PART G: DATA ANALYSIS

19. Describe how the data will be analyzed (e.g. *statistical methodology, statistical evaluation, statistical measures used to evaluate results*)

An inductive-based method of qualitative data analysis will be used. A review of researcher's notes, selective transcripts, and other materials (e.g., photos of available facilities and equipment) will be conducted to identify general themes or patterns. Data also will be compared against a standard knowledge base for consistency and completeness. Projections or recommendations for training modification will be generated from the analysis.

20. If applicable, please indicate the anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

12/15/2006 Month/Day/Year

PART H: BENEFITS

21. Describe the benefit to the volunteer from participating in this study, *if any*, and the benefit to society that will be gained from the study. Please note that monetary compensation is not considered a benefit.

The benefit to participants is increased awareness of techniques for cooling food products. Overall benefits include the ability to better inform curriculum development and implementation to focus on effectiveness in regard to adult learning with the expectation of positive changes in behaviors. Better cooling practices of food items reduces the opportunity for pathogen growth and thus, reduces the risk of causing foodborne illnesses.

PART I: RISKS

The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological, emotional, legal, social or financial risk.

22. ☐ Yes ☒ No Is the *probability* of the harm or discomfort anticipated in the proposed research greater than that encountered ordinarily in daily life or during the performance of routine physical or psychological examinations or tests?
23. ☐ Yes ☒ No Is the *magnitude* of the harm or discomfort greater than that encountered ordinarily in daily life, or during the performance of routine physical or psychological examinations or tests?
24. Describe any risks or discomforts to the subjects and how they will be minimized and precautions taken. Do *not* respond with N/A. If you believe that there will not be risk or discomfort to subjects you must explain why.

A risk participants might be exposed to is potential anxiety about doing things "right" or giving the "right" answers. Participants will be reassured that the project will have the best success if they give their honest answers, do what they normally do, and that they are not in a position to be reported for inaccuracies.

25. If this study involves vulnerable populations, including minors, pregnant women, prisoners, educationally or economically disadvantaged, what additional protections will be provided to minimize risks?

NA

PART J: COMPENSATION

26. ☒ Yes ☐ No Will subjects receive compensation for their participation? If yes, please explain.

Do not make the payment an inducement, only a compensation for expenses and inconvenience. If a person is to receive money or another token of appreciation for their participation, explain when it will be given and any conditions of full or partial payment. (E.g., volunteers will receive \$5.00 for each of the five visits in the study or a total of \$25.00 if he/she completes the study. If a participant withdraws from participation, they will receive \$5.00 for each of the visits completed.) It is considered undue influence to make completion of the study the basis for compensation.

The compensation will be provided at the time they finish the interview process, whether that is when the process is completed or when they decide to withdraw from participation. The compensation will be in the form of a gift card between \$10 and \$15 (depends on budget, but all interviewees will receive the same amount) and there is only one data collection session with each participant so there is no opportunity for partial payment.

PART K: CONFIDENTIALITY

27. Describe below the methods that will be used to ensure the confidentiality of data obtained. For example,, who has access to the data, where the data will be stored, security measures for web-based surveys and computer storage, how long data (specimens) will be retained, etc.)

Only the PI will have access to the full list of participants and all data. Co-investigators will not have access to any of the data keys that might link participants to responses or results. All data collected will be stored in a restricted-access office and on secured computers. Any written instruments that will be completed (questionnaires, etc.) will be coded for confidentiality. Identification keys will be maintained separately.

PART L: REGISTRY PROJECTS

To be considered a registry: (1) the individuals must have a common condition or demonstrate common responses to questions; (2) the individuals in the registry might be contacted in the future; and (3) the names/data of the individuals in the registry might be used by investigators other than the one maintaining the registry.

- ☐ Yes ☒ No Does this project establish a registry?

If "yes," please provide the registry name below.

Checklist for Attachments

The following are attached (please check ones that are applicable):

- ☒ A copy of the informed consent document OR ☒ Letter of introduction to subjects containing the elements of consent
☐ A copy of the assent form if minors will be enrolled
☐ Letter of approval from cooperating organizations or institutions allowing you to conduct research at their facility
☒ Data-gathering instruments (including surveys)
☐ Recruitment fliers, phone scripts, or any other documents or materials the subjects will see

Two sets of materials should be submitted for each project – the original signed copy of the application form and one copy and two sets of accompanying materials. **Federal regulations require that one copy of the grant application or proposal be submitted for comparison with the application for approval.**

FOR IRB USE ONLY:

Initial action by the Institutional Review Board (IRB):

- ☒ Project approved. Date: _____
☐ Pending further review. Date: _____
☐ Project not approved. Date: _____

Follow-up action by the IRB:

Kenneth Anderson
 IRB Approval Signature

5/24/06
 Date

SECTION III: ENVIRONMENTAL HEALTH AND SAFETY INFORMATION

- ☐ Yes ☒ No Does this project involve human cell or tissue cultures (primary OR immortalized), or human blood components, body fluids or tissues? If the answer is "no", please proceed to SECTION III: APPLICATION FOR IRB APPROVAL. If the answer is "yes," please proceed to Part A: Human Cell Lines.

PART A: HUMAN CELL LINES

- ☐ Yes ☒ No Does this project involve human cell or tissue cultures (primary OR immortalized cell lines/strains) that have been documented to be free of bloodborne pathogens? If the answer is "yes," please attach copies of the documentation. If the answer is "no," please answer question 1 below.

- 1) Please list the specific cell lines/strains to be used, their source and description of use.

CELL LINE	SOURCE	DESCRIPTION OF USE

Add New Row

- 2) Please refer to the ISU "Bloodborne Pathogens Manual," which contains the requirements of the OSHA Bloodborne Pathogens Standard. Please list the specific precautions to be followed for this project below (e.g., retractable needles used for blood draws):

--

Anyone working with human cell lines/strains that have not been documented to be free of bloodborne pathogens is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the Bloodborne Pathogens Manual (<http://www.ehs.iastate.edu/bs/bbp.htm>).

PART B: HUMAN BLOOD COMPONENTS, BODY FLUIDS OR TISSUES

- ☐ Yes ☒ No Does this project involve human blood components, body fluids or tissues? If "yes", please answer all of the questions in the "Human Blood Components, Body Fluids or Tissues" section.

1) Please list the specific human substances used, their source, amount and description of use.

SUBSTANCE	SOURCE	AMOUNT	DESCRIPTION OF USE
<i>E.g., Blood</i>	<i>Normal healthy volunteers</i>	<i>2 ml</i>	<i>Approximate quantity, assays to be done.</i>

Add New Row

2) Please refer to the ISU "Bloodborne Pathogens Manual," which contains the requirements of the OSHA Bloodborne Pathogens Standard. Specific sections to be followed for this project are:

--

Anyone working with human blood components, body fluids or tissues is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the Bloodborne Pathogens Manual (<http://www.ehs.iastate.edu/bs/bbp.htm>).

FOR ENVIRONMENTAL HEALTH AND SAFETY USE ONLY

Signature of Biological Safety Officer

Date

APPENDIX B. INTERVIEW GUIDE

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

ISU IRB #:	06-254
EXEMPT DATE:	May 25, 2006
IRB #:	AS

College of Human Sciences
Department of Apparel, Educational Studies,
and Hospitality Management
31 MacKay Hall
Ames, Iowa 50011-1120
515 294-7474
FAX 515 294-6364
e-mail aeshm@iastate.edu

June XX, 2006

Fname Lname
Address
City, ST Zip

Dear foodservice employee,

I request your participation in the Foodservice Cooling Study. The purpose of this study is to understand how food products are cooled in foodservice operations. The results will be used to improve food safety training programs that include cooling processes and techniques.

Your participation involves one interview at a workplace site. The interview should take about 1.5 hours to discuss and show ways to cool hot foods. While participating in this study you are not likely to be exposed to any risks. If you decide to participate in this study you **may directly benefit by reevaluating your current food handling practices**. It is hoped that the information gained in this study will benefit foodservice operations in the state Iowa.

Compensation in the form of a gift card to a local store will be provided for your time. Your participation in this study is **completely voluntary** and you may refuse to participate. The information you provide will be kept confidential, meaning that your name or other personal information will not be connected to what you say or do with respect to cooling foods during the interview. However, federal government regulatory agencies and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information. To ensure confidentiality to the extent permitted by law your responses will be kept in a restricted-access office and on secured computers. If the results are published, your identity will remain confidential.

Questions about the rights of research subjects or research-related injury should be directed to Ginny Austin Eason, IRB Administrator, (515) 294-4566, austingr@iastate.edu, or Diane Ament, Research Compliance Officer (515) 294-3115, dament@iastate.edu.

You may also contact the researcher if you have any questions about this study.

I look forward to visiting with you.

Sincerely,

Jason Ellis, MS
Lecturer
PH: 515-294-7549
jdellis@iastate.edu

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

**Foodservice Cooling Procedures Study
Participation Consent Form**

ISU IRB #:	06-254
EXEMPT DATE:	May 25, 2006
Initial By:	AS

College of Human Sciences
Department of Apparel, Educational Studies,
and Hospitality Management
31 MacKay Hall
Ames, Iowa 50011-1120
515 294-7474
FAX 515 294-6364
e-mail aeshm@iastate.edu

I, _____ agree to participate in the
Print name
Foodservice Cooling Study. I understand that my participation involves attending
an interview at a workplace site. The interview should take about 1.5 hours to
discuss and show ways to cool hot foods. I understand that my responses will be
recorded on audiocassette for analysis. If I choose not to complete the interview, I
will inform the researcher, and thus end my participation in the project. Your
participation is voluntary! The information that you share will be kept confidential.
This means that your name or other identifying personal information won't be
connected to what you say or do with respect to cooling foods during the interview.

Signature

Date

Please complete this form and return to Jason Ellis. I look forward to talking with you.

Jason Ellis, MS
Dept. of Apparel, Educational Studies, and Hospitality Management
31 MacKay Hall
Iowa State University
Ames, IA 50011-1121
515-294-7549

If you have concerns or questions about your rights as a participant in food service research, please contact the Iowa State University IRB at austingr@iastate.edu or 515-294-4566.

ISU IRB #:	06-254
EXEMPT DATE:	May 25, 2006
Initial By:	AS

Question Guide

FOODSERVICE COOLING STUDY

1. Begin interview without pot of chili visual prompt.

- a. Tell me about hot foods that you usually deal with in this kitchen.

Prompt: Hot foods in other kitchens or jobs?

- b. Can you give me an example of a food that you have to cool down daily? Weekly? Occasionally?

Prompt: What use do you have for the cooled-down foods?

Prompts: What are challenges in cooling? What's easy about it?

Prompt: How cool does it actually have to get?

- c. Given X [example from above], can you describe how you would cool this food?

Prompts: What equipment? May I see them [if accessible]?

Prompt: How would you rate this—as easy or hard or in between? What is challenging or easy?

- d. Can you give me an example of when this process might change?

Prompts: What does this change do to the process? Anything? Easier, harder, or about the same? Speeds it up, slows it down or not really any difference?

Prompt: Why would you change the process?

2. Start chili visual prompt

- a. What foods do you cool that are similar to the chili?

Prompt: How frequently do you cool these foods?

- b. What are the steps that you would take to cool this pot of chili?

Prompt: Can you show me?

- c. Is the chili easier, harder, or about the same to cool when compared to other foods?

Prompt: Which other foods are you comparing it to?

ISU IRB #:	06-254
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Initial By:	AS

d. Can you give me an example of when this cooling process didn't work like you wanted it to?

Prompts: Why didn't it work this time? What was different about this time than others?
What was the same?

3. Post-chili activity follow-up think-alouds

a. To what extent was the way you handled the chili typical of the way you would do it normally?

Prompts: Similar or different from cooling other foods? Rationale for sameness or difference?

b. Where or from whom did you learn the techniques described or used earlier?

Prompts: Trainings or workshops? Directions from supervisors, peers, or inspectors?
Operational policy manual or signs? Watching others at this or previous job or kitchen? Etc.

c. Which foods take the longest to cool? The shortest?

Prompts: What is it about these foods that make them cool differently? Rationale for categorization.

d. What can be done, if anything, to change the speed foods cool?

Prompts: How can these be applied to different foods? What causes the foods to cool at different speeds?

APPENDIX C. INTERVIEW AND OBSERVATION NOTES FORM

Date: _____ Start time: _____ Participant ID: _____

Location: _____ End time: _____

Know		Do	
Notes	Code	Practice	Code
		Divide: Small/ Shallow	
		Ice after division	
		Blast chill	
		Cold steam kettle	

ISU IRB #: 06-254
 EXEMPT DATE: May 25, 2006
 Initial By: AS

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[illegible]

APPENDIX D. DEBRIEFING GUIDE

ISU IRB #:	06-254
EXEMPT DATE:	May 25, 2006
Initial By:	AS

Debriefing Outline

CHILI COOLING STUDY

1. Thank foodservice employee for being a participant in the study. The information they have shared is very useful to the outcomes of the project.
2. Remind participants of the procedures that will be taken to maintain their anonymity. Also remind them that if the results of the project are to be published, they will be done so in aggregate and no identifiers of individuals will be included.
3. Review the originally stated purpose of the study: to gather information about how hot foods are cooled in foodservice operations so training programs can be better informed based on in-use practices.
4. Inform participants that an additional component of the project is to see how employees' knowledge of basic science concepts, in this case heat, play a role in decision making regarding food handling. Reinforce the point that no individual data will be selected; only the collection of interviews as a whole will be analyzed for themes or patterns.
5. State that this was not provided at the beginning was so that this component of the project did not influence or have any known or unknown effects on their responses.
6. Remind participants that they may choose to withdraw from the project and their information will not be used in the project.
7. A. If participants choose to remain a part of the project, thank them for their time and let them know the gift card will be sent to their attention at their place of employment.

B. If participants choose not to remain as part of the project, note it on the bottom of their consent form, have them sign it again, and provide them with the audio tape of the interview and the completed observation form. Thank them for their time.

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