SUBJECTIVE NORMS IN FOOD SAFETY: AN EVALUATION OF CLASSROOM AND POPULAR WEB-BASED KEY INFLUENCERS' IMPACT ON CONSUMER FOOD SAFETY

by

Tressie Barrett

A Thesis

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Master of Science

Department of Food Science

West Lafayette, Indiana

May 2020

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Yaohua Feng, Chair
Department of Food Science

Dr. Amanda Deering
Department of Food Science

Dr. Hui-Hui Wang
Department of Agriculture Sciences Education and Communication

Approved by:
Dr. Arun Bhunia

Dedicated to my parents, Larry K. and Zoma A. Barrett

ACKNOWLEDGMENTS

I am especially grateful for my parents for their constant love, support, and encouragement in all my endeavors. I would also like to thank Eric and Brittany Maloney, Zach and Amy Barrett, and Rev. Dr. and Mrs. Steven Gorman along with their families for their love, care and investment in me.

Thank you to Dr. Yaohua Feng who has been a great mentor and invested significant time and energy into helping me grow professionally and personally. I am grateful to Drs. Amanda Deering and Hui-Hui Wang for serving as my committee members and for lending their expertise to the development and execution of my research studies.

I would also like to extend my gratitude to my colleagues Juan Archila, Han Chen, Emily Chuang, Merlyn Thomas, and Adley Tong for always pushing me to improve and for making my experience memorable. I am grateful to all the undergraduate students with whom I had the pleasure of working. Thank you for all the hours you spent helping review videos and blogs. Finally, I would like to thank all the educators, students, faculty, and staff who made my research studies possible.

I am sincerely thankful for the funding provided by National Institute of Food and Agriculture, U.S. Department of Agriculture which supported many of my research projects.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

High-school-aged youths have limited food safety knowledge and lack safe food-handling skills. However, these youths will prepare food for themselves and are frequently employed in the food service industry, where their food-handling practices can directly impact public health. Youths' beliefs about safe food-handling behaviors are affected by Key Influencers in their lives such as peers, classroom instructors, parents, and celebrities including popular web-content authors or video hosts. Societal changes have prompted the elimination of Family and Consumer Science courses from many schools and the reduction of food-handler role models at home, while increasing access to unregulated sources of food-handling information such as information published on web-based platforms. These societal changes largely remove peers, classroom instructors, and parents from influencing youths' food-handling behaviors.

The purpose of this study was to (1) evaluate the effectiveness of a researcher-developed food safety educational intervention at changing students' food-handling behaviors specifically focusing on the role of subjective norms in generating behavior change and (2) conduct an exploratory content analysis of food safety messages delivered by blog authors and video hosts of popular web-content.

The researcher-developed curriculum was evaluated for adherence to academic standards and overall usability in the classroom using the Delphi Technique by a panel of secondary educators who were considered experts in the education field. The curriculum was evaluated for effectiveness at changing high school students' food-handling behaviors through self-reported surveys and observation using GoPro head mounted and stationary cameras. Finally, content analysis was performed on food safety messages disseminated by authors and video hosts of popular blogs and YouTube videos, respectively.

Findings from the study demonstrated that youths' food-handling behaviors are affected by Key Influencers including their peers and classroom instructor. However, post-intervention, a role-reversal was observed and reported as students became influencers who sought to improve their Key Influencers' food-handling behaviors. Differences in influencing power within these relationships could impact the sustainability of youths' safe food-handling behaviors. In particular, imbalances in influencing power of celebrities in the absence of other Key Influencers could leave students vulnerable to adopting unsafe food-handling practices.

CHAPTER 1. INTRODUCTION

1.1 Foodborne illness and youth

Foodborne illnesses are estimated by the U.S. Centers for Disease Control and Prevention (CDC) to impact millions of people each year. In the U.S. alone, foodborne illnesses are approximated to result in 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths annually (Centers for Disease Control and Prevention). Many instances of foodborne illness infection are attributed to consumers' food-handling behaviors at home (Foudnation, 2013; Scott, 2003). Practicing safe food-handling behaviors can reduce consumers' risk for developing foodborne illness. Food safety education at the high school level is essential for imparting food safety knowledge and correct food-handling techniques to protect students and the public from foodborne illness. High-school-aged youth are an integral part of the workforce, especially in jobs involving food handling. A higher proportion of youth ages 16 to 19 are represented in food and beverage serving, as well as related occupations compared to all other occupations (Bureau of Labor Statistics, 2019). Youth are also involved with food preparation at home. A survey of 257 youth indicated that 79% of youth prepare meals and 87% help prepare meals with a family member (Cunningham-Sabo & Lohse, 2013). However, high school students' food safety knowledge (Burke & Dworkin, 2015) is inadequate to protect themselves and the public they serve. Many students do not recognize their need for food safety training. Students reported practicing safe food-handling behaviors, but they achieve low food safety knowledge scores on food safety surveys (Majowicz et al., 2015). Byrd-Bredbenner and collegues (2010) attributed youths' lack of safe food-handling knowledge and behavior to two primary factors: lack of formal food safety education and lack of role models at home (Byrd-Bredbenner, Abbot, & Quick, 2010). Classes like Home Economics that were designed to equip students with the knowledge and skills required to safely prepare food have declined or been eliminated in many secondary schools (Goldstein, 2012; Worsley, Wang, Yeatman, Byrne, & Wijayaratne, 2016). Youths' observation of role models preparing meals at home has decreased due in part to the increase in the number of parents entering the workforce and the ubiquity of convenience meals (Byrd-Bredbenner et al., 2010). The development and delivery of food safety interventions is one method that has been employed to address students' food safety knowledge and food-handling gaps.

1.2 Previous food safety education programs for youth

A variety of education methods have been used to improve elementary- and middle-school-aged youths' food safety knowledge and food-handling behaviors. One study in which middle school students were provided with an electronic game, Kitchen Ninja to the Rescue, indicated that educational games can increase students' food safety knowledge and confidence in their abilities to handle food safely (Quick, Byrd-Bredbenner, & Corda, 2011). Other studies have noted that rhyming is an effective method to increase recall, and repeatedly practicing a procedure can have different learning impacts when compared to only listening to information or observing the behavior of others (Ovca, Jevšnik, & Raspor, 2018; Yiannas, 2015). However, few food safety interventions have been developed specifically for high school students. Food safety interventions targeted toward high school students have been evaluated for effectiveness at changing food safety knowledge, attitudes, and behaviors. A longitudinal study conducted by Majowicz et al. (2017) in Canada tracked the food safety knowledge and attitudes of high school students at three time points, following an educational intervention delivered in food and nutrition courses. Student knowledge increased significantly after the intervention but attenuated twelve weeks after intervention; student interest in learning how to prevent contracting a foodborne illness also significantly decreased, which was attributed to the content's loss of novelty (Majowicz et al., 2017). A more recent study provided 53 high school students with a 90-minute in-class food safety educational intervention that utilized a Positive Deviance model to increase student food safety knowledge and elicit behavior change. Students' overall knowledge score improved significantly; however, discrepancies existed between student food safety knowledge and knowledge application in food-handling activities (Whited, Feng, & Bruhn, 2019).

1.3 Behavior change theories and education models

Educational interventions developed using theories of behavior change have been suggested to be more effective than traditional methods (Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Prestwich, Webb, & Conner, 2015; Young, Thaivalappil, Greig, Meldrum, & Waddell, 2018). The Theory of Planned Behavior (TPB) can be used to predict behaviors, making TPB a strong basis for developing food safety educational interventions to elicit behavior change. The Theory of Planned Behavior asserts that a person's behavior intention is directly linked to the person's performed behavior (Glanz, Rimer, & Viswanath, 2015; Young et al., 2017). A person's behavior intention is influenced by the person's attitudes about the behavior, perceived behavior control, and subjective norms (Ajzen, 1991; Glanz et al., 2015). Attitude about the behavior relates to a person's positive or negative assessment of performing the behavior; positive outcomes resulting from performing a behavior are associated with positive attitudes. Perceived behavior control refers to the difficulty of performing a behavior in relation to a person's self-efficacy for performing the behavior. Subjective norms refer to a person's belief of whether others, who are important, influential individuals (Key Influencers) to the person, approve of performing a behavior and to the person's motivation to conform to the behavior they believe is viewed as acceptable by these individuals. Risk-perception can be factored into the TPB to generate a modified TPB model (B. A. Mullan, Wong, & Kothe, 2013). Many studies have applied TPB to food safety-related practices, but few studies have used TPB to predict safe food handling practices among youth. Mullan and colleagues (2013) evaluated how well knowledge alone predicted behavior intention and practiced behavior among 205 youth. This study found TPB factors combined with risk-perception were much stronger predictors of behavior intentions and practiced behavior compared to knowledge alone (B. A. Mullan et al., 2013). TPB has also been used to evaluate individual components of food-handling practices like variation in hand hygiene among caterers and consumer consumption of thoroughly cooked meat (Clayton & Griffith, 2008; Mari, Tiozzo, Capozza, & Ravarotto, 2012; B. Mullan, Allom, Sainsbury, & Monds, 2015). The use of TPB and modified versions of TPB that consider additional behavior-influencing factors can be used to develop interventions that target a study population's specific motivations and barriers (Glanz et al., 2015; B. Mullan et al., 2015).

While studies have used the TPB model to evaluate individual components of food safety or have focused on evaluating the influence of the TPB factors as predictors of behavior, few studies have focused on evaluating the role of Key Influencers in eliciting behavior change among students. Two studies conducted among college students and adolescents using the TPB model to predict practiced food-handling behavior evaluated subjective norms using a single question compared to the other TPB factors for which four to six questions were asked (B. A. Mullan et al., 2013; B. A. Mullan & Wong, 2009). The question related to subjective norms asked respondents generally about the people who were important to them, but no questions were asked about specific individuals such as family members, friends, or peers. Another study among college students that examined food-handling behaviors distinguished between injunctive, students' perception of the behaviors Key Influencers would approve of, and descriptive norms, students' perception of the behaviors performed by Key Influencers (Conner & Sparks, 2005; B. Mullan et al., 2015; B. A. Mullan & Wong, 2009). However, this study also grouped Key Influencers as a generalized, vaguely defined population.

Although the TPB model does not link knowledge to performed behaviors, knowledge may still be an important factor to consider for novice food-handlers, such as high-school-aged youths, who are developing new skills. Measuring knowledge change aids in understanding whether lack of knowledge is an inhibiting factor in food-handling behavior performance. As mentioned, food safety knowledge has significantly increased following educational interventions; however, students' knowledge attenuated over time (Majowicz et al., 2017). Few other food safety studies have measured food safety knowledge retention, and additional research is needed in this area. Past research in the area of knowledge retention established that periodic review of information rather than prolonged intense study sessions improve knowledge retention (Cepeda, Vul, Rohrer, Wixted, & Pashler, 2008). Newer youth education strategies such as providing students with personalized information to review based on student performance improved student knowledge retention compared to traditional mass study techniques that are not personalized (Lindsey, Shroyer, Pashler, & Mozer, 2014). The method used to present the information, either via online and face-to-face instructional platforms, did not produce significantly different long-term knowledge retention among students (Edwards, Rule, & Boody, 2017). Differences between pedagogy also appears to have limited influence in long-term knowledge retention. The effectiveness of lectures was compared to team-based learning, an active learning method in which students interact within teams to solve a problem and publicly present the solution (Farland, Franks, Barlow, Rowe, & Chisholm-Burns, 2015; Sibley & Ostafichuk, 2015). Finding from this study demonstrated there was no significant difference between the two pedagogies and students' overall long-term knowledge retention, but there were significant differences for certain topics. Therefore, selecting an appropriate pedagogy for a given topic could influence students' long-term knowledge retention. Knowledge retention studies conducted among students in nutrition and health science courses have found that the educational interventions increase students' knowledge following the intervention; however, their knowledge attenuates five months to one year later

(Farland et al., 2015; Ferreira, Maguta, Chissaca, Jussa, & Abudo, 2016; Matvienko, Lewis, & Schafer, 2001).

As previously mentioned, the PD model is another model that can be used to influence behavior change. The PD model is an asset-based strategy in which practitioners seek to identify members in a given setting who are successfully overcoming the challenge of interest (Herington & van de Fliert, 2018; LeMahieu, Nordstrum, & Gale, 2017). Positive Deviant can be defined as individuals who are able to achieve a desired result when the majority of the population is not thriving when faced with the same circumstances (Hendryx et al., 2017). The PD model is considered asset-based because solutions to challenges are generated using the behaviors practiced already being successfully employed by the Positive Deviants (Rose & McCullough, 2017). This model allows for open discussion regarding best practices based on observations of and interviews with Positive Deviants (LeMahieu et al., 2017). The PD model has been used frequently and successfully in community health applications and has the power to influence the population's subjective norms (Herington & van de Fliert, 2018). Educational interventions developed using the PD model allow students to interact with their peers while instructors act as facilitators who aid in identifying and emphasizing Positive Deviant behaviors (Whited et al., 2019). This design can impact student behavior by demonstrating how they can apply specific behaviors in their own circumstances and by influencing their beliefs about what their peers, who are Key Influencers, view as desirable practices.

Experiential learning is teaching strategy with demonstrated implications to motivate behavior change and improve learning outcomes. Experiential learning bridges the gap between theoretical knowledge and real-world applications using hands-on activities to prepare students to solve real-world problems; it also serves as a means to relate work, personal development, and education (Gonczi, 2013; D. A. Kolb, 2014; Wenger, 2009). In an experiential learning context, learners have an experience, reflect on the experience, make modifications or generate new ideas based on their reflections, and experiment using new ideas, thereby generating a new experience to complete the cyclic learning process (D. A. Kolb, Boyatzis, & Mainemelis, 2001). Students demonstrate an understanding of content through practical application rather than rote memorization, as is commonly used in some traditional methods to evaluate student content mastery. Experiential learning can encompass many different activities, including simulation (Heron, 1999). Simulations have been used widely in college settings to prepare students to address real-world problems

(Gonczi, 2013). Simulation provides instructors with the opportunity to allow students to experience workplace challenges without leaving the classroom, a highly advantageous attribute when access to workplace environments is infeasible (Rochester et al., 2012). Through participation in simulation activities, students develop professional skills, including data collection, data analysis, and communication. Research studies have also demonstrated the effectiveness of experiential learning at improving student recall of concepts and increasing student engagement in learning (Kuh, 2008).

1.4 Barriers to food safety education in classrooms

Barriers to food safety education in classrooms have been identified for incorporating new curricula, like food safety educational interventions, into the classroom: student engagement, resource availability, time constraints, instructor expertise, and usability across schools. As previously mentioned, student interest in food safety topics has been shown to decease after exposure to food safety information. Student engagement is multifaceted, including emotional, behavioral, and cognitive components (Mo, 2008). According to Corso et al. (2013), student engagement is influenced by internal factors, such as a student's personality, as well as external factors. External student engagement can be assessed by students' interaction with the instructor, their peers, and the material being learned. Students are likely to engage in experiences related to their interests, thus building skills in these areas that translate into confidence (Nauta, Kahn, Angell, & Cantarelli, 2002). Student engagement is paramount in curriculum design and is achievable through the implementation of tasks and activities based on principles in each content area (Lee & Brophy, 1996; Uçar & Sungur, 2017). These external engagement factors, students' social environment and their interests, may influence students' self-efficacy and performance (Nugent et al., 2015).

Resource limitations of the target population's school system is a challenge that needs to be addressed. Lack of financial resources may be a limiting factor in food safety education in public schools. According to a 2017 report, schools in many states are still recovering from budgetary cuts resulting from the 2008 recession (Leachman, Masterson, & Figueroa, 2017). A study conducted with Home Economics instructors indicated that funding for food literacy programs across schools was variable; instructors from many public schools indicated their budgets were small or nonexistent (Ronto, Ball, Pendergast, & Harris, 2017). Food safety curriculum design must account for the financial constraints of targeted schools. Challenges associated with lab space availability may also arise for instructors in fields other than science, and schools may lack kitchen space for students to apply and test the concepts they learned.

Time constraints and time management have been identified by instructors as a concern (Christou, Eliophotou-Menon, & Philippou, 2004; Melnick & Meister, 2008). Instructors are under pressure to meet academic standards and have limited time to incorporate content unaligned with these academic standards. Adapting food safety curriculum to align with academic standards in other core disciplines such as science classes could address the issue of in-class time constraints. However, many instructors cited the preparation time required to teach lesson as a concern (Melnick & Meister, 2008). Instructors with limited food safety knowledge may find it time consuming and challenging to design a curriculum that meets academic requirements and provides practical applications in disciplines in which food safety has not been taught historically. Multidisciplinary food safety educational interventions can be designed by food safety experts to address these constraints. Food safety interventions intended for classroom use should be designed for use by lay instructors to mitigate potential deficits in curriculum delivery to students. This includes the incorporation of detailed lesson plans and relevant resources aimed at enhancing and supplementing instructors' knowledge to increase instructor self-efficacy. Instructor self-efficacy has been linked to instructor effectiveness, and the ability to provide students with learning opportunities that promote positive student performance outcomes (Shoulders & Krei, 2015).

Another consideration is the usability of the food safety curricula across schools. The design of food safety educational interventions can enhance usability by addressing additional school requirements. Career-ready education has been emphasized as part of academic standards at the state level. Career-ready education is critical in providing students with skills necessary to analyze and solve real-world challenges. Chen et al. (2016) asserted that traditional teaching methods fall short in preparing students to solve industry problems due to the differences in the types of problems encountered in a traditional classroom versus industry setting. They claimed curriculum design should integrate personal and professional development components to prepare students for careers in industry (D.-F. Chen et al., 2016). Curriculum designed to integrate Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) is one non-traditional method demonstrated to provide students with the technical and social skills required for career competency. There has been a nationwide call to increase the number of students entering STEAM fields to meet the growing demand for workers in STEAM careers (Mohr-Schroeder, 2019). The U.S. Department of Agriculture estimated more than 1 in 4 careers in food, agriculture, renewable natural resources, and the environment would be STEAM-related from 2015 to 2020 (U.S. Department of Agriculture). STEAM education dismantles education silos by facilitating learning across disciplines through an emphasis on linking concepts from different disciplines to interpret and analyze content in a more true-to-life context. Many food safety challenges require multidisciplinary approaches to provide adequate, feasible solutions. STEAM incorporation into food safety curricula will equip students to address food safety challenges by teaching them to combine concepts and skills from multiple disciplines to generate solutions. STEAM education can enhance students' ability to link together and generate a deeper understanding of concepts, to utilize problem-solving as they apply their knowledge to generate tangible solutions, and to cultivate teamwork skills.

1.5 Evaluating curriculum design and effectiveness

Curriculum design effectiveness can be evaluated using the Delphi technique. Prior studies have used the Delphi technique to design a curriculum for secondary and post-secondary education (Krijtenburg-Lewerissa, Pol, Brinkman, & van Joolingen, 2019; Masud et al., 2014). The Delphi technique uses rounds of surveys to generate consensus among a panel of experts who remain anonymous (Löfmark & Mårtensson, 2017). Anonymity prevents dominant experts from controlling the discussion and generating a false consensus (Humphrey-Murto, Varpio, Gonsalves, & Wood, 2017). There are no firmly established protocols for an adequate number of survey rounds, a definition of an expert, and criteria for consensus *(Löfmark & Mårtensson, 2017; Sourani & Sohail, 2015)*. Researchers have used different methods to determine the survey cessation point, including pre-establishing the number of surveys to be conducted—usually three or four rounds—surveying until a certain level of consensus has been reached, and continuing to survey experts until there is no statistically significant difference in results between the current survey and the subsequent survey (Dajani, Sincoff, & Talley, 1979; Fan & Cheng, 2006; Heiko, 2012; Seagle & Iverson, 2002). Some applications of the Delphi technique begin with experts answering open-ended questions related to the topic; these answers are then categorized and developed into structured questions for subsequent survey rounds (Krijtenburg-Lewerissa et al., 2019).

The curriculum effectiveness can be evaluated by measuring students' knowledge, attitude, risk, and behavior change using surveys and direct observation. Surveys can be an effective method for gathering participant food safety knowledge, attitudes, and barriers; however, surveys requiring participants to self-report behaviors can be affected by participants' perceptions and recall bias (Schrempft, van Jaarsveld, & Fisher, 2017). An observational study indicated that study participants had higher levels of food handling knowledge than they practiced (Mazengia, Fisk, Liao, Huang, & Meschke, 2015). Food handler observational studies provide more accurate depictions of actual food handling practices, but these studies are not without limitation. Past observational studies have relied on real-time recording of food handling (Her, Seo, Choi, Pool, & Ilic, 2019; Majowicz et al., 2017; Ovca et al., 2018; Soon, 2019); this can result in missed recordings of food handling practices, especially in group settings where one person is recording food handling practices of multiple participants simultaneously.

Video recording devices can be used to increase the accuracy of recording food handler behaviors by allowing the observer to pause or replay scenes. Camera-based observational studies have utilized video collection methods including stationary and wearable cameras. A recent observational study was conducted in which participants prepared a meal in a model kitchen with ceiling mounted cameras used to capture the participants' food handling techniques and kitchen hygiene practices (Evans & Redmond, 2018). Wearable cameras have been utilized in health based studies to evaluate participants' diets and activity levels, and recently, to study home environments (Schrempft et al., 2017). The wearable camera can be attached to a lanyard, worn around the neck, and secured with tape on the participant's back to provide stability (Schrempft et al., 2017). The wearable camera may increase the observer's ability to track participant behavior and document how the participant is interacting with the surrounding environment when compared to stationary cameras by reducing "shot blocking" and participant movement outside the camera's field of view. Combining data from survey and camera-based collection methods will generate a more holistic view of food handler motivations and barriers to learning and sustaining safe food handling practices.

1.6 Other sources of food safety information

Outside the classroom, food safety information can be disseminated through Web-based sources. Web-based resources are frequently used for learning about cooking and for sharing recipes. Free video-streaming, food blogs, and free online forums enable consumers to post and share recipes easily. Content posted on these web-based forums has the potential to reach a broad consumers base. In a recent study, young adults were found to be more likely than previous generations to access web-based content for meal preparation resources, such as food blogs and YouTube videos (Feng, 2020). Consequently, a reliance on web-based sources may continue to increase. Given this increased reliance on online resources, exposure to web-based content that models or promotes unsafe food-handling behaviors may lead to a higher risk for foodborne illness among consumers, especially young adults.

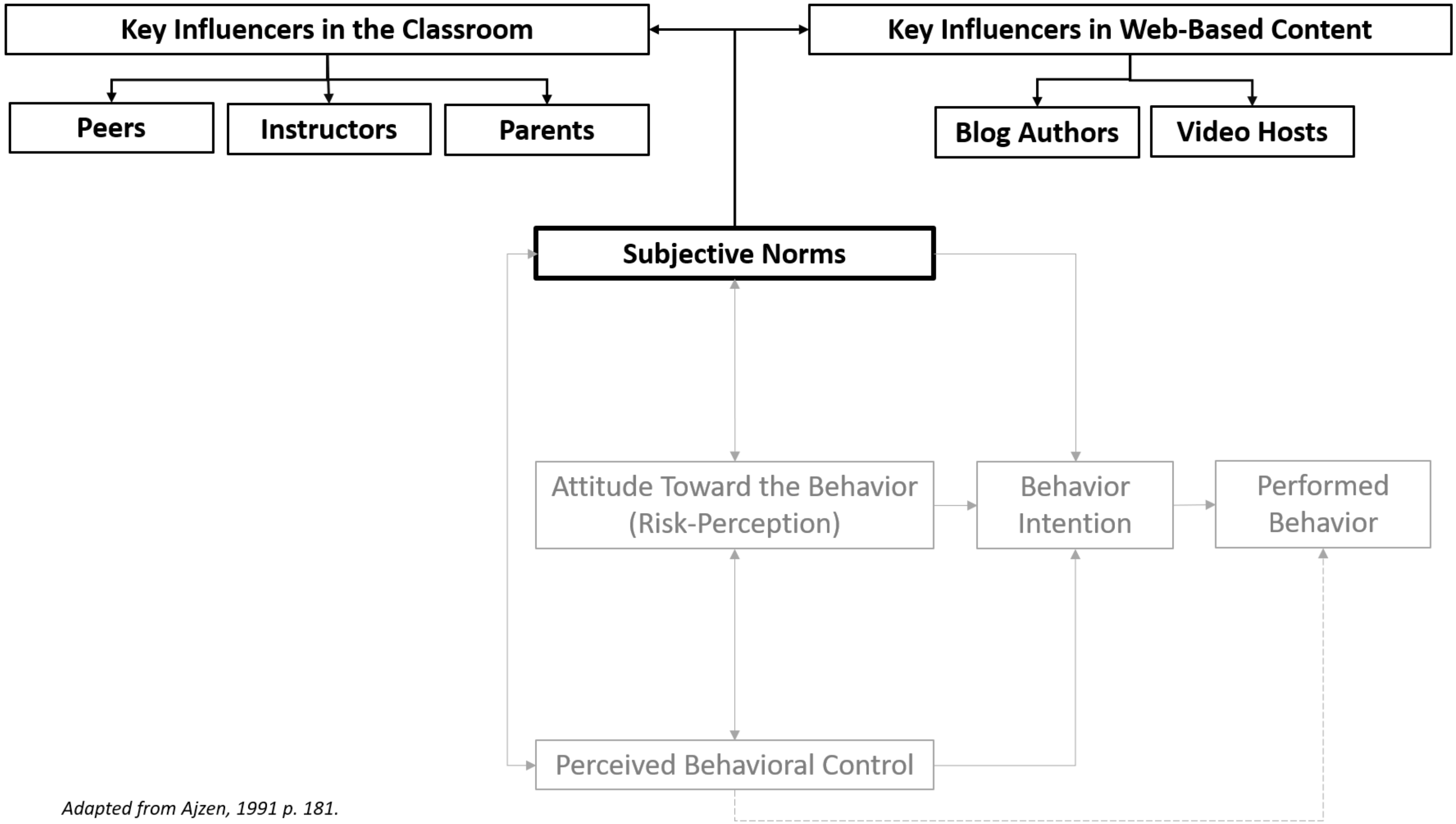
1.7 Key Influencers in the classroom and popular web-based sources

As previously discussed, the Key Influencers in TPB food-handling studies were not explicitly defined. In learning food-handling behaviors, parents were identified as Key Influencers who are likely to provide food-handling training to youth (Chow & Mullan, 2010; B. A. Mullan et al., 2013), Figure 1.1. These learned behaviors can be carried into the classroom. In the classroom, Key Influencers of students' subjective norms include instructors and peers; the degree to which students feel accepted by instructors and peers can impact students' classroom engagement (Corso, Bundick, Quaglia, & Haywood, 2013). These Key Influencers likely have a significant impact on students' food-handling behaviors. A study investigating the strength of TPB factors in predicting behavior intent indicated that subjective norms were the most influential of the TBP factors in predicting behavior intent (Chow & Mullan, 2010). It has been suggested that, compared to adults, youths are more responsive to peer influences in the context of health-related behaviors (B. A. Mullan et al., 2013).

Media has also been identified as a Key Influencer (Chow & Mullan, 2010). Blogs and YouTube are frequently used web-based cooking resources. The video-sharing platform, YouTube, is estimated to have over two billion users (Her et al., 2019), with 87% of users identifying YouTube as an important source of how-to information (Aaron Smith, 2018). YouTube allows consumers to post how-to videos, including those related to preparing food. Blogs are another popular and influential information-sharing channel for the dissemination of food-related content (Cuomo, Tortora, Festa, Giordano, & Metallo, 2017). Popular blogs can attract 5 million unique viewers each month, and the trustworthiness of content provided influences the likelihood that viewers will follow the authors' recommendations (Dickinson, Watson, & Prichard, 2018;

Morrison & Young, 2019). Food blogs and YouTube videos' content creators have a range of experiences from novice to professional chef. Moreover, the food safety messages in blogs and YouTube videos are unregulated and may spread misinformation.

Celebrities and influencers model food preparation techniques that consumers use in their own lives. Previous evaluations of safe-food preparation media concluded that television-chef role models made food-handling errors frequently and that this, in turn, could impact consumers' food-handling behaviors (Maughan, Chambers IV, & Godwin, 2017; Woods, 2015). Studies that reviewed food safety messages in blogs focused on recommended food-handling behaviors related to eggs, meat, poultry, seafood, and raw produce (Godwin, Maughan, & Chambers, 2016; Morrison & Young, 2019). These studies highlighted a lack of food safety messages in blogs and other web-based sources, while the food safety messages that were provided contained inaccurate information.



Adapted from Ajzen, 1991 p. 181.

Figure 1.1. Youths' Key Influencers identified in the classroom and in web-based content

CHAPTER 2. EXPERIMENT I: CURRICULUM DEVELOPMENT

2.1 Objectives

The objectives of this study are to use the Delphi technique to evaluate a researcher-developed food safety curriculum using a panel of instructors and to understand instructors' barriers to teaching food safety topics in their classrooms. The curriculum can be accessed using the following weblink: https://ag.purdue.edu/foodsci/Fenglab/extension-articles/. The food safety curriculum was evaluated for the following topics.

1. Feasibility of incorporating the curriculum into classrooms;
2. Ease of use for an instructor with no prior food safety experience;
3. Student engagement;
4. Experiential learning in the context of food safety;
5. Transferability of the curriculum across STEAM fields; and
6. Introduction of students to careers in agriculture and food safety.

2.2 Materials and Methods

Curriculum Development

The researchers targeted Indiana Academic Standards for Agriculture, Advanced Life Science: Food (August 2018) for food safety curriculum alignment. The food safety curriculum was aligned to Indiana Academic Standards for Agriculture, Advanced Life Science: Food (August 2018) and developed for students in grades 9-12. This curriculum was modified from a previous curriculum that included the Fight BAC! Campaign's four core principles of clean, cook, chill, and separate, and an added fifth concept of choosing safe food as food-safety foundational pillars (Feng, Bruhn, Elder, & Boyden, 2019). The modified curriculum incorporated an introduction to Hazard Analysis Critical Control Point (HACCP) development that asked students to identify biological, chemical, physical, and radiological hazards in their fictitious processing facility and then develop a plan to control the hazards they identified. One day of instruction was allotted for each topic, with the topics "cook" and "chill" being combined into one lesson to generate a five-day food safety unit. In-class activities were designed to provide experiential learning by having students participate in simulations that reflected activities in the food industry relevant to each foundational pillar. To successfully complete simulation activities, students needed to combine two or more STEAM components, with the choosing-safe-food simulation requiring students to use all five components to address the challenge. All activities occurred in the context of a fictitious food manufacturing company. During each lesson, students developed professional skills by applying the food safety concepts they learned to solve common industry challenges. Take-home activities were designed to improve students' personal growth in knowledge and practices of food safety at home. Two days of cooking labs and pre- and post-tests were built into the curriculum prior to and post the five-day unit. The cooking labs allowed students to practice safe food handling through experiential learning. During the five-day unit, students were able to reflect on the safety of their food handling and make modifications to their practices, prior to participating in the final cooking lab.

Expert Panel Selection

This study was approved by Purdue University's Institutional Review Board for Human Subjects Research. A panel of experts in the field of education evaluated the curriculum. Experts were defined as individuals who had been in the field of education for a minimum of 10 years, had been a classroom instructor, and were qualified to teach curriculum for secondary education, either by license or endorsement. The definition of experts was used as expert-selection criteria. Experts were recruited through an Indiana agricultural instructor Listserv and by emailing secondary instructors in agriculture, science, mathematics, and FACS, using faculty contact information on school websites. Expert demographic information was collected via an online survey and reviewed to ensure all criteria were met. Experts who did not meet the criteria were excluded from the study.

Questionnaire Design

Each survey included statements about the curriculum, as outlined in Figure 2.1 and Table 2.1. Ten questions were asked on the first survey, relating to all the study topics, excluding experiential learning in the context of food safety and the introduction of students to careers in agriculture and food safety. The second survey included 21 questions and covered each study topic, excluding alignment with academic standards. This survey was used to delve deeper into questions for which no consensus was reached in the first survey round and to explore new topics based on expert feedback. The goal of round three of the survey was to gain consensus on questions for which no consensus was reached in prior rounds of the survey. This survey contained three questions related to the feasibility of incorporating the curriculum into the classroom: the curriculum should be expanded to 3-5 days per topic, low-cost lab and activity alternatives should be incorporated, and factors that should be considered inhibitory to incorporating the curriculum into the classroom, including unavailable kitchen space, insufficient lab or classroom space, and cost to purchase materials for the cooking activities and HACCP. Experts were asked to briefly explain each of their answers for this round of the survey to provide researchers with further insights by which to determine final changes to be made to the curriculum, should consensus not be reached about the question in the final round. Each survey asked demographic questions, including gender, age, years of teaching, and subjects taught.

Experts were asked to use a 5-point Likert scale from "strongly disagree" to "strongly agree" to rate the degree to which they agreed with each statement. Likert-scale questions were evaluated for consensus by grouping the five categories into "agree," "neither agree nor disagree," and "disagree" categories. Responses of "agree" or "strongly agree" were grouped under the "agree" category. The "disagree" category included responses of "disagree" or "strongly disagree." In the second and third round of surveys, experts were asked to indicate which factors from a provided list would inhibit the incorporation of the curriculum into the classroom. These questions were multiple-answer: experts could check all choices that applied. Display logic was used to provide one additional question for inhibitory factors, which are referred to as barriers henceforth, related to student interest, instruction time, and required approvals to use the curriculum. The additional question asked respondents to identify why the factor would be a barrier, or from whom approval would be required. "Select all that apply" answers were considered "agree" if a factor was selected as a barrier, and "disagree" if the factor was not selected

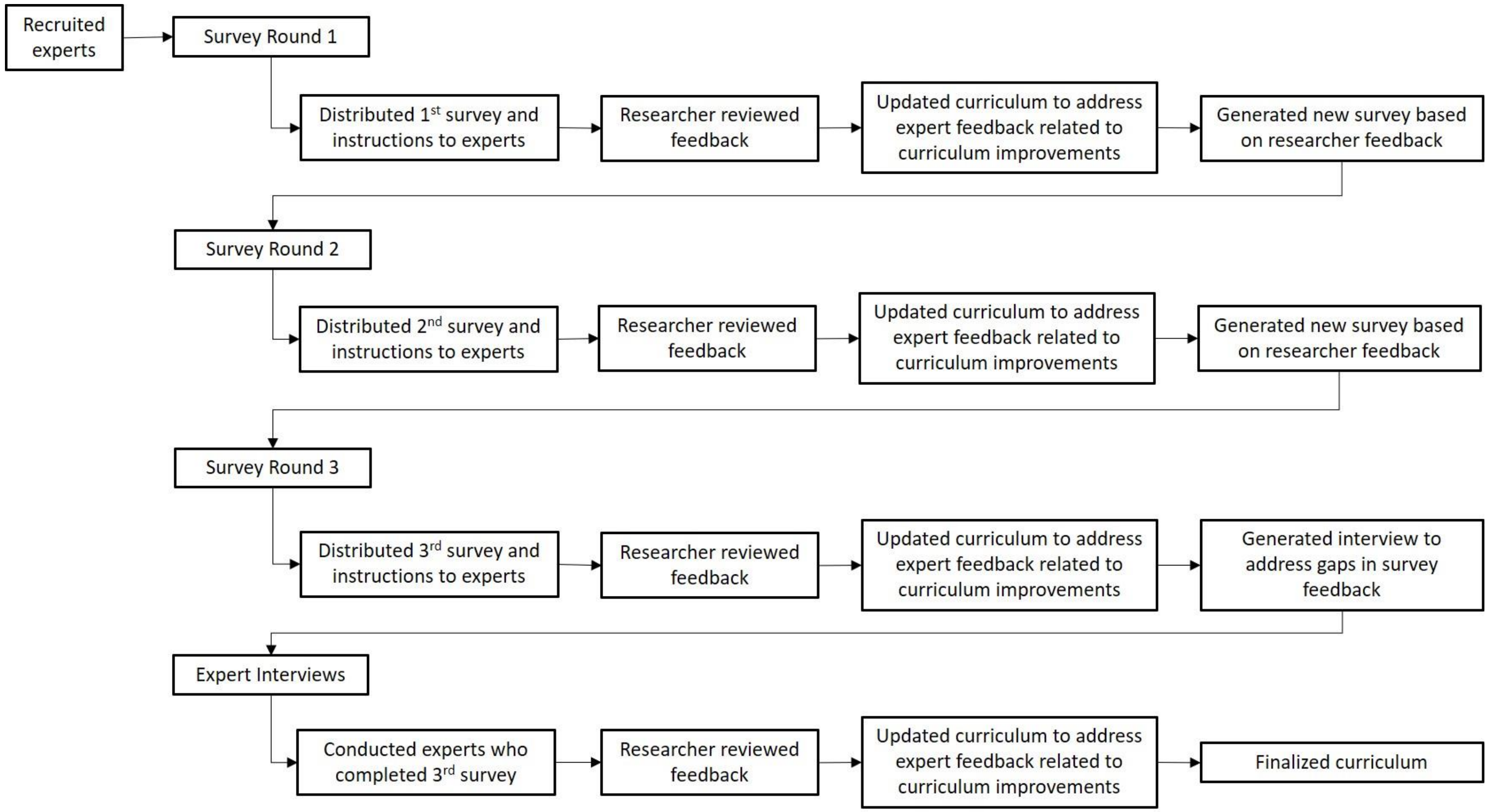


Figure 2.1. Data collection sequence for Delphi technique and expert interviews

Table 2.1. Questions asked and degree of expert consensus in each round of surveys

Round 1 **N=23** **Females: 61%** **45-54 years old: 30%** **Master's degree: 70%**			**Round 2** **N=19** **Females: 79%** **25-34 years old: 37%** **Master's degree: 63%**			**Round 3** **N=16** **Females: 88%** **25-34 years old: 44%** **Master's degree: 58%**		
Round 1: Consensus Reached	**% of Experts**	**Topic #**	**Round 2: Consensus Reached**	**% of Experts**	**Topic #**	**Round 3: Consensus Reached**	**% of Experts**	**Topic #**
The curriculum addresses the state standards* cited for each topic in the unit.	95.7%	1	The length of IN-CLASS activities is appropriate for high school students.	94.7%	1	Alternative, low-cost labs and activities should be incorporated in each lesson.	75.0%	1
The length of TAKE-HOME activities is appropriate for high school students.	87.0%	1	If lessons were expanded to 3-5 days per topic, end-of-unit quizzes with answer keys should be included to assess student knowledge.	100.0%	1			
Food safety education is important for high school students.	100.0%	1	Based on how this curriculum is written currently, what would inhibit the incorporation of this curriculum in the classroom?					
The curriculum is the correct difficulty level for high school students.	95.7%	3	▪ Principal, school board, or other committee approval would be hard to obtain	78.9%**	1			
The activities presented are engaging.	100.0%	3	▪ Students' interest					
			▪ Insufficient instruction time	78.9%**	1			
			▪ Cost to purchase materials for CLEAN activities	84.2%**	1			

Table 2.1 (Continued)

			▪ Cost to purchase materials for CHILL/COOK activities	78.9%**	1
				84.2%**	1
The ideas and concepts presented are appropriate for high school students.	100.0%	3	▪ Cost to purchase materials for CROSS-CONTAMINATION activities	78.9%**	
			▪ Cost to purchase materials for CHOOSE activities	100.0%**	
			It would be easy for a instructor to set up the experiments as described.	89.5%	1
			It would be easy for a instructor with no experience in food safety to use this curriculum.	89.5%	2
			This curriculum would benefit from having a instructor training video to illustrate how to conduct the lessons and facilitate discussion.	73.7%	2

Table 2.1 (Continued)

This curriculum is appropriate for high school students.	100%	3
Which component(s) of this curriculum is (are) not appropriate for high school students?		
1. CLEAN activities		
2. CHILL/COOK activities	100%***	3
3. CROSS-CONTAMINATION activities	100%***	3
4. CHOOSE activities	100%***	3
5. HACCP activities		
	100%***	3
	100%***	3
Lessons should be designed to incorporate experiential learning in general.	73.7%	4
Experiential learning activities are incorporated into this curriculum.	89.5%	4
Incorporating STEM and STEAM education makes the curriculum, in general, more relevant in today's classroom.	100%	5
Food safety curriculum, in general, would be more relevant if it were taught using STEM or STEAM.	78.9%	5

Table 2.1 (Continued)

STEM or STEAM activities are integrated into this curriculum.	100.0%	5
It is important to incorporate career education into the curriculum in general.	94.7%	6
This food safety curriculum successfully incorporated career education.	78.9%	6
More examples of food-related careers should be included in the lesson plans (e.g., culinary arts, dietetics, regulatory agencies, and waitstaff) of this curriculum.	78.9%	6
This curriculum is unique from other science/agriculture curriculum with respect to the unification of lessons through a common career theme.	84.2%	6
This curriculum effectively causes students to critically compare industry food safety to home food safety.	94.7 %	N/A
This curriculum adequately addresses food safety topics.	100%	N/A

Table 2.1 (Continued)

Round 1: Consensus not reached	% of Experts	Topic #	Round 2: Consensus not reached	% of Experts	Topic #	Round 3: Consensus not reached	% of Experts	Topic #
The length of IN-CLASS activities is appropriate for high school students.	69.6%	1	Based on how this curriculum is currently written, what would inhibit the incorporation of this curriculum in the classroom?			Based on how this curriculum is currently written, what would inhibit the incorporation of this curriculum in the classroom?		
			▪ Unavailable kitchen space	52.6%	1	▪ Unavailable kitchen space	62.5%**	1
			▪ Insufficient lab/classroom space to set up experiments	52.6%**	1	▪ Insufficient lab/classroom space to set up experiments	68.8%**	1
			▪ Cost to purchase supplies for cooking activities	57.9%	1	▪ Cost to purchase supplies for cooking activities	62.5%	1
			▪ Cost to purchase materials for HACCP activities	68.4%**	1	▪ Cost to purchase materials for HACCP activities	62.5%**	1
It would be easy for a instructor to set up the experiments as described.	60.9%	1	This curriculum should be expanded to spend 3-5 days on each of the five topics.	57.9%	1	This curriculum should be expanded to spend 3-5 days on each of the five topics.	68.8%	1
It would be easy for a instructor with no experience in food safety to use this curriculum.	60.9%	2	Alternative, low-cost labs and activities should be incorporated for each lesson.	68.4%	1			

*State standards means Indiana Academic Standards

**Indicates reverse coding. Experts agreed with the statement.

***Indicates the percentage was calculated out of the number of correctly completed responses.

Study design

The food safety curriculum for review and a link to the corresponding online survey were emailed to each expert. All surveys were designed using Qualtrics (Qualtrics, Provo, Utah), and the three survey rounds were administered from December 2018 through June 2019 (Humphrey-Murto, Varpio, Gonsalves, & Wood, 2017). No formal brainstorming survey was conducted. As noted by Sitlington and Coetzer (2015), incorporating brainstorming would add an additional round and could contribute to higher attrition rates. However, all surveys contained an open-ended question asking experts to provide any additional feedback related to the curriculum that was not addressed by the survey questions. Additional questions were generated for the second survey from the first survey's open-ended question feedback.

Experts were given two weeks to review the curriculum and complete the survey. Edits were made to the curriculum based on expert feedback, and the updated curriculum was provided to the expert panel for review in subsequent survey rounds. Survey question responses were reviewed after each round for consensus. A consensus was defined as 70% expert agreement or disagreement with a statement, or a neutral response (Humphrey-Murto et al., 2017). Questions for which no consensus was reached remained on the survey, and the corresponding mean and median responses were provided to the experts. During the final round of surveys, experts were asked to provide a brief explanation for each of their responses. This served as a basis for the researchers to make decisions on final curriculum changes related to topics for which consensus was not reached.

After conducting the three rounds of the survey, experts who completed the third round were contacted for a brief follow-up interview to clarify expert opinions that remained unclear. Follow-up interviews, after the Delphi technique implementation, are a common method used by researchers to gain further insights into expert answers, including response stability and validity (Krijtenburg-Lewerissa et al., 2019). Follow-up interviews were conducted with nine experts. The follow-up questions are listed in Table 2.2 and addressed all six study topics previously mentioned.

Table 2.2. Follow-up instructor interview questions related to study topics

Topic	Question
1	The cost of HACCP supplies is one area in which we did not have agreement at the study's end. What are the costs associated with HACCP supplies that would inhibit incorporation of this curriculum into the classroom? *Note: HACCP supplies were note-taking and take-home activity sheets as well as free online videos outlining the basic principles of HACCP and hazard analysis.*
2	What additional materials or information would help new instructors or instructors with limited food safety knowledge teach this curriculum?
3	What would increase student interest in food safety topics?
4	Do you have any recommendations for improving the experiential learning components of this curriculum? Were there any experiential learning components you would definitely recommend keeping?
5	In which activities did you see examples of STEAM components?
6	What would improve the career education component of the curriculum? For example, should there be more career paths represented or should the activities more realistically simulate how problems would be presented in industry?

Data Analysis

Expert responses for each Likert-scale and multiple-choice survey questions, expert feedback from open-ended questions, and responses to interviews were analyzed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA, 2016). The percentage of experts who agreed, were neutral, and disagreed was calculated for each Likert-scale question. For multiple-answer questions related to an inhibiting factor, each factor selected was assessed individually. The percentage of experts who selected each factor was calculated. Likert-scale and multiple-choice questions were evaluated for consensus. An additional question displayed when experts indicated student interest, instruction time, or required approvals could inhibit incorporation of the curriculum into classrooms. These additional questions were not evaluated for consensus since only the experts who selected these inhibiting factors were provided the question. These questions and responses to open-ended questions were grouped thematically (Table 2.3).

Table 2.3. Expert feedback related to the study's objectives

Expert Quote	**Feedback Source**
Topic 1, Feasibility of incorporating the curriculum into classrooms	
"This is a much-needed topic at the high school level. With funding cuts, programs are cut. If students can't take a foods course, it needs to be implemented in other science areas."	Survey
"I teach both Food Science and Advanced Life Science: Foods, and I really believe this curriculum is a little advanced for the first class but hits the standards of the ALS class completely. I have done a few of the activities, and they went well. I really appreciated the guided answer section and the standards this curriculum covered."	Survey
"I felt that the in-class activities were very lengthy, and there may have been too many things planned for a single class period. Unless the school operated on a block schedule, there is no way a instructor could get through the materials on certain days. While I do think that it is better to have more planned for a period than less—at times it seemed like way too much material to cover."	Survey
I like to go farther in-depth about topics in my class. That way, I can hit more of the different 'levels' of students in my class, allowing for more differentiation.	Survey
In my experience teaching food safety, some topics (especially critical control points, internal cooking temps, and various forms of contaminants) require more in-depth instruction and application. Others may be effectively taught in a day or two.	Survey
"As educators, we can adjust as needed because of the variety of schedules that each school has the instructor will have flexibility."	Survey
"In terms of instructors being limited to labs because of space, all instructors are very resourceful whether they have 1 stove or microwave for their lab space or a full kitchen lab space. We always make adjustments to what fits our department the best. I think that the labs and activities provide flexibility to what resources are open."	Survey
"Some departments are very limited on space, but again, if a instructor is planning on incorporating lessons, all are very resourceful and will find ways to make it happen. Trust me, educators are creative, and all can make adjustments if needed."	Survey
"Some of the materials that are needed in the activities sum up to a large amount of money. Coming from a school with a low average family income, my students do not pay much in lab fees. Therefore, experiments and activities that require a great deal of materials are not usually what I am to use in my room, simply for the reason that I cannot afford the materials with the money generated into my classroom account."	Survey
"Cost and availability of lab space/kitchen equipment will be the biggest factors preventing most School [schools] from incorporating these types of lessons if they aren't already trying. Most schools charge lab fees for courses, and unfortunately, these are barely enough or short of what is required to do the labs we are already trying to incorporate to improve student learning."	Survey
"With limitations in school budgets for classroom supplies, I believe providing alternative low-cost labs and activities would allow more instructors across the state to provide this important food safety curriculum to their students…"	Survey

Table 2.3. (Continued)

"Limited lab space would be the issue for many schools, including mine. There is a shared kitchen between the Home EC instructor and me (food science) when I teach it. I've given up on offering food science because it is so hard to make that work…"	Interview
"It may be difficult to get all the materials (food, ingredients) for a non-food science class. There may not be a budget for it in a biology or Ag class even though they would be excellent lessons."	Survey
"Some Food Science instructors, like myself, do not have access to some of the materials used....especially the equipment for the pasteurization lab. I have a haggle with the science department to get things, and not everything is always available. Would there be a way to have at least one other lab option for the same lesson that might use less materials as far as the equipment is concerned?"	Survey
Topic 2, Ease of use for a instructor with no prior food safety experience	
"The curriculum will be easy to teach if supplies and classroom lab space/kitchen space are available."	Survey
"This curriculum was well thought out and easy to follow. Instructor set up should be relatively easy. However, as with any class that requires a lab set up, it would depend on the instructor's prep period, number of classes to be taught, and length of a class period. Over all, I can see this as a valuable resource for instructors and students."	Survey
"I think this curriculum would be easy for any instructor to implement as long as they were willing to do so."	Survey
"I think the materials and vocabulary lists at the beginning of the unit were a helpful addition for instructors who might not feel as comfortable with the content in the unit… I also found the inclusion of the videos in the shared folder to be a great resource. The rubric is another useful addition to the curriculum. While basic in its design, instructors could easily adapt this rubric to fit the needs and requirements this wish to set for their students. The guided answers also are extremely beneficial in helping guide instructors as they work with the students to complete the activities in the unit since this unit of student [study] is more career-focused than previous units most instructors have encountered."	Survey
"I think the lab is incredible...but also know it would take a lot of effort and planning for a newer instructor…"	Survey
"As far as a new instructor teaching directly from this written material, other instructors are available to assist them if needed."	Survey
"This curriculum is written so that both the novice and the experienced classroom instructor can deliver the food safety content effectively to their students using the lessons and resources provided."	Survey
"I like the activities. I would definitely incorporate some of the ideas into my curriculum. I do not have a strong background knowledge, but I have seen the food-safety materials they use to certify people, and I would incorporate those as well."	Survey
"The curriculum is extremely detailed and extensive…I think it would be a little overwhelming to some instructors, especially those with little or no lab experience."	Survey

Table 2.3. (Continued)

"To have a instructor teach this curriculum without being a FACS instructor and or AG instructor would not be beneficial...instructors need to have extensive background to be able to do this...not only knowledgeable in the curriculum but lab set up as well...this is asking a lot from a instructor that is not trained in the curriculum."	Survey
"I believe that instructors would benefit greatly from a hands-on training with the labs, especially for our newest instructors who may not have as much experience in conducting foods-based labs and/or the HACCP program."	Interview
Topic 3, Student engagement	
"I think the activities and instruction methods outlined in this curriculum are varied and applicable to students! They seem fun and engaging!"	Survey
"…bringing in more science-based curriculum helps make this [food safety] content more relevant to students…the level of rigor and detail in this curriculum helps make it more interesting and applicable to students…"	Survey
"[The curriculum] is extremely detailed, yet offers the hands-on activities that bring the unit to life and allow the students to gain some social time with other classmates…"	Survey
"I love this curriculum. I think it is hands-on and valuable to learn for all students."	Survey
"The activities are engaging, and the labs are something my students would be interested in."	Survey
"I think maybe some case studies or testimonial videos about what happens if you get a foodborne illness could help [increase students' interest in food safety]."	Interview
"I think having some "entertaining" videos to tie to lesson for visual learners would be awesome! More than just someone explaining. I'm constantly searching for videos and have a hard time finding them."	Interview
"I also really enjoy the help and guidance to create lab activities to provide hands-on experiences to teach food safety. All too often, this is the unit [where I lack] the lab piece."	Survey
"Love the information about "What Role does pH have in Food Safety." My students are trained in ServSafe, but I haven't effectively taught this concept. I like the way it's addressed here."	Survey
"I do love how the pretzels were used throughout the whole curriculum. My kids really wanted to make pretzels at the end."	Survey
"I think adding a part where the kids can actually see a pretzel factory would help with the little steps along the way. I don't know if that looks like a video… or a list of pretzel factories in Indiana that we could go tour. I think that would make it more concrete for them."	Interview

Table 2.3. (Continued)

Topic 4, Experiential learning in the context of food safety	
"This curriculum relies heavily on a project-based, experiential learning design which requires students to engage in labs and hands-on activities."	Survey
"The hands-on is good for kids to be able to really gain an understanding of how things work more so than reading a book or watching a video. This curriculum does a good job of giving kids insight into safe food handling, which is good for their lives. The way it was structured helped them see some career pathways that are out there."	Interview
"I really like "Pete's Soft Pretzel" lab. The flow chart of each step is very thorough. The activity sheet with it is intense and really involves the student to use critical thinking and problem-solving skills."	Survey
Topic 5, Transferability of the curriculum across STEAM fields	
"STEM was present throughout. In the unit, there was a nice integration of all the components of STEM. Students did and were engaged in mathematics. They were having to design their own ideas, which is part of the engineering component. A lot of people will make it art, but I like that, in unit, "A" refers to agriculture because that is one of the major industries in our country. I like that agriculture was incorporated into the STEM activities, and it became STEAM. Simulation with the pepper pretzels was a really good example of integrating all the STEAM components."	Interview
"The cross-contamination activity did have STEAM integration because math is not just numbers and calculations, it's also the thought process where you look at things logically and make connections. We don't just use numbers, especially when we get more abstract. As a math instructor, I don't just think of math as numbers. I think of it as a logical thought process and the study of patterns"	Interview
"Day 3, Activity 1 and Day 5, Activity 2 [have integrated STEAM components]"	Interview
Topic 6, Introduction of students to careers in agriculture and food safety	
"This strong career focus is an added benefit for Indiana instructors since our new high school graduation requirements require a career education component."	Survey
"The industrial focus would be perfect for food science, but may be too intense for the average orientation to foods class, which will reach many more students… You might consider scaling back the emphasis on HACCP, especially if looking at doing this for a wider audience class like Orientation to Foods, as it has been significantly minimized in the newest ServSafe materials… Overall, I would consider your audience and scope of your curriculum again...If you are really trying to improve the safety of food preparation of student in high school (and middle school), shift focus away from the industrial application a little, and tailor the resources used to be more simple so they may be geared towards freshman-level Nutrition and Wellness...you will reach many more students that way. In addition, while I think the industrial tie-in is very cool and should not be abandoned, I would definitely scale its emphasis so that it is easier to see the real-life applications of the concepts to the students at home..."	Survey

Table 2.3. (Continued)

"I think the curriculum did a nice job of demonstrating to kids how learning about food and the safe handling of food could lead to careers in the food industry. I think there is an opportunity to see other careers. Students did cooking and got to see the culinary arts. I think adding a component where kids explore food as its being produced, and safe food handling needs to be included. The unit, as it is, focuses more on manufacturing. When I see farm to table in media, I think about how to get the food from the field to manufacturing safely and all the careers involved with that. I know there are careers involved with that, but I don't know what they are."	Interview
"Also, bringing in experts or people that work in the field to explain how food safety can be used in their lives or possibly their careers can help increase interest in food safety. "	Interview

2.3 Results

Twenty-three experts met the definition of an expert in the first round of surveys. One expert was included despite not meeting the criterion for number of years in the field of education. This expert had been a licensed instructor for seven years at the start of the study and held a master’s degree, which the researchers recognized as two additional years of experience and also provided deeper insight into the field of education. Nineteen experts completed the second survey, and 16 experts completed the third. The majority of experts who completed all three surveys were female (88%), were in the field of education between 10 and 15 years (50%), and held a master’s degree (68%). Of the experts who completed all three survey rounds, most were agriculture (38%) and family and consumer science instructors (38%); however, mathematics (6%) and science (19%) instructors were also represented. Eighty-one percent of the instructors taught at a senior high or combined junior and senior high school. Table 2.4 contains expert demographic information from all survey rounds.

Feasibility of incorporating the curriculum into classrooms

The feasibility of incorporating the curriculum into classrooms included four categories: alignment of the curriculum with academic standards, time restrictions, space and instructional material requirements, and costs associated with labs and activities. After the first survey, experts reached consensus (95.7%) that the cited standards in the curriculum aligned with the Indiana Academic Standards for Advanced Life Science: Foods.

> “I teach both Food Science and Advanced Life Science: Foods, and I really believe this curriculum is a little advanced for the first class but hits the standards of the ALS class completely,” stated an agriculture instructor on the survey (Table 2.3).

For the category of time restrictions, a consensus was reached that the length of in-class activities was appropriate for high school students (94.7%) and that insufficient instructional time was not a barrier to implementing the curriculum in classrooms (78.9%).

Table 2.4. Expert demographics in each round of surveys

Characteristics		Round 1	Round 2	Round 3
Number of Schools Represented		N=20	N=17	N=14
Number of Experts		N=23	N=19	N=16
Gender				
	Female	17 (74%)	15 (79%)	14 (88%)
	Male	6 (26%)	4 (21%)	2 (12%)
Number of Years in the Education Field				
	<10 years[1]			
	10-15 years	1 (4%)	1 (5%)	1 (6%)
	16-20 years	8 (35%)	9 (47%)	8 (50%)
	21-25 years	4 (17%)	2 (11%)	2 (13%)
	26-30 years	4 (17%)	2 (11%)	1 (6%)
	31-35 years	3 (13%)	3 (16%)	3 (19%)
	36-40 years	1 (4%)	1 (5%)	1 (6%)
	More than 40 years	1 (4%)	1 (5%)	0 (0%)
		1 (4%)	0 (0%)	0 (0%)
Highest Level of Education				
	Bachelor's degree	7 (30%)	7 (37%)	5 (42%)
	Master's degree	16 (70%)	12 (63%)	11 (68%)
	PhD	0 (0%)	0 (0%)	0 (0%)
Subjects Taught[2]				
	Agriculture	---	9 (47%)	6 (38%)
	Science	---	3 (16%)	3 (19%)
	Mathematics	---	1 (5%)	1 (6%)
	Family and Consumer Science	---	6 (32%)	6 (38%)
Level Taught[3]				
	Sr. High	---	12 (63%)	10 (62%)
	Jr./Sr. High	---	4 (21%)	3 (19%)
	Jr. High	---	3 (16%)	3 (19%)
Positions Held in the Education Field				
	Classroom instructor			
	Curriculum developer	23 (100%)	19 (100%)	16 (100%)
	Instructional coach	4 (17%)	4 (22%)	2 (13%)
	Purdue Extension Educator	1 (4%)	1 (6%)	3 (19%)
	Counselor	1 (4%)	1 (6%)	1 (6%)
		1 (4%)	1 (6%)	1 (6%)
State				
	Washington	1 (4%)	1 (6%)	1 (6%)
	Iowa	1 (4%)	1 (6%)	1 (6%)
	Indiana	21 (92%)	17 (89%)	14 (88%)

1 There was one participant who had been licensed to teach for seven years at the start of the study and held a master's degree, which the researchers recognized as equivalent to two years of teaching. Researchers classified this person as an expert.

2 Data were not collected for subjects taught in the first round of surveys

3 Data were not collected to determine level taught in the first round of surveys

The majority of experts did not view space and instructional material requirements for in-class activities as barriers to feasibly incorporating the curriculum into classrooms. Experts reached a consensus that experiments would be easy to set up, as described in the curriculum (89.5%). The majority of experts indicated that unavailable kitchen space (62.5%) and insufficient lab or classroom space (68.8%) were not barriers to incorporating the curriculum into the classroom.

> "In terms of instructors being limited to labs because of space, all instructors are very resourceful whether they have 1 stove or microwave for their lab space or a full kitchen lab space. We always make adjustment[s] to what fits our department the best. I think that the labs and activities provide flexibility to what resources are open," stated an agriculture instructor on the survey (Table 2.3).

> "Some departments are very limited on space, but again, if an instructor is planning on incorporating lessons, all are very resourceful and will find ways to make it happen. Trust me, educators are creative, and all can make adjustments if needed," stated an agriculture instructor on a survey (Table 2.3).

At the conclusion of the third survey round, only cost to purchase supplies for the cooking labs (62.5%) was identified as a barrier to incorporating the curriculum.

> "Cost and availability of lab space/kitchen equipment will be the biggest factors preventing most School [schools] from incorporating these types of lessons if they aren't already trying," stated an agriculture instructor on the survey (Table 2.3).

Student engagement and ease of use for instructors with no prior food safety experience

Instructor and student interaction with the curriculum are crucial indicators of curriculum fidelity during delivery and how effective the curriculum will be in achieving learning outcomes. Ease of curriculum use and instructor resources can enhance instructor delivery of the curriculum. After the second survey, experts agreed the curriculum would be easy to implement for a instructor with limited food safety knowledge (89.5%).

For a curriculum to be effective, students must be actively engaged in learning, which requires a curriculum to be appropriately challenging and interesting for the target students. After the first round of surveys, experts agreed the curriculum was engaging. The second round of surveys established that all components of the curriculum were appropriate for high school students, and 78% of experts did not identify student interest as a barrier to implementing the food safety curriculum.

> "I think the activities and instruction methods outlined in this curriculum are varied and applicable to students! They seem fun and engaging!" stated a FACS instructor on a survey (Table 2.3).

Evaluation of experiential learning, STEAM, and career-education components

Experts agreed that experiential learning (73.7%) and career-education (94.7%) should be included in the curriculum, that STEAM incorporation makes the curriculum more relevant in today's classroom (100.0%). According to the expert panel, each of these components was successfully integrated into the curriculum design, and the curriculum could be used across disciplines (100.0%).

Most experts (89.5%) agreed the curriculum design included experiential learning. One expert indicated the experiential learning design would actively engage students through labs and hands-on activities (Table 2.3). Experiential learning components in the curriculum promoted the development of critical thinking and problem-solving skills, and were the appropriate difficulty level for high school students (95.7%).

> "I really like 'Pete's Soft Pretzel' lab [one in-class activity]. The flow chart of each step is very thorough. The activity sheet with it is intense and really involves the student to use critical thinking and problem-solving skills," stated a instructor (unspecified) on the survey (Table 2.3).

All experts agreed that STEAM components were integrated into the curriculum. However, levels of STEAM integration were perceived differently. Opinions regarding the degree to which the curriculum could be used in different disciplines varied among reviewers. Experts who were asked where they identified STEAM integration in the curriculum identified from two lessons to all lessons (Table 2.3). Activities that had students design a HACCP plan or trace an outbreak to a contamination source were two activities where STEAM integration was less apparent. One expert argued the cross-contamination activity incorporated STEAM integrated components through the combination of science (S) and mathematics (M) in the context of a food system representing agriculture (A).

> "The cross-contamination activity did have STEAM integration because math is not just numbers and calculations, it's also the thought process where you look at things logically and make connections. We don't just use numbers, especially when we get more abstract. As a math instructor, I don't just think of math as numbers. I think of it as a logical thought process and the study of patterns," stated a mathematics instructor in a follow-up communication (Table 2.3).

Experts reached a consensus that career-education was included in the curriculum (78.9%). One expert indicated the career focus was beneficial to Indiana instructors due to new requirements that students must have career-education to graduate high school (Table 2.3). The career-education provided in this curriculum required students to specifically explore careers in the food industry while assessing and addressing common industry challenges. Instructor assessment of student answers to in-class activities may require some knowledge of industry. Experts assessed the guided answers that were designed to fill gaps in instructors' industry knowledge (Table 2.3).

> "The guided answers also are extremely beneficial in helping guide instructors as they work with the students to complete the activities in the unit since this unit of student [study] is more career-focused than previous units most instructors have encountered," stated a mathematics instructor on a survey (Table 2.3).

Recommended improvements for future curriculum

At the conclusion of the study, three components of the curriculum were identified for improvement: increasing the number of instructional days for each unit, incorporating instructor training resources, and increasing the variety of food-related careers to which students are exposed.

Experts did not reach consensus regarding the number of instructional days needed to teach the curriculum adequately (68.8%). Experts expressed concern about adequately covering the concepts presented in the curriculum during the planned eight-day instructional period. Expert-identified factors that would influence the number of days required to teach curriculum included whether the school followed a block schedule, time for formative and summative assessment, student maturity level, student engagement with the topic, and student ability to comprehend the material and produce the desired outputs (Table 2.3). Some experts noted that increased instructional time would allow students to ask more questions and delve deeper into concepts. An agriculture instructor indicated going more in-depth would allow for more student-centered learning; the information could be presented to students at their own levels, thereby allowing differentiation in the classroom. A FACS instructor with experience teaching food safety identified the depth of instruction and application needed to effectively teach different topics as determining factors for instruction length. This expert described many components associated with the HACCP lesson as too time-consuming to teach. Another FACS instructor emphasized the need for extended instructional time to allow students to learn the vocabulary associated with the labs.

Instructor familiarity with curriculum topics and methods for teaching was another area identified for improvement. Experts agreed (73.7%) that additional training videos demonstrating how to facilitate the activities and discussions would be beneficial. Expert feedback identified two groups of instructors who could benefit from instructional videos: instructors who were less experienced teaching food safety and new instructors. One FACS instructor noted that some FACS instructors are not receptive to teaching material with which they are less familiar and that experiments could pose a challenge to implement (Table 2.3). New instructors may be faced with similar challenges as instructors with limited food-safety teaching experience. Video training or in-person training could improve new instructor receptivity to adopting and ability to teach food safety curriculum with many lab components.

> "I believe that instructors would benefit greatly from a hands-on training with the labs, especially for our newest instructors who may not have as much experience in conducting foods-based labs and/or the HACCP program," stated a FACS instructor in a follow-up communication (Table 2.3).

To appeal to a wider student population, experts agreed the curriculum should include more examples of food-related careers (78.8%). Instructors may not be familiar with careers involving producing safe food, from crop growing to animal raising, or how food safety relates to other professions in nutrition or medicine. Instructors who are aware of food safety applications across different career disciplines can better facilitate student engagement with the material by helping students understand the relevance of food safety to their lives and potentially to their future careers.

> "I think there is an opportunity to see other careers. Students did cooking [activities] and got to see the culinary arts. I think adding a component where kids explore food as its being produced and safe food handling needs to be included. The unit, as it is, focuses more on manufacturing. When I see farm to table in media, I think about how to get the food from the field to manufacturing safely and all the careers involved with that. I know there are careers involved with that, but I don't know what they are," stated a mathematics instructor in a follow-up communication (Table 2.3).

2.4 Discussion

Experts identified cooking-lab supply expenses as the top barrier to incorporating the curriculum. Concerns about cooking lab expenses were not isolated to instructors whose course content did not have a budget for cooking lab supplies. FACS instructors typically have budgets for purchasing cooking supplies, but some FACS instructors in this study noted they might need to adjust the lab structure to accommodate budget restrictions. A lack of funding to purchase the supplies necessary for food literacy, including food safety, is not unique to the curriculum reviewed in this study. Ronto and colleagues (2017) interviewed 22 home economics instructors (HETs), and most HETs interviewed identified financial limitations as a barrier to food literacy instruction, especially for practical application instruction in high schools. Public schools can charge student fees to cover the costs associated with labs, but as one expert noted, these fees may not be sufficient, especially for the introduction of a new curriculum. In order to address the cost barrier, alternative activities with lower cost can be developed or instructors could team-teach the material across disciplines.

Experts, regardless of their content areas, agreed food safety is an important topic for students and can be taught across different disciplines. Food science and nutrition integrated STEAM curricula have been developed and successfully disseminated (Craig & Alleman, 2016; Merrill & Lawver, 2019). Integrating food safety into STEAM curricula has the potential to impact future food handlers and preparers. Vasquez and colleagues (2013) outline three approaches for schoolwide STEAM integration: multidisciplinary or thematic, interdisciplinary, and transdisciplinary. Multidisciplinary approaches allow instructors from different disciplines to select an overarching theme and construct lessons from each discipline that match the theme. Interdisciplinary approaches focus on combining concepts from different disciplines to teach a common skill or concept. Transdisciplinary approaches provide students with an overarching challenge to solve, and instructors from each discipline equip students with the skills and knowledge required to address the challenge. Adopting one of these approaches could allow instructors to form an integrated team and provide multidisciplinary learning experiences for students. Students will develop integrated perspectives and generate interdisciplinary solutions to challenges representative of problems encountered by individuals in agriculture-based careers.

Experts agreed the curriculum successfully incorporated career-education and used experiential learning activities. The career-education presented in this curriculum is influenced by experiential learning simulations and integrated STEAM. Experiential learning modules, such as those used in the researcher-developed food safety curriculum, can improve student preparedness for entering industry by training students to critically think and apply their knowledge to solve real-world challenges *(Alberts & Stevenson, 2017; Wolter et al., 2013)*. Experiential learning activities provide students with other professional development opportunities, including improving communication, improving social interactions, and promoting collaborative participation (Paolini, 2015). The curriculum presented in this study featured career reflection in in-class and take-home activities, providing students with a deeper understanding of why some solutions are appropriate for industry but not for homes, and vice versa. The reflection process is an essential component of experiential learning (Kolb et al., 2001). Through experiential learning simulations, students are introduced to different career pathways within the food industry. Researchers agree these types of career-education opportunities are critical components of educational curriculum to introduce students from kindergarten through high school seniors to potential careers (ACT Research and Policy, 2013; Glessner, Rockinson-Szapkiw, & Lopez, 2017). The integration of STEAM components in the curriculum allows students to explore how the concepts they are learning in different disciplines combine to address challenges in different careers. Exposure to careers in the context of STEAM could promote interest in STEAM careers (Craig & Alleman, 2016).

Most experts preferred to extend the curriculum instruction time. They argued the instructional materials were very extensive for the proposed timeframe and suggested that student comprehension of the material would improve if students were given additional time for engaging in deeper discussion and completing in-class activities (Table 2.3). Block schedules were recognized as a means to provide instructors with enough instructional time to teach the lessons and complete in-class activities in greater depth to enhance students' comprehension. Prior research demonstrates student mastery and retention of content knowledge can be enhanced through discussions and participation in activities (Weimer, 2006), supporting the experts' assessment. A differentiated learning approach can be integrated into future curricula, allowing students to partner with instructors and individualize their learning experience (Chandra Handa, 2019).

The majority of experts indicated including instructor training would benefit instructors who lack food safety knowledge or who are new instructors. Instructor self-efficacy in leading discussions and activities can impact the adoption of the curriculum and influence student engagement (Allinder, 1994). The findings from this study suggest that instructors were less likely to incorporate HACCP content because they were unfamiliar with the topic and had low self-efficacy. Training videos can potentially increase instructor's self-efficacy in food safety and other specific topics. Instructors can access videos at their own convenience, ensuring consistent information delivery (Parsons, Rollyson, & Reid, 2012). Incorporation of instructor training videos would provide a reference for how lessons were intended to be taught, how to prepare materials for and execute in-class activities, and how to teach concepts with which they might be less familiar, such as leading students to develop a HACCP program.

The Delphi technique allowed the opinions of experts from Washington, Iowa, and across Indiana, representing 14 different schools, to provide feedback related to the curriculum, thereby providing a broader perspective on the curriculum. Experts from multiple states bring different perspectives, and their differing responses highlight the need for instructors to understand how their states are unique (Stewart, Lambert, Ulmer, Witt, & Carraway, 2017). Experts from Indiana may be familiar with or teach Advanced Life Science: Food, which could contribute to different opinions and expectations of the curriculum from those who are less familiar with this standard. Another advantage of using the Delphi technique for this study was that all instructors could freely express their opinions. Respondents in a curriculum-development Delphi study concluded one strength of the study was lack of discussion domination by respondents, as noted by one of the study respondents: “a useful process to ensure that consensus is not skewed by the perspectives of a particular group” (Sitlington & Coetzer, 2015). The majority of experts in the present study were from Indiana and taught either FACS or agriculture. The anonymity afforded by the Delphi technique allowed experts from other states or from other disciplines to express their opinions without majority pressure.

There were five primary study limitations to consider. First, the overall sample size of experts in each round of the survey was small. The opinions expressed and consensus generated in this study may not accurately reflect the views of instructors in STEAM fields or instructors from different states. A second study limitation was expert identifiers were not linked to their responses; there was no way to track accurately how each expert answered questions. It was, therefore, impossible to determine if consensus was achieved in subsequent rounds of the survey due to expert attrition. This could impact survey result validity if consensus was reached after experts with differing opinions from the majority ceased participating in the survey (McPherson, Reese, & Wendler, 2018). Another study limitation was the minimization of expert interactions prior to and during the study. Expert recruitment potentially impacted expert anonymity. Some of the recruited experts were from the same school, and it is possible some experts worked together prior to participating in the study. Yeh and colleagues (2016) noted that expert interactions, including prior communication and working together, may generate results that are not independent. During the study, all experts were asked not to discuss their participation in the study. However, experts who worked in the same school may have an increased likelihood of discussing the study with other experts participating in the study. A fourth limitation of this study was curriculum effectiveness was not evaluated in practice; experts were not asked to implement the curriculum in the classroom and provide feedback for the effectiveness in engaging students or ease of conducting activities. Lastly, the opinions of students, for whom the curriculum was designed, were not collected to determine factors such as curriculum engagement and strength of career-education components.

In order to more accurately assess the curriculum, additional investigation is required. Future investigations of curriculum designed for STEAM courses should include a larger sample size with equal representation of experts from each STEAM field and state in which the curriculum will be used to address the unique education requirements in each state. To improve consensus validity, experiment protocol in future curriculum evaluations should link expert responses to their answers and minimize expert recruitment from the same school district to reduce the risk of compromising anonymity and effects of expert interaction. A more thorough assessment of the curriculum would include expert and student evaluation of the curriculum after implementation in the classroom.

CHAPTER 3. EXPERIMENT II: CURRICULUM EVALUATION, OBSERVATION

3.1 Objectives

The two objectives of this study were to:

1. Evaluate the effectiveness of a researcher-developed food safety educational intervention in changing students' food-handling behaviors using the TPB model to interpret audio and video recordings of student cooking sessions.
2. Evaluate the data collection capabilities of stationary versus wearable cameras.

3.2 Materials and Methods

Participant Recruitment

The study was approved by the Purdue University Institutional Review Board. Indiana high school agriculture and science instructors were contacted via email. One agriculture and one microbiology instructor from the same school corporation were selected to participate with their high school students.

Curriculum Design

The curriculum was designed to be delivered by course instructors in eight 50-minute class sessions during the school day. This included five days of food safety educational intervention, one day of student presentations summarizing their learnings for each lesson, and two days for pre- and post-intervention assessment of student food-handling behaviors. The Partnership for Food Safety Education's Fight BAC! Campaign's four core food-safety practices of clean, cook, chill, and separate, as well as an added concept of choosing safe food, served as the foundational pillars for educational content delivered during the four educational intervention class sessions (Partnership for Food Safety Education). In the last educational intervention class session, students were asked to combine the knowledge from the previous four class sessions to develop a Hazard Analysis Critical Control Point (HACCP) plan. The researcher-developed curriculum published through Purdue Extension is available at https://ag.purdue.edu/foodsci/Fenglab/extension-articles/. Students used photovoice-style presentations to present how the food safety information provided in the educational intervention was relevant to them (Simmonds, Roux, & Avest, 2015). Two video-recorded cooking sessions were used to assess student food-handling behaviors. The first cooking session measured baseline food-handling behaviors prior to the educational intervention. The second cooking session occurred after the educational intervention and was used to assess changes in students' food-handling behaviors with respect to the baseline measurement.

Recipe Selection

Two recipes were chosen for each cooking session. The recipes required students to prepare a burger patty, burger garnish, and a vegetable-based side dish. Recipes were selected for each cooking session to measure students' food-handling behaviors when exposed to raw meat and vegetables. The vegetable side dish for the first cooking session was baked, while the vegetable side dish in the second cooking session did not have a heat treatment step. Requiring a heat treatment step in the first cooking session lowered the risk of contracting a foodborne illness for students who had limited food safety knowledge or poor food-handling behaviors prior to the intervention.

Cooking Sessions

The school's instructional kitchen was used. The kitchen included six stations, five of which were similar in design. The sixth station had more counterspace than the other five stations. Use of the sixth station was minimized for consistency. Each station was assigned to one group comprised of three to four students, with the exception of one two-person group. Stations were equipped with necessary cooking utensils. Researchers placed two printed recipes at each cooking station: one for burgers and one for the side dish. Researchers also placed cooking equipment at each station, including skillets, baking sheets, mixing bowls, spatulas, knives, and measuring spoons. Students had unrestricted access to cabinets and drawers that contained additional cooking equipment. Cloth towels were placed at each station, and each station had its own paper towel dispenser. Students had access to handwashing soap and dishwashing soap. Gloves, salt and pepper shakers, cooking spray, and parchment paper were located on a shared space between every two lab stations. Perishable ingredients were stored in the refrigerator. All other ingredients and cooking thermometers were stored on a common table.

Prior to starting the cooking sessions, the researcher introduced the recipes and location of supplies, including gloves and cooking thermometers. Students were not instructed on how to divide cooking tasks. The researcher did not demonstrate how to use the cooking thermometers, nor instruct students to use the thermometers. Students were to notify the researcher when they were finished cooking, and then the researcher checked the final temperature of the burger patty. Researchers provided students with Fisherbrand thermometers (model S90201). This thermometer was used by the researcher when measuring the final temperatures of the burger patties.

While the researcher did not answer students' questions related to food-handling behaviors, instructors were permitted to answer students' questions and provide recommendations to simulate a classroom environment. Safe food-handling techniques were not demonstrated for students; students were only provided with basic kitchen safety information, including oven, stove, and knife safety (Diplock et al., 2018).

Data Collection

The observational study began in late November and concluded in mid-December 2018. Video and audio recordings were captured by iPads (iPad model A1395) mounted at each cooking station and GoPro cameras (GoPro Hero5 Black) worn by the same student in the pre- and post-cooking lab. It was anticipated the meat-handler would be responsible for most cross-contamination during meal preparation. To ensure the food-handling behaviors of the student handling the meat was captured, the student preparing and cooking the meat patties wore the GoPro in each group, The iPads provided stationary, third-person perspective video footage. GoPro cameras were mounted on students' heads using a GoPro head strap and quick-clip. GoPros were set to 1080p60, SuperView field of view (FOV). Research protocol stipulated the same student should cook the burger patties prior to and after the educational intervention. The GoPro camera captured first-person perspective video footage.

Observational data, including audio and visual information, were recorded using a standardized student food-handling observation form input into Microsoft Excel (Microsoft Corp., Redmond, WA, USA, 2016). The observation form was developed from protocols from previous food-handling observation studies (Feng et al., 2019; Kendall et al., 2004). Eleven student food-handling behaviors related to hand hygiene, cooking station cleanliness, cross-contamination, and thermometer-use were recorded. Observed behaviors in the cooking sessions were denoted as correct or incorrect based on adherence to USDA- and FDA-recommended practices. Student conversations related to food safety and food-handling were recorded on the form.

The TPB model was used to understand student food-handling observational data, including audio and video recordings, as outlined in Figure 3.1. Attitudes, 'subjective norms', and 'perceived behavior control' were measured and assessed from audio recordings of student-student and student-instructor conversations. Intention was measured using a combination of audio and video records to more fully understand the intent of students' actions as behaviors did not always align with conversations. Practiced behavior was measured and assessed from the students' food-handling behaviors captured in the video footage.

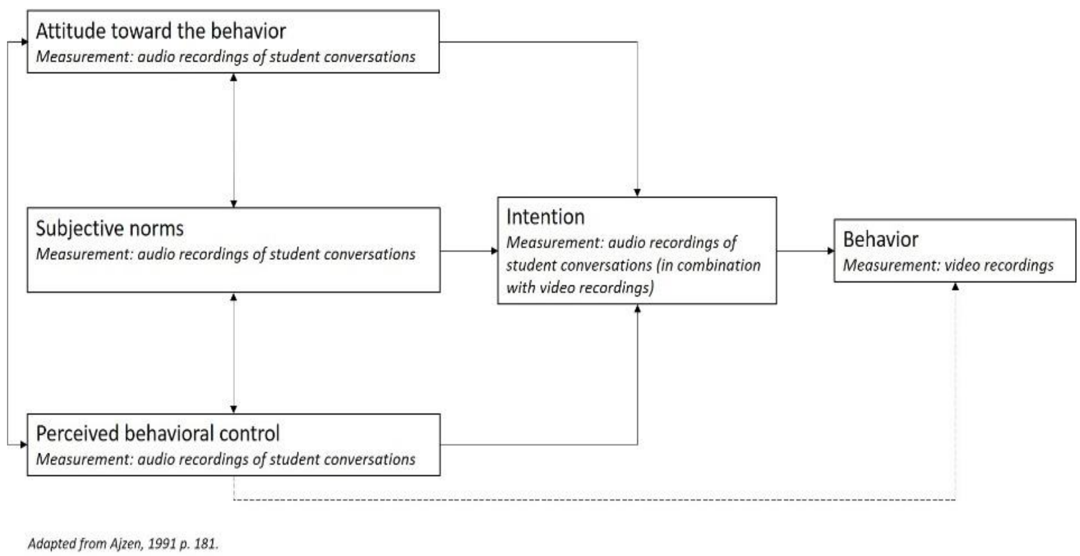


Figure 3.1. Theory of Planned Behavior construct used to analyze audio and video recording

Data Analysis

Observational data from iPad cameras and GoPro cameras were collected from 28 cooking lab groups. Data for one group was rendered unusable due to an iPad being bumped and subsequent loss of the group from the view frame. In total, 54 videos from iPads and 56 videos from GoPros were reviewed. This equated to 36 hours of footage from iPads and 37.3 hours of footage from GoPros. Video footage was reviewed independently by two trained video coders. Students' food-handling behaviors before and after the educational intervention were each recorded by the two coders using the student food-handling observation form in Microsoft Excel. A third trained video coder reviewed the coding forms of the two video reviewers and rectified any discrepancies.

Observed food-handling events for hand hygiene and thermometer use were summed, and the percentage of correct and incorrect food handling was calculated for pre- and post-cooking sessions. Students were considered as a single, large group for these calculations. The number of groups who used a cooking thermometer and who performed environmental cleaning was recorded prior to and after the intervention. These calculations were conducted for each group of 3-4 students. McNemar's test, at a significance level of 0.05, was used to determine significant differences between the percentage of correct and incorrect food-handling events in pre- and post-cooking sessions for the single, large group and each group of 3-4 students.

For cross-contamination events, the number of times a cooking utensil or kitchen surface was cross-contaminated was summed for each utensil or surface. Four events were considered as cross-contamination event initiators: students touching (1) raw meat, (2) raw produce, (3) mobile phones (Diplock et al., 2018), or (4) exposed, unwashed skin (such as students touching their faces). A recent study indicated that bacteria can sustainably be transferred from contaminated gloves to surfaces even at the nineteenth consecutive touch of the gloves on surfaces (Tahir et al., 2019). Due to the large number of students per group and the complex food-handling interactions between students, cross-contamination events were only recorded the first three consecutive touches. For example, after a student handled raw meat and did not perform handwashing, the next three items the student touched were recorded as being contaminated. If a student performed a cross-contamination event initiating activity before completing the three consecutive touches from a prior cross-contamination event, the event count reverted to 0. For example, if a student handled raw meat, touched two items, and then touched raw meat again, the next three items the student touched would be considered contaminated. The map (Figure 3.2) was color-coded to signify the concentration of events per area. Cross-contaminated cooking utensils were ranked in order from most frequently contaminated to least frequently contaminated. Kitchen surface cross-contamination events were mapped on the kitchen schematic representative of each cooking station using Microsoft Excel.

Student conversations from iPad and GoPro audio were reviewed for relevancy to food safety topics. Conversations related to food safety were transcribed. The conversations were then grouped thematically by food safety topic including hand washing, glove wearing, and thermometer use. Under each food safety topic, the conversations were further divided into the context of the Theory of Planned Behavior. For example, conversations related to risk-perception were grouped, and conversations related to subjective norms were grouped.

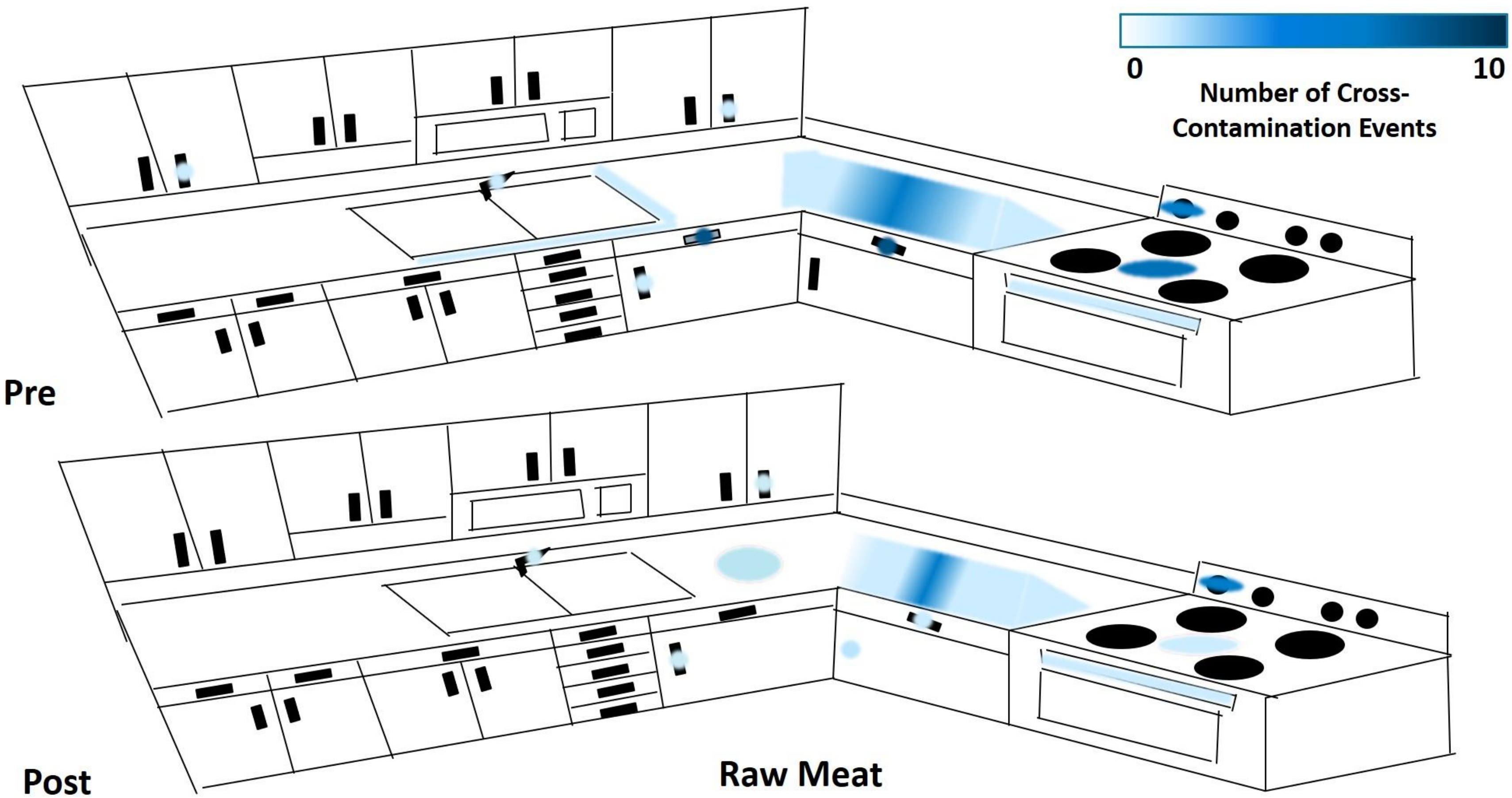


Figure 3.2. Cross-contamination events resulting from students' handling raw meat while cooking, where dark blue indicates the most cross-contamination events. The number of cross-contamination events did not significantly decrease from the pre-cooking lab to the post-cooking lab. The pattern of cross-contamination did not differ significantly from the pre-cooking lab to the post-cooking lab.

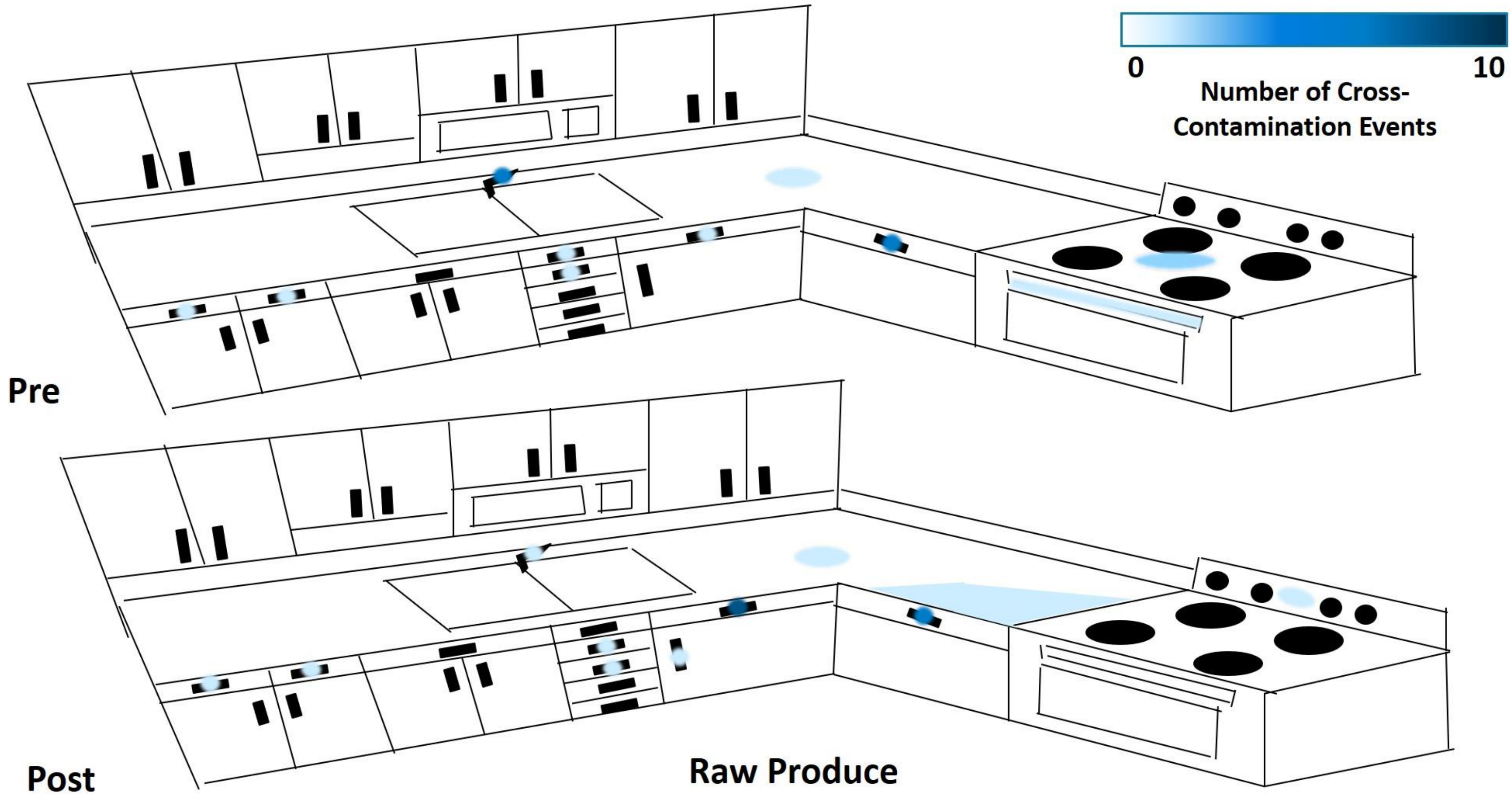


Figure 3.3. Cross-contamination events resulting from students' handling raw produce while cooking, where dark blue indicates the most cross-contamination events. The number of cross-contamination events did not significantly decrease from the pre-cooking lab to the post-cooking lab. The cross-contamination pattern shifted from the pre-cooking lab to the post-cooking lab; more cross-contamination events on the counter during the post-cooking lab.

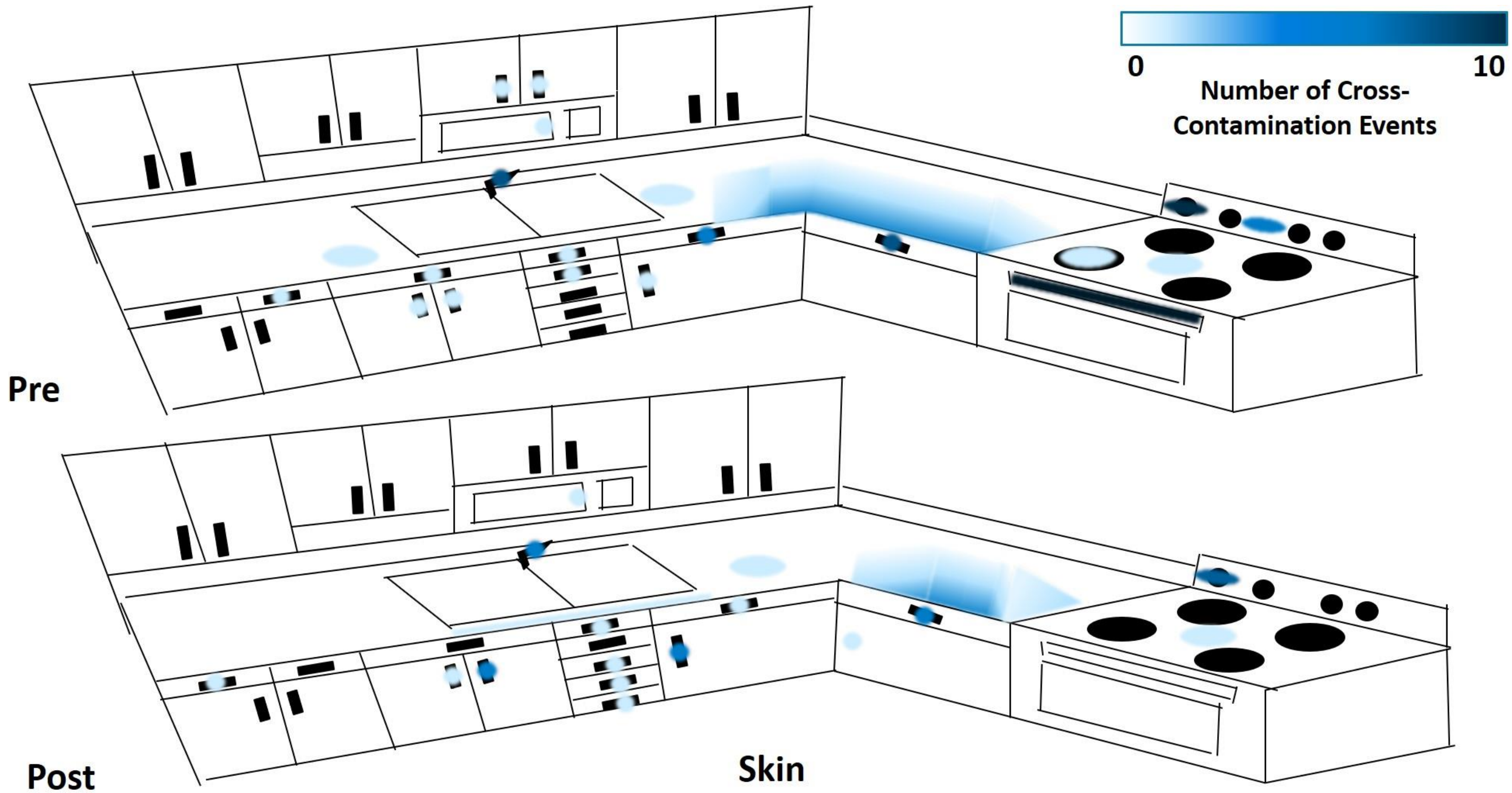


Figure 3.4. Cross-contamination events resulting from students' touching their skin while cooking, where dark blue indicates the most cross-contamination events. The number of cross-contamination events did not significantly decrease from the pre-cooking lab to the post-cooking lab. The area of cross-contamination decreased.

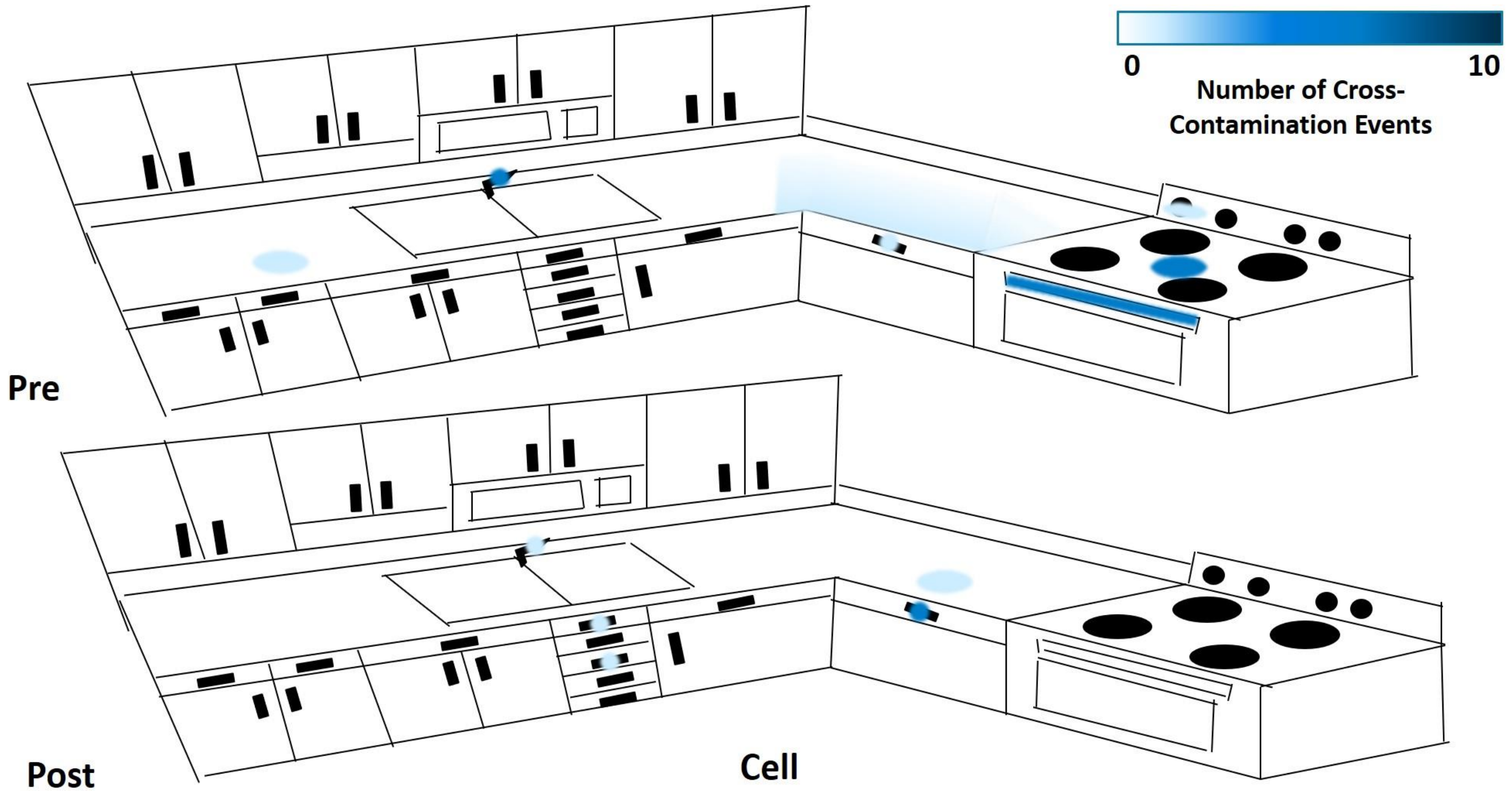


Figure 3.5. Cross-contamination events resulting from students' handling their cell phones while cooking, where dark blue indicates the most cross-contamination events. Cross-contamination decreased from the pre-cooking lab to the post-cooking lab.

Using Microsoft Excel, student comments were reviewed and categorized thematically as they related to food-handling practices, such as cooking thermometer usage, handwashing, and glove changing. Comments were further divided into categories for each TPB variable. As demonstrated in Figure 3.1, relationships can exist between antecedent variables. Only one category was chosen for each variable based on situational context. All quotes are representative.

3.3 Results

Study sample demographics

Freshmen through senior students (N = 100) from a high school in southern Indiana completed the pre- and post-cooking sessions. Most students were white, non-Hispanic (94%), and female (53%) (Table 3.1). Two students were absent the first day of the study, and their food-handling behaviors were therefore removed from the data set. Student demographics are presented in Table 3.1.

Table 3.1. Student demographics, N=100

Characteristic		**Total % (N)**
Gender		
	Male	46 (46)
	Female	53 (54)
	Unknown	1 (1)
Ethnicity		
	Asian	4 (4)
	Hispanic	1 (1)
	White (non-Hispanic)	94 (95)
	Unknown	1 (1)

Handwashing among students

Students' handwashing technique improved after the intervention. 'Subjective norms', such as peer expectations, influenced group handwashing. Students reminded their group members to wash their hands prior to cooking (Table 3.2). We observed a significantly higher percentage

(38%) of handwashing attempts that met the recommended 20-second wash time and a concomitant significant decrease in handwashing attempts that were between 5 and 19 seconds. Students were confident in their ability to reduce their risk of contracting a foodborne illness through handwashing.

> Student: "I have yet to contract Salmonella and/or any other disease, knock on wood, at home, and I never where gloves. I just wash my hands beforehand and afterward."

Table 3.2. Observed student performance of food-handling behaviors

Food-handling Behavior	Pre-intervention % of total (# of occurrences)	Post-intervention % of total (# of occurrences)
Personal Hygiene		
Handwashing attempts		
Water only	5 (8)	10 (15)
Soap and water	95 (145)	90 (131)
Length of handwashing		
<5 seconds	7 (11)	12 (17)
5-9 seconds	21 (32)	15 (21)*
10-19 seconds	42 (63)	35 (50)*
≥20 seconds	30 (45)	38 (55)*
When hands were washed		
Before preparing a meal	79 (80)	78 (77)
After handling raw meat	30 (17)	29 (9)
After touching unwashed produce	9 (3)	36 (4)*
After touching skin	6 (17)	20 (30)*
After touching cell phone	11 (2)	8 (1)
After handling garbage	8 (2)	40 (6)*
Method used for hand drying**		
Dried by shaking	6 (11)	9 (14)
Dried on clothes	2 (4)	1 (1)
Dried on fresh cloth	6 (12)	2 (3)
Dried on used cloth	11 (21)	5 (8)*
Dried on a paper towel	74 (138)	84 (132)*
Glove usage		
Did not wear gloves	70 (71)	50 (50)*

Table 3.2 (Continued)

Did not change or wash gloves when contaminated or torn	69 (110)	54 (92)*
Washed gloves with soap and water	0 (0)	5 (8)
Changed gloves, did not wash hands	25 (40)	26 (44)
Changed gloves, washed hands with water only	1 (1)	1 (1)
Changed gloves, washed hands with soap and water	5 (8)	15 (26)*
When gloves were changed		
After handling raw meat	33 (26)	53 (30)*
When gloves were torn	50 (1)	50 (1)
After touching unwashed produce	24 (4)	56 (5)*
After touching skin (Performed)	10 (1)	7 (4)
After touching cell (Performed)	n/a	77 (10)
After handling garbage (Performed)	15 (2)	80 (8)*
Thermometer Usage		
Used the cooking thermometer incorrectly	30 (39)	28 (21)

*Behavior frequencies were recorded as well as the corresponding percentage. Significant change in percentage from pre- to post-intervention observation per McNemar's Test using a significance value of 0.05.

**Hand drying events were noted after hand washing and dish washing

Students' attitudes were favorable toward handwashing, especially after handling raw meat. One student expressed the need to wash hands after handling meat (Table 3.3). Student conversations demonstrated awareness of how cross-contamination events occur, and students also had the general attitude that handling raw meat and subsequently touching ingredients and equipment with unwashed hands contributes to cross-contamination. One student communicated his intention to perform handwashing prior to handling other ingredients (Table 3.3). However, favorable attitudes toward and behavior intentions to perform handwashing did not eliminate cross-contamination.

> Student: "I can't pick it [the gloves] up because my hands are pretty bloody [from raw meat]."

Less than a minute following this comment, the student picked up salt and pepper shakers without washing his hands. Students demonstrated significant increases in handwashing performance after handling raw produce (26%), touching skin (20%), and picking up garbage (36%), as shown in Table 3.2. However, handwashing was performed in less than half of handwashing-inciting events after the intervention.

Glove usage among students

The number of students who did not wear gloves significantly decreased from pre- (N = 71) to post-intervention (N = 50) cooking sessions. Student conversations exhibited changes in attitudes toward and risk-perception of contracting a foodborne illness if recommended food-handling practices were not followed. Prior to intervention, students were aware that foodborne illness is associated with raw meat, but their risk perception was low, as evidenced by the following student interaction.

> Student: "Salmonella [as he touched his group member's arm without washing his hands]!"

After the intervention, students had a higher risk-perception of developing a foodborne illness. The following conversation occurred between two students who were opening a raw meat package.

> Student 1: "No, dude, you don't have any gloves on."
>
> Student 2: "Why do you need gloves?"
>
> Student 1: "Because I can contract foodborne illness if I don't."

Subjective norms also contributed to students' decisions about whether to wear gloves. When deciding whether to wear gloves, students relied on observation of their peers' glove-wearing behaviors and asking their peers if gloves should be worn. One student decided to wear gloves after observing other students were wearing gloves.

> Student: "I'm supposed to wear gloves because everybody else is wearing gloves."

Another student refused to listen to his group member's recommendations to wear gloves after asking another group about their intention to wear gloves while cooking.

> Student 1: "Is that gloves?"
>
> Student from another group: "Who wears gloves when they cook?"
>
> Student 1: "A lot of people do."
>
> Student 2: "They are [wearing gloves]." Student 2 points to another group.
>
> Student 2: "We'll tell [Student 3] . . . . Hey, [Student 3], there are gloves you need to use . . . You need gloves."
>
> Student 3: "Are you wearing gloves [to another group]?" [The other team indicated they were not wearing gloves. Student 3 did not wear gloves.]

Some students were more persuaded by their instructor's food-handling recommendations than by their peers' arguments.

> Student 1: "We don't need gloves."
>
> *[Instructor then mentions wearing gloves to Student 1.]*
>
> Student 2: "We're putting it on the stove. We'll be fine. Dude, don't put on gloves. No. We don't need gloves. We'll be fine. I ain't putting on gloves. We don't need gloves."
>
> Student 3: "No one said anything about gloves. My hands are clean."
>
> Student 2: "Exactly."
>
> *[Student 1 put on gloves and showed instructor.]*
>
> "Here you go [instructor's name]. Is this better?"
>
> *[Student 1 used gloves to handle the meat and then removed the gloves.]*

Table 3.3. Student conversations related to the Theory of Planned Behavior construct

Theory of Planned Behavior Component	Quotation
Handwashing	
Attitudes	Student 1 reached for gloves but did not touch them: "I can't pick it [gloves] up because my hands are pretty bloody."
	Less than a minute later Student 1 picked up salt and pepper shakers without changing gloves.
Attitudes	Student 1 after handling meat: "I need to wash my hands."
Attitudes	Student 1 scolding group member: "You had meat on your hands!"
	Student 1 took bowl away from group member.
Perceived Behavioral Control	Student 1: "I have yet to contract *Salmonella* and/or any other disease, knock on wood, at home. And I never where gloves. I just wash my hands beforehand and afterhand."
Subjective Norms	Student 1 to another group: "Come wash your hands."
Behavior Intention	Student 1: "I washed my hands. I will wash them again before I handle any other ingredients."
Glove Usage	
Attitudes	Student 1 was mixing meat with both hands, then slapped teammate's arm: "*Salmonella*."

Table 3.3 (Continued)

Attitudes	Student 1: "Yeah, cause everybody that told me they used gloves today, they got… raw meat on it, and then they went and touched their zucchini and got raw meat on their zucchini, which is nasty."
Attitudes	Two students who were opening a raw meat package. Student 1 "No, dude, you don't have any gloves on" Student 2: "Why do you need gloves?" Student 1: "Because I can contract foodborne illness if I don't."
Perceived Behavioral Control	Student 1 to group member: "Take those [gloves] off because that has like meat on it, and it's getting meat everywhere."
Perceived Behavioral Control	Student 1 to group member: "Keep your gloves on. I'm taking mine off and washing my hands real quick [inaudible]."
Subjective Norms	Student 1: "I'm supposed to wear gloves because everybody else is wearing gloves."
Subjective Norms	Student 1: "We don't need gloves." Instructor mentioned wearing gloves to Student 1. Student 2: "We're putting it on the stove. We'll be fine. Dude, don't put on gloves. No. We don't need gloves. We'll be fine. I ain't putting on gloves. We don't need gloves." Student 3: "No one said anything about gloves. My hands are clean." Student 2: "Exactly." Student 1 put on gloves and showed instructor: "Here you go [instructor's name]. Is this better?" Student 4: "They're not using gloves." Student 5: "Yeah, why do we have to use gloves? Is anyone else using gloves except [other student]?" Student 1 points to another group: "They're using gloves." Student 1 used gloves to handle the meat and then removed the gloves.
Subjective Norms	Student 1: "Should I be wearing gloves?" Student 2: "No." Student 1 did not wear gloves.

Table 3.3 (Continued)

Subjective Norms	Student 1: "Is that gloves?" Student 2: "Who wears gloves when they cook?" Student 1: "A lot of people do." Student 3 pointing to another group: "They are [wearing gloves]. We'll tell [Student 4] … Hey, [Student 4], there are gloves you need to use... You need gloves." Student 4 to another group: "Are you wearing gloves?" The other team indicated they were not wearing gloves. Student 4 did not wear gloves.
Subjective Norms	Student 1: "Yeah, why do we have to use gloves? Is anybody else using gloves?" Student 2: "They're using gloves." Student 1: "Yeah, they're messing with meat."
Subjective Norms	Student 1: "Should I change gloves?" Red handled meat packaging. Student 2: "Yeah."
Subjective Norms	Student 1: "Hey, should I … take off the gloves and put on the salt and pepper and then re-put on the gloves?" Student 2: "Probably, yeah."
Behavior Intention	Student 1 to group member: "Why did you touch that [spatula]?" Student took the spatula from her group member and washed the spatula; however, the student had meat contaminated gloves, too.
Thermometer Usage	
Attitudes	Student 1: "If it's pink, it's not done."
Perceived Behavioral Control	Student 1 to another group: "Hey, do we just stick that thing [thermometer] in the meat?"
Perceived Behavioral Control	Student 1: "I don't know how to work it [thermometer]."
Perceived Behavioral Control	Student 1: "They're looking pretty done, but I still see some pink in them." Student 2: "You're not supposed to do it based on color, but we don't have temperature."
Subjective Norms	Student 1: "The way my dad would tell [if patty is cooked] is if you press on it and there's no more blood coming out, [then] it's ready to eat."
Behavior Intention	Student 1: "If this [temperature on thermometer] hits 160, I'm taking them [burgers] off 'cause they look done." Student 2: "Yeah, they look way done [laughing]." Student 1: "They're [burgers] coming out." Student 1 took the thermometer out of the burger patty.

Table 3.3 (Continued)

Behavior Intention	Student 1: "I'm sorry, but whenever I'm cooking a burger at home, I'm not going to look at its temperature."
Environment Cleaning	
Attitude	Student 1 started to put the cover back on the thermometer, stopped, started to put cover on thermometer again, stopped.
	Student 1: "I need to wash this [thermometer] off."
Attitude	Student 1: "I'm dropping this beef on the table. We probably should have sanitized the table."
Subjective Norms	Student 1: "Do we just use this [hand soap]to wash it [dishes]? Hand soap? So, what do we do?"
	Student 2: "[Inaudible] didn't wash dishes with soap."
	Student 1: "So do you just take this [sponge] and just like [rubbing sponge on spatula]?"
	Student 2: "Yeah."
	Student 1 washed dishes without soap.

For students who wore gloves, the percentage of glove-changing events per recommendations (47%) increased significantly after the intervention. The percentage of glove-changing events increased significantly after handling raw meat (52%), unwashed produce (56%), and garbage (80%). Student conversations indicated students believed cross-contamination events can result from failure to change gloves when handling raw meat.

> Student: “Yeah, ‘cause everybody that told me they used gloves today, they got like raw meat on it, and then they went and touched their zucchini and got raw meat on their zucchini, which is nasty.”

During the post-intervention cooking sessions, students demonstrated confidence in their ability to prevent cross-contamination by changing their gloves or by providing glove-changing recommendations to group members.

> Student: “Keep your gloves on. I’m taking mine off and washing my hands really quick...”

Another student noticed one of her group members was still wearing meat-handling gloves but was no longer handling meat. This student intervened to mitigate the risk of cross-contamination.

> Student: “Take those [gloves] off because that has . . . meat on it, and it’s getting meat everywhere.”

Students' behavior intentions were to prevent cross-contamination by identifying cross-contamination events and taking appropriate action to reduce or eliminate the risk. A student noticed one of her group members was holding a spatula with meat-contaminated gloves.

Student: "Why did you touch that [spatula]?"

[Student took the spatula from her group member and washed the spatula; however, the student had meat contaminated gloves, too.]

Despite a significant increase in glove-changing events that included handwashing between glove changes, handwashing was only performed in 15% of total glove-changing events after the intervention.

Students' cooking thermometer usage

After the intervention, there was a 42% decrease in thermometer-use attempts and a 10% decrease in the number of groups who used a thermometer. However, student conversations demonstrated increased knowledge that checking the burger patty's internal temperature was the safest way to determine if the food was cooked thoroughly. The following representative quotes between students illustrate the knowledge gained from the intervention.

> Student 1: "Why are you cutting the burgers? …. Okay, when we were going through the lessons, they said some burgers will still be a little bit pink at 160 [°F], and some will be completely brown at 150 [°F]."
>
> Student 2: "Yeah."
>
> Student 1: "It just matters on the temperature."

Despite increased knowledge that using a cooking thermometer is the safest way to determine if the burger patties were thoroughly cooked, student attitudes that color is an indicator of doneness remained largely unchanged. Students still referred to color as a primary indicator of doneness.

Student: "It's cooked [checked the burger patty's interior color]."

'Perceived behavior control' impacted students' thermometer usage. Students were unsure of how to operate cooking thermometers, appropriate techniques for using a cooking thermometer, and where to find thermometers in the classroom. A student encouraged a fellow group member to exchange the thermometer she had selected for a thermometer that was "easier" to use after the group could not change the thermometer from Celsius to Fahrenheit. Another student who was trying to use a cooking thermometer to measure the burger patty's internal temperature did not know how to operate the thermometer.

> Student: "I don't know how to work it [thermometer]."

One group inquired about thermometer insertion techniques.

> Student: "Hey [to another group], do we just stick that thing [thermometer] in the meat?"

Another student tried to direct his fellow group member to use a thermometer instead of color to determine if the burger patty was thoroughly cooked, but he perceived a lack of thermometer availability.

> Student: "You're not supposed to do it based on color, but we don't have a thermometer."

'Subjective norms' influenced students' perception of food handling practices. Students referenced cooking techniques used by their parents.

> Student: "The way my dad would tell [if patty is cooked] is if you press on it and there's no more blood coming out, [then] it's ready to eat."

Student conversations revealed behavior intentions. Students' comments indicated they would behave differently if they were not part of the research study or if they were not being video-recorded. Student conversations revealed they would use less sanitary techniques when cooking, would not comply with requests, and would not use a thermometer to check that food was thoroughly cooked.

> Student: "I'm sorry, but whenever I'm cooking a burger at home, I'm not going to look at its temperature."

Station cleaning among students

Most cross-contamination events resulted from students touching their skin and then handling equipment or touching work surfaces (51%). Cross-contamination of environmental surfaces decreased significantly for raw meat, skin touches, and cellphone touches after the educational intervention. However, there was an increase in observed cross-contamination events from raw produce handling. Figure 3.2.A.-D. demonstrates that the counter next to the stove was frequently contaminated for all cross-contamination types. Environmental cross-contamination events predominately resulted from students handling meat or touching their skin. The most frequently contaminated ingredients and cooking utensils are listed in Table 3.4 by cross-contamination category.

Table 3.4. Top five most frequently contaminated items by cross-contamination type

Cross-contamination Category	Contamination Frequency (1 = most frequently cross-contaminated and 5 = least frequently cross-contaminated) 1	2	3	4	5
Raw meat	Skillet (37)	Spatula (37)	Mixing bowl (35)	Pepper shaker (35)	Salt shaker (31)
Raw produce	Cutting board (24)	Knife (22)	Recipe (14)	Salt shaker (11)	Pepper shaker (9) RTE food (9)
Skin	Skillet (63)	RTE food (56)	Recipe (48)	Spatula (39)	Thermometer (39)
Cell phone	Recipe (8)	RTE food (6)	Cloth towel (4)	Hot pad (4)	Knife (4)

Raw produce, skin, and cellphone cross-contamination type categories had two items in common that were frequently contaminated: ready-to-eat (RTE) food and the printed recipe. In the post-intervention cooking session, students' attitudes were favorable toward post-use cleaning of the cooking thermometer. A student who used a thermometer to measure the temperature of burger patties began to replace the thermometer cover without first washing the thermometer. The student stopped and decided that cleaning the thermometer was important to food safety, as evidenced by the following statement.

Student: "I need to wash this [thermometer]."

After the intervention, the number of groups who washed station surfaces with soap and water increased by 4% (Table 3.5). However, less than half (47%) of the groups cleaned their work surfaces with soap and water after the intervention. Prior to the intervention, one group sanitized station surfaces, but no groups sanitized their station surfaces after the intervention.

Table 3.5. Percentage of groups who performed environmental cleaning and used a cooking thermometer

Food-handling Behavior	Pre-intervention % (# of groups)	Post-intervention % (# of groups)
Environmental Cleaning		
Dry wiped surfaces	67 (18)	48 (13)
Wiped surfaces with water only	30 (8)	33 (9)
Wiped surfaces with soap and water	44 (12)	48 (13)
Wiped surfaces with sanitizer	4 (1)	0 (0)
Wiped stove	56 (15)	44 (12)
Wiped counter	74 (20)	67 (18)
Wiped sink	4 (1)	11 (3)
Thermometer Use		
Used thermometer to measure burger patty internal temperature	74 (20)	67 (18)

*No significant changes were observed per McNemar's Test using a significance level 0.05

Stationary cameras provided a consistent view of the groups' food-handling behaviors and group interactions. Stationary cameras were not able to capture food-handling behaviors in common areas where ready-to-eat food and common ingredients were stored. Approximately 10 hours of video during which students left the cooking station were lost by stationary cameras. Due to the location of the stationary cameras, they predominantly recorded conversations from groups other than the filmed group. GoPro cameras captured the camera wearer's food-handling behaviors and interactions with other group members. The GoPro view frame was dependent on the direction of the camera wearer's head, which resulted in the loss of the camera wearer's food-handling behaviors. The GoPro view frame was also limited in its ability to capture students touching their head and face, which constituted recordable cross-contamination events. GoPro cameras recorded audio from the observed group more clearly.

3.4 Discussion

After the intervention, 67% of groups used a cooking thermometer, and no significant difference was observed in the number of groups who used a cooking thermometer. A hypothesis of this study was that student thermometer use would significantly increase after the intervention, as demonstrated in a prior observational study of high school students' food-handling practices (Diplock et al., 2018). Students' attitudes and 'perceived behavior control' were possible contributing factors to the lack of cooking thermometer usage. Some students were unsure of how to properly use the cooking thermometer, which could contribute to lower 'perceived behavior control'. A review paper describing cooking thermometer-use barriers noted that a common barrier to thermometer use is lack of knowledge about how to use the thermometer (Cates, Carter-Young, Durocher, Williams, & Conley, 2002; Elshahat, Woodside, & McKinley, 2019; Koeppl, 1998; Redmond et al., 2006; York et al., 2009). In one of the reviewed studies, one participant indicated the intention to use a cooking thermometer contingent upon being shown how to use the thermometer (Bermudez-Millan, Perez-Escamilla, Damio, Gonzalez, & Segura-Perez, 2004; Feng & Bruhn, 2019). Other students claimed they would not use a cooking thermometer at home, indicating the educational intervention was not effective at changing students' attitudes toward thermometer use, despite changing the students' knowledge that using a cooking thermometer is the safest method for determining whether food is thoroughly cooked. A review paper focused on meat thermometer usage concluded that, in studies using intervention methods, thermometer use was not solely dependent on consumers' knowledge that cooking thermometers should be used (Elshahat et al., 2019).

For 'subjective norms', three Key Influencers were identified: peers, instructors, and parents. Adolescents have been observed to change their attitudes and behaviors to align with those of their peers (Gommans, Sandstrom, Stevens, ter Bogt, & Cillessen, 2017). In the present study, students relied on observation of and discussion with their peers for guidance on how to safely handle and prepare food. Students can be influenced by their peers positively or negatively, where negative influences are generally associated with the performance of risky behaviors, and positive influences are associated with avoidance of risky behaviors (Karakos, 2014; McConchie, Hite, Blackard, & Cheung, 2019). Most of the observed students demonstrated positive influence as they tried to persuade their peers to follow recommended food safety practices. In general, students did not dispute their peers' recommendations related to thermometer usage, but recommendations to wear gloves were more frequently rebuffed. The students' food safety knowledge could have contributed to the difference in response to peer recommendations. The educational intervention focused on when and how to use thermometers, whereas glove usage information only related to how to use gloves. Peers' popularity or status may influence persuasion effectiveness. Previous studies have suggested that individuals considered to be high status or popular possess greater influencing power over their peers (Choukas-Bradley, Giletta, Cohen, & Prinstein, 2015;

Gommans et al., 2017). This dynamic of the student-peer relationship was not explored in the present study, but future studies investigating the effect of peer status and popularity on food-handling behaviors could improve safe food-handling interventions developed for youth.

Instructors have a key role in influencing students' food safety behaviors. A recent study of food safety practices of future food handlers and instructors of courses involving food handling found a link between students' food-handling behaviors and the actions modeled by their instructors (Ovca et al., 2018). The present study suggests that instructors' recommendations can have a greater influence on students' food-handling behaviors compared to a students' peer group. This was exhibited by the student who chose to comply with the instructor's recommendation to wear gloves despite his peer group's efforts to dissuade him from wearing gloves. These findings suggest that instructors providing food-handling recommendations one-on-one to students may be more effective at changing student behaviors; only the students who were targeted with the recommendation changed their food-handling behaviors.

Students' intentions to modify their behaviors for the research study suggests that 'subjective norms' may influence situational behavior change, but not personal behavior change. In situational behavior change, students modify their behaviors in response to changes in the environment, such as the presence of an instructor who has established expectations for student food-handling behaviors. In contrast, personal behavior change occurs when students practice certain food-handling behaviors irrespective of environmental influences. Reputation Management Theory asserts that individuals modify their behaviors when they are being watched to portray desirable characteristics, which are commonly influenced by 'subjective norms' (Cañigueral & Hamilton, 2019). The findings from the present study suggest that students' home environments affect their food safety behavior intention more strongly than classroom environments. Ruby and colleagues (2019) found that behavior intention was most closely linked to 'subjective norms', with family expectations bearing crucial influence over behavioral intentions (Ruby, Abidin, Lihan, Jambari, & Radu, 2019). Students cited methods their parents used to prepare food, which included sensorial evaluation of meat rather than thermometer use. Recent studies confirm that regular use of cooking thermometers is low among meal-preparers (14%) and that many meal-preparers who do not use thermometers rely on color to determine meat doneness (Feng & Bruhn, 2019; Rhodes & Kuchler, 2020).

Observed food safety behaviors suggested a shift in food safety climate. While there is no universally agreed-upon definition of food-safety climate, proposed definitions take into account the role that work environments, personnel, procedures, and policies play in promoting food safety (Sharman, Wallace, & Jespersen, 2020). Food safety climate has been researched as it relates to the food industry, but few studies have focused on the effects of food safety climate related to classroom food safety educational interventions. In the classroom, food safety climate is derived from students' emotions, thoughts, and behaviors, which can be influenced by their instructor (Sharman et al., 2020). Research has demonstrated a positive relationship between food safety climate and food safety behaviors, where food safety behaviors are comprised of two parts: food safety compliance and food safety participation. Food safety compliance measures a person's adherence to recommended food-handling behaviors, and food safety participation measures a person's willingness to ensure other group members are working safely (De Boeck, Mortier, Jacxsens, Dequidt, & Vlerick, 2017). Students demonstrated post-intervention improved safety compliance; there was a significant increase in the percentage of correctly performed handwashing and glove-changing events. In food safety participation, students extend their 'perceived behavior control' from their own situation to the situation of other students, and they begin to use their peer subjective norm influence to promote their attitudes to other students. Thus, students begin attempting to change the behavior intentions and behaviors of other students. In the present study, students began to intervene when they disagreed with the food-handling behaviors of their group members. This was evidenced by students reminding their group members to avoid cross-contamination and students educating their group members on foodborne illness risks from handling raw meat.

Although a shift in food safety climate was observed, compliance with many of recommended food-handling behaviors associated with handwashing and glove-changing remained below 50% after the intervention. Where the TPB lacks provisions to understand why behavior intentions are not converted to actual behavior, Skill Acquisition Theory can be used to interpret results. Skill Acquisition Theory categorizes skill learning into three stages: declarative, procedural, and automatic. In the declarative stage, learners gain knowledge about the skill through verbal and nonverbal training. During the procedural stage, learners begin to practice the new skill to make the transition from slow, thoughtful task performance to a more rapid, visceral task performance.

In the automatic stage, learners are able to perform the task can be performed consistently and instinctively with minimal errors (DeKeyser, 2007).

Observed students were in the post-intervention procedural stage. Students were still contemplative of their actions, as evidenced by the student who grappled with whether to wash a cooking thermometer after use. Students began to identify when to perform specific food-handling behaviors and put them into practice, but with a high margin of error. For example, students understood the concept of cross-contamination and tried to prevent cross-contamination from their own actions and their group member's actions. However, students still cross-contaminated utensils and surfaces after the educational intervention. With the exception of vegetable cross-contamination events, there was a general decreasing trend in number of cross-contamination events per each kitchen location post-intervention. This reflects students' conversion of knowledge into actions as they transition to the procedural stage. Overall, students in the study did not reach the automatic stage. Students may have increased the number of cross-contamination events when handling vegetables after the intervention due to the requirement to use more vegetables in the post-intervention recipe compared to the pre-intervention recipe. Handling more vegetables increased students' likelihood of handling the raw vegetables before performing other tasks or placing the unwashed raw vegetables on surfaces.

In the case of glove usage and handwashing, it is possible students may need to revert to the declarative stage to address knowledge gaps. Consistent with a previous study that observed food-handling practices of future food handlers, handwashing rates among glove-wearers was low, which could indicate students lack the understanding that wearing gloves does not eliminate food safety risks (Ovca et al., 2018). Low rates of glove changing and handwashing to prevent cross-contamination may also be explained by Skill Acquisition Theory. Students' food-handling behaviors were progressing toward alignment with recommendations of glove usage and handwashing; significant improvement in the percentage of glove-changing and handwashing attempts were observed in categories, such as after handling raw vegetables, skin, garbage, and raw meat. However, compliance with recommended handwashing and glove-changing practices still remained around 50% or less for all categories, except garbage handling. One strategy for moving students from the procedural to the automatic stage for handwashing and glove changing is to prompt students to perform the behavior. A study of school-aged children demonstrated that making environmental changes to promote handwashing without verbal prompting from instructors subtly increased student handwashing events from 4% to 74% in six weeks (Dreibelbis, Kroeger, Hossain, Venkatesh, & Ram, 2016). Other interventions to improve handwashing have used signage and verbal warnings from instructors to prompt handwashing (Ovca et al., 2018; Schroeder et al., 2016). Further research is needed to determine best practices for creating and disseminating food safety to move students through all three stages of skill acquisition and to promote sustained safe food-handling behaviors.

In this study, the use of stationary and GoPro cameras provided a more holistic method for evaluating students' behaviors and factors influencing behaviors than when used singularly. Few research studies related to food-handling behaviors have utilized multiple cameras to capture food-handling behaviors. The combination of the two camera systems increased the research team's ability to record inter- and intragroup interactions, which was crucial for the evaluation of 'subjective norms.' Stationary cameras provided the bulk of group food-handling behavior data due to consistent visibility of all group members, and the GoPro was useful for fine-tuning data collection, especially in the case of conversations between group members. The positioning of the cameras allowed students to see themselves, which could have served as a reminder they were being recorded, and therefore, contributed to false food safety behavioral changes. A prior study by Evans and Redmond (2018) utilized a ceiling-mounted camera (Evans & Redmond, 2018). Mounting the camera on the ceiling removes the camera from the study participants' direct line of sight while they engage in cooking behaviors, thus potentially reducing observation bias.

There were two notable limitations in this study: lack of a control group and differences in environmental factors among groups. Because the cooking sessions occurred during school hours, all students were provided with the food safety educational intervention to minimize instructional losses for participating students and instructors. The layout of the kitchen stations was not consistent due to classroom design. Use of cooking stations that differed significantly from the other cooking stations was minimized. The equipment available to students at the beginning of the cooking sessions differed. Some cooking sessions were scheduled for consecutive class periods, affording the research team limited time to clean and reset any unwashed equipment and utensils.

CHAPTER 4. EXPERIMENT III: CURRICULUM EVALUATION, SELF-REPORT

4.1 Objectives

The objectives of this study were to

1. Evaluate the effectiveness of two educational interventions at changing high school students' food safety knowledge, attitudes, and behaviors,
2. Evaluate food safety education intervention effectiveness for students enrolled in an agriculture course compared to students enrolled in a microbiology course.

4.2 Materials and Methods

Participant Recruitment

Purdue University's Institutional Review Board approved this study. High school agriculture and science instructors in Indiana were contacted via email. One agriculture instructor and one microbiology instructor were selected from the respondents to teach their students food safety using the curricula provided by the researchers.

Curriculum Design

Two curricula, an original version and a modified version, were developed by the researchers. The original curriculum was constructed using a Positive Deviance approach. The PD model generates solutions to issues using the behavioral practices already being successfully employed by individuals in the given system (Rose & McCullough, 2017). This model allows for open discussion regarding best practices based on observations of and interviews with Positive Deviants (LeMahieu et al., 2017). The original curriculum centered around classroom discussions to identify positive deviants for each food safety topic addressed. In-class activities were designed to illustrate concepts and generate discussions about safe food-handling among students. Through the discussions, students would learn from their positive deviant peers how to overcome barriers to safe food-handling. The modified curriculum was constructed using an Experiential Learning approach. Experiential learning (EL) is another teaching method with demonstrated implications to motivate behavior change and improve learning outcomes. EL is a cycle involving four steps: experience, reflection on experience, modification in approach or new idea generation based on reflection, and experimentation (Kolb et al., 2001). Research studies have demonstrated the effectiveness of EL at improving student recall of concepts and increasing student engagement in learning (Kuh, 2008). The modified curriculum was student-centered and allowed students to address real-world, professional challenges using a multipronged approach including student identification of required resources, independent research, application of knowledge and techniques, and teamwork (Boud & Feletti, 2013; Jonassen & Hung, 2015). In the modified curriculum, students role-played as employees in a fictitious food company to address industry-related food safety challenges through case study and simulation activities.

The curricula included background information and scripting for the instructors, lessons, activities, answer keys, and pre- and post-surveys. Microbiology and agriculture instructors were provided with the same instructional materials. The Partnership for Food Safety Education's Fight BAC! Campaign Core Four concepts were used to construct the educational content framework included in the lessons (Gould et al., 2013). The Core Four concepts included chilling and cooking food to the recommended temperatures, preventing cross-contamination, and cleaning food contact areas. An additional topic of choosing safe food was added to both curricula, and an introduction to Hazard Analysis Critical Control Point (HACCP) plan development was added to the modified curriculum.

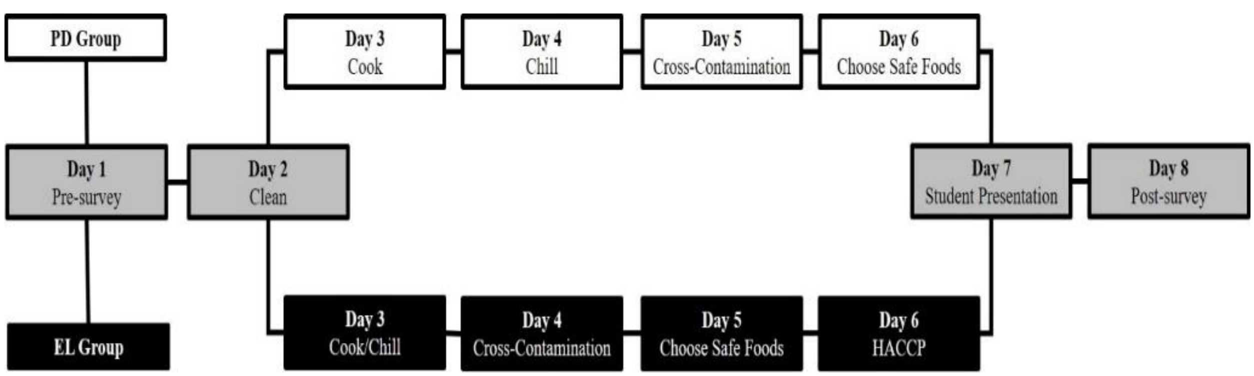


Figure 4.1. PD Group and EL Group curriculum composition and lesson flow

Both curricula were designed to be taught by course instructors regardless of the instructors' personal experience with or knowledge of food safety concepts. The curricula were developed to be taught in 50-minute class sessions during the school day for eight consecutive days: two days for knowledge assessment, five days for food safety education, and one day for student presentations communicating learnings and reflecting on the impact of food safety in their daily lives (Simmonds et al. 2015). Figure 4.1 outlines the course learning flow of each curriculum.

Survey Design

The effectiveness of curricula was measured by pre-, post- and 1-year follow-up-surveys. All surveys were divided into three sections: participant demographics, knowledge, and risk-perception and perceived behavioral control. The final survey included two additional sections: students' interest in and engagement with food safety curriculum and students' perception of the relevancy of food safety to their lives. Each of these sections are described below in further detail.

1. Participant demographics including ethnicity, gender, and grade-level were collected.
2. Knowledge change was measured using a combination of true/false, fill-in-the-blank, and multiple-choice questions. Questions from all food safety topics addressed in the education intervention, excluding HACCP, were included on the survey.
3. Risk-perception and perceived behavioral control change were measured using two and three pre- and post-survey questions, respectively. Each question was scored on a five-point Likert scale and asked students to rate how strongly they agreed or disagreed with a statement.
4. Student interest and engagement were measured using a combination of preference ranking, open-ended, and five-point Likert-scaled questions related to in-class and take-home activities. Students' learning-style preferences as well as their interest and perceived competency in agricultural-based career fields were measured using five-point Likert scaled questions. Instructor impact on students' engagement with the curricula was measured using a combination of Likert-scaled and open-ended questions related to instructor performance.
5. Students' perception of food safety relevancy in their lives was measured using an open-ended question asking students to describe how they used the food safety information they learned in the past year.

Data Collection

The agriculture and microbiology instructors taught both curricula. The agriculture instructor divided students into two groups and taught one curriculum for each group, same as the microbiology instructor. One group was taught using the original curriculum, and the other group was taught using the modified curriculum as outlined in Figure 4.1. All students received the same Qualtrics (Qualtrics, Provo, Utah) pre- and post-surveys. Surveys were distributed electronically through Google Classroom and took approximately 15 minutes for students to complete. Microbiology students completed the pre- and post-surveys in November and December 2018, and Agriculture students completed both surveys in December 2018. All students completed the follow-up survey in January 2020.

Data Analysis

Student data were divided into four groups for analysis based on the course in which they were enrolled and the curricula they were taught. Data divided by the course is represented by the terms “Microbiology Students” and “Agriculture Students”. Data divided by the curricula is represented by “PD Group” and “EL Group” for the curricula designed using the positive deviance model and experiential learning methods, respectively.

Student pre- and post-survey responses were downloaded from Qualtrics and input into IBM SPSS (Armonk, NY: IBM Corp). Survey reliability was determined to be reasonable (0.67 – 0.87) per a Cronbach’s alpha of 0.68 (Taber, 2018). The difficulty of knowledge questions asked on the survey was evaluated using a difficulty index (DI), which represents the proportion of students who correctly answered each question on the pre-survey compared to the number of students who completed the survey (Kwiatkowska, 2016). DI’s range from 0 to 1, where a DI of 1 represents all students correctly answered the question. DI’s greater than 0.7 indicate low difficulty, 0.4 – 0.7 average difficulty, and less than 0.4 high difficulty (Kwiatkowska, 2016). Each knowledge question response was converted to binary scale; correct answers received a score of “1”, while incorrect answers were assigned “0” points. Questions with more than one correct answer were assigned one point for each correct answer, resulting in 24 possible points for the knowledge section. Each student was assigned a knowledge score (KS) corresponding to the number of questions they correctly answered on the pre- and post-survey. Significant differences between pre- and post-survey responses were determined using McNemar's tests for knowledge questions and t-tests for risk-perception and perceived behavioral control questions. A 0.05 significance level was used for McNemar's and t-tests. Binomial logistic regression was used to determine if gender or the course in which students were enrolled significantly influenced their ability to achieve a mastery-level score on the knowledge portion of the survey. The mastery-level score was defined as answering 75% or more of the questions correctly (Balasubramaniam et al., 2018).

4.3 Results

A total of 100 students completed the pre- and post-survey. Between the post-survey and follow-up survey, 4 students moved, 2 students graduated, and another student left the school system at the end of a foreign-exchange student program. In total, 88 students completed the pre-, post- and follow-up-surveys. Most students were white, non-Hispanic (98%), female (56%), and sophomores (67%). Sixty-seven percent of the students were enrolled in a microbiology course. Student demographics by curriculum type are in Table 4.1. Most students (91%) reported that their parents or grandparents were the primary meal preparers.

Table 4.1. Demographics of students in each curricula Group

Characteristic	PD Group (N=41) % (N)	EL Group (N=47) % (N)	Total (N=88) % (N)
Course			
Agriculture	42 (17)	25 (12)	33 (29)
Microbiology	58 (24)	75 (35)	67 (59)
Gender			
Male	44 (18)	45 (21)	44 (39)
Female	56 (23)	55 (26)	56 (49)
Ethnicity			
Asian	2 (1)	2 (1)	2 (2)
White (non-Hispanic)	98 (40)	98 (46)	98 (86)
Grade-Level			
Freshman	7 (3)	13 (6)	10 (9)
Sophomore	71 (29)	64 (30)	67 (59)
Junior	20 (8)	23 (11)	22 (19)
Unknown	2 (1)	0 (0)	1 (1)

Risk-perception and Perceived Behavioral Control

Microbiology Students and Agriculture Students reported significant changes in risk-perception and perceived behavioral control from the pre-survey to the post-survey. Between the two curricula, only the EL Group experienced significant changes in risk-perception and perceived behavioral control, Table 4.2. Post intervention, perception of the importance of food treatment methods and purchase points to maintain safe food significantly increased in the EL Group compared to their pre-intervention perceptions. These students also became significantly more confident in their ability to safely store food and clean food-contact surfaces. Microbiology students reported significantly increased confidence in the aforementioned areas and in their ability to prepare food that is safe to eat. When surveyed one year after the intervention, the risk-perception and perceived behavioral control for remained significantly higher in these areas than their pre-survey responses for the EL Group, and these students also became more confident in their ability to prepare food that is safe to eat. Microbiology Students' risk perception and perceived behavioral control remained significantly higher than their pre-survey responses. Microbiology Students and Agriculture Students demonstrated significantly increased risk-perception compared to both their pre- and post-survey responses for questions related to personal risk for developing foodborne illness and food treatment methods, respectively.

Knowledge

Students in the PD Group and EL Group demonstrated significant increases in overall food safety knowledge post intervention compared to their pre-survey scores and met the mastery level score by correctly answering at least 75% of the knowledge questions (18), Table 4.2. Microbiology Students demonstrated significant knowledge improvement and achieved the highest knowledge growth, an average increase of 3.27 points. Agriculture Students scored significantly lower on the post-survey than the pre-survey and were an average of 2.62 points below mastery-level. On the follow-up-survey, only the EL Group achieved significantly higher scores compared to the pre-survey without a significant decrease from the post-survey score. Microbiology Students maintained a significantly higher follow-up-survey score compared to the pre-survey, but their knowledge significantly attenuated from the post-survey score.

Results from the pre-survey indicated that students were proficient in topics spanning several categories including cleaning, cooking, and cross-contamination prior to the intervention. Eighty-five percent or more of the PD Group and the EL Group correctly answered pre-survey questions about the effectiveness of rinsing hands to remove bacteria, the need to wash hands even if they are wearing gloves, and the need to wash produce grown at home. Prior to the intervention, at least 83% of the PD Group and the EL Group knew that cross-contamination can occur in home kitchens, could identify ways bacteria can be transferred onto food, that reusable grocery bags can be a source of cross-contamination and that washing meat and poultry under running water can spread bacteria. Cross-contamination questions were correctly answered on the pre-survey by a higher

Table 4.2. Mean scores of students for risk-perception and self-efficacy questions (1=lowest, 5=highest)

	PD Group (N=41)			EL Group (N=47)			Microbiology Students (N=59)			Agriculture Students (N=29)		
Question	**Pre-survey % (N)**	**Post-survey % (N)**	**Follow-up Survey % (N)**	**Pre-survey % (N)**	**Post-survey % (N)**	**Follow-up Survey % (N)**	**Pre-survey % (N)**	**Post-survey % (N)**	**Follow-up Survey % (N)**	**Pre-survey % (N)**	**Post-survey % (N)**	**Follow-up Survey % (N)**
Risk of developing foodborne illness[R]	3.07 ± 0.75	3.15 ± 0.82	3.34 ± 0.79	3.34 ± 0.87	3.38 ± 0.77	3.57 ± 0.71	3.25 ± 0.66	3.22 ± 0.62	3.54 ± 0.73[1,2]	3.14 ± 1.09	3.38 ± 1.08	3.31 ± 0.81
Influence of purchase point and food treatment methods on food safety[R]	3.61 ± 1.51	3.73 ± 1.52	3.76 ± 1.22	3.19 ± 1.42	4.19 ± 1.24[1]	4.28 ± 1.04[1]	3.41 ± 1.42	4.32 ± 1.25[1]	4.00 ± 1.20[1]	3.34 ± 1.61	3.28 ± 1.41	4.10 ± 1.05[1,2]
Confidence in ability to clean food-contact surfaces[B]	3.41 ± 1.18	3.61 ± 1.41	3.83 ± 1.30	3.40 ± 1.14	4.02 ± 1.17[1]	4.26 ± 0.92[1]	3.46 ± 0.97	3.98 ± 1.15[1]	4.10 ± 1.14[1]	3.31 ± 1.47	3.52 ± 1.53	3.97 ± 1.12
Confidence in ability to safely store food[B]	3.37 ± 1.16	3.51 ± 1.52	3.76 ± 1.14	3.28 ± 1.02	3.96 ± 1.16[1]	3.98 ± 0.90[1]	3.25 ± 0.90	3.93 ± 1.30[1]	4.02 ± 0.92[1]	3.45 ± 1.38	3.38 ± 1.40	3.59 ± 1.15
Confidence in ability to prepare food that is safe to eat?[B]	3.51 ± 1.29	3.68 ± 1.33	3.83 ± 1.36	3.57 ± 1.04	3.94 ± 1.15	4.09 ± 1.00[1]	3.51 ± 0.99	4.00 ± 1.20[1]	4.07 ± 1.10[1]	3.62 ± 1.45	3.45 ± 1.24	3.76 ± 1.33
Knowledge Score (KS)[3]	16.88 ± 2.26	18.78 ± 3.62[1]	17.44 ± 4.14[2]	16.66 ± 3.21	18.81 ± 3.31[1]	18.87 ± 2.76[1]	17.20 ± 2.86	20.47 ± 2.05[1]	19.39 ± 2.35[1,2]	15.86 ± 2.47	15.38 ± 3.18[1]	15.79 ± 4.26

R = risk perception question

B= perceived behavioral control question

1 Significantly different than Pre. McNemar's Test was conducted to determine statistical significance using a significance level of 0.05.

2 Significantly different than Post (Follow-up only). McNemar's Test was conducted to determine statistical significance using a significance level of 0.05.

3 = KS the mean survey score for students. The minimum survey score is 0, and the maximum survey score is 24

percentage of Microbiology Students than Agriculture Students. In the cooking category, at least 90% of the PD Group and the EL Group recognized that using a cooking thermometer is the best method to check the temperature of food after it has been cooked.

Significant knowledge changes occurred for questions related to cleaning, cooking, and chilling, Table 4.3. The PD Group and the EL Group demonstrated a significant increase in their ability to identify the most sanitary drying methods. The number of students who correctly identified single-use paper towels as the most sanitary drying method nearly doubled for the PD Group. The number of Microbiology Students who correctly answered this question doubled, which was significant. Students lacked knowledge of how to safely prepare food. On the pre-survey, 39% of the PD Group and 43% of the EL Group knew that checking the color of meat is not the most reliable way to determine if the meat is thoroughly cooked. On the post-survey, the number of students who correctly answered this question significantly increased for the PD Group and EL Group. Nearly all (98%) Microbiology Students answered this question on the post-survey correctly, which was significantly higher than the pre-survey results (51%). Most students in the PD Group and the EL Group did not know the recommended cooking temperature for ground beef and chicken. Post intervention, the number of students who knew the recommended cooking temperature for ground beef significantly increased in both Groups. However, the number of students able to provide the recommended cooking temperature for chicken only significantly increased in the EL Group. Microbiology Students demonstrated low initial knowledge of the recommended cooking temperatures for ground beef and chicken; however, they demonstrated significant knowledge increases for both questions on the post-survey. Knowledge of recommended chilling practices was high across each cohort group, but the number of students who knew leftovers should be divided into shallow containers significantly increased in the PD Group and the EL Group. All Microbiology Students correctly answered this question on the post-survey, a significant increase from 73% on the pre-survey.

Table 4.3. Correct response rate to knowledge questions on pre-, post-, and follow-up-surveys

Survey Question	PD Group (N=41)			EL Group (N=47)			Microbiology Students (N=59)			Agriculture Students (N=29)		
	Pre-Survey % (N)	**Post-Survey % (N)**	**Follow-Up - Survey % (N)**	**Pre-Survey % (N)**	**Post-Survey % (N)**	**Follow-Up-Survey % (N)**	**Pre-Survey % (N)**	**Post-Survey % (N)**	**Follow-Up-Survey % (N)**	**Pre-Survey % (N)**	**Post-Survey % (N)**	**Follow-Up Survey % (N)**
Rinsing your hands in running water washes all the bacteria off. (DI=0.92)	98 (40)	95 (39)	93 (38)	87 (41)	94 (44)	96 (45)	92 (54)	97 (57)	98 (58)	93 (27)	90 (26)	86 (25)
Which of the following drying methods is the most sanitary? (DI=0.53)	42 (17)	81 (33)[1]	71 (29)[1]	64 (30)	98 (46)[1]	96 (45)[1]	46 (27)	97 (57)[1]	93 (55)[1]	69 (20)	76 (22)	66 (19)
You don't need to wash your hands if you are using gloves. (DI=0.90)	85 (35)	95 (39)	85 (35)	94 (44)	96 (45)	96 (45)	90 (53)	98 (58)	97 (57)	90 (26)	90 (26)	79 (23)
Produce that you grow at your home is not a source of harmful bacteria and you don't have to wash it. (DI=0.99)	100 (41)	90 (37)	93 (38)	98 (46)	96 (45)	100 (47)	98 (58)	97 (57)	98 (58)	100 (29)	86 (25)[1]	93 (27)[1]
The safest way to know if you have cooked meat and killed the bacteria is to cut the meat and check the color. (DI=0.41)	39 (16)	85 (35)[1]	63 (26)[1,2]	43 (20)	89 (42)[1]	83 (39)[1]	51 (30)	98 (58)[1]	85 (50)[1,2]	21 (6)	66 (19)[1]	52 (15)[1]

Table 4.3 (Continued)

Checking the temperature of the food after it is cooked is best done by (DI=0.15)	95 (39)	88 (36)	98 (40)	96 (45)	96 (45)	94 (44)	98 (58)	98 (58)	98 (58)	90 (26)	79 (23)	90 (26)
When the internal temperature of chicken reaches ________ degrees F, it is done. (DI=0.25)	20 (8)	34 (14)	39 (16)	11 (5)	47 (22)[1]	36 (17)[1]	10 (6)	53 (31)[1]	48 (28)[1]	24 (7)	17 (5)	17 (5)
When the internal temperature of ground beef reaches ________ degrees F, it is done. (DI=0.24)	22 (9)	61 (25)[1]	39 (16)[2]	28 (13)	83 (39)[1]	28 (13)[2]	29 (17)	83 (49)[1]	41 (24)[2]	17 (5)	52 (15)[1]	17 (5)[2]
Refrigeration and freezing kill bacteria. (DI=0.76)	73 (30)	90 (37)	81 (33)	79 (37)	62 (29)	72 (34)	73 (43)	75 (44)	80 (47)	83 (24)	76 (22)	69 (20)
The best way to cool a big pot of chili or soup is to divide it into small, shallow containers. (DI=0.72)	73 (30)	93 (38)[1]	95 (39)[1]	70 (33)	94 (44)[1]	89 (42)[1]	73 (43)	100 (59)[1]	98 (58)[1]	69 (20)	79 (23)	79 (23)
Cross-contamination is not a concern in home kitchens; only big food companies need to worry about cross-contamination. (DI=0.91)	90 (37)	90 (37)	93 (38)	92 (43)	94 (44)	92 (43)	95 (56)	100 (59)	98 (58)	83 (24)	76 (22)	79 (23)
In which of the following ways can harmful bacteria ˜travel" onto other food: (DI=0.94)	93 (38)	93 (38)	90 (37)	96 (45)	94 (44)	98 (46)	98 (58)	100 (59)	97 (57)	86 (25)	79 (23)	90 (26)

Table 4.3 (Continued)

There is no risk of cross-contamination when using reusable grocery bags. (DI=0.93)	95 (39)	83 (34)	90 (37)	92 (43)	87 (41)	94 (44)	95 (56)	95 (56)	97 (57)	90 (26)	66 (19)[1]	83 (24)
Washing meat and poultry under running water can spread bacteria up to three feet by splashing water. (DI=0.89)	88 (36)	90 (37)	88 (36)	89 (42)	94 (44)	94 (44)	92 (54)	100 (59)	97 (57)	83 (24)	76 (22)	79 (23)
Pasteurization reduces milk/juice's nutritional value significantly. (DI=0.52)	51 (21)	71 (29)	54 (22)	53 (25)	66 (31)	51 (24)	59 (35)	71 (42)	54 (32)[2]	38 (11)	62 (18)	48 (14)
Home canned food made from your grandma's recipe is always tasty and safe. (DI=0.83)	81 (33)	85 (35)	78 (32)	85 (40)	89 (42)	85 (40)	86 (51)	97 (57)	86 (51)	76 (22)	69 (20)	72 (21)
Irradiated meat and poultry is safer than untreated meat and poultry. (DI=0.51)	51 (21)	54 (22)	68 (28)	51 (24)	68 (32)	62 (29)	56 (33)	66 (39)	58 (34)	41 (12)	52 (15)	79 (23)[1,2]
Which groups are at the highest risk for foodborne illness?												
Young children (DI=0.81)	83 (34)	66 (27)[1]	78 (32)	79 (37)	77 (36)	89 (42)	83 (49)	88 (52)	89 (53)	76 (22)	38 (11)[1]	72 (21)[2]
Older adults (people 50 years and older) (DI=0.67)	71 (29)	73 (30)	66 (27)	64 (30)	64 (30)	79 (37)	68 (40)	76 (45)	83 (49)[1]	66 (19)	52 (15)	52 (15)

Table 4.3 (Continued)

People with diabetes (DI=0.41)	49 (20)	59 (24)	29 (12)[1,2]	34 (16)	43 (20)	45 (21)	39 (23)	58 (34)[1]	34 (20)[2]	45 (13)	35 (10)	45 (13)
People with chronic disease (DI=0.5)	56 (23)	59 (24)	32 (13)[1,2]	45 (21)	49 (23)	57 (27)	48 (28)	58 (34)	48 (28)	55 (16)	45 (13)	41 (12)
People with weakened immune system (0.81)	85 (35)	81 (33)	71 (29)	77 (36)	77 (36)	85 (40)	88 (52)	92 (54)	92 (54)	66 (19)	52 (15)	52 (15)
Pregnant women (0.67)	73 (30)	76 (31)	61 (25)	62 (29)	55 (26)	75 (35)[2]	71 (42)	73 (43)	78 (46)	59 (17)	48 (14)	48 (14)
Young men (0.78)	76 (31)	88 (36)	90 (37)	81 (38)	72 (34)	94 (44)[1,2]	83 (49)	80 (47)	93 (55)[2]	69 (20)	79 (23)	90 (26)[1,2]

1 Significantly different than Pre-Survey

2 Significantly different than Post-Survey (Follow-Up-Survey only)

*Significant change from pre- to post-survey. McNemar's tests were conducted to determine statistical significance using a significance level of 0.05.

DI calculated for control and treatment groups combined. DI = 0.71-1.00 (low difficulty), DI = 0.41-0.70 (average difficulty), DI = 0.00-0.40 (high)

One year after the intervention, students in the PD Group and the EL Group retained the food safety knowledge they learned related to recommended methods for hand drying and for safely storing large quantities of food. The number of students who correctly answered both of these questions did not differ significantly from the number of students who correctly answered these questions on the post-survey. Microbiology Students retained the knowledge they gained for these questions from the post-survey to the follow-up-survey. The PD Group demonstrated a significant decrease in knowledge that cutting meat and checking the internal color is not a reliable method for determining if the food is thoroughly cooked. However, these students still achieved significantly higher follow-up survey scores for this question compared to their pre-test scores. The EL Group retained the knowledge they gained related to this question. Knowledge of the recommended end cooking temperature for chicken remained unchanged in the EL Group; however, knowledge of the correct end cooking temperature for ground beef significantly decreased from post-surveys scores for both Groups. Microbiology Students retained their knowledge of the recommended end temperature for chicken, but not for ground beef.

Post-survey scores highlighted topics for which students still needed practice post intervention. Although significant improvement was seen in the number of students in the PD Group and the EL Group who knew the recommended temperature for cooking chicken, less than half of students correctly answered this question on the post-survey (PD: 34%, EL: 47%). Many students did not identify individuals with diabetes or chronic disease as members of the high-risk population for developing foodborne illness. Follow-up survey results affirmed the need for continued practice in the areas identified from post-survey responses. Less than half of students in both Groups (PD: 39%, EL: 36%) were able to recall the recommended end cooking temperature of chicken; however, there was no significant change for this question from the post-survey. Additionally, students in both Groups experienced a significant decrease in knowledge of recommended end cooking temperatures for ground beef (PD: 39%, EL: 28%). Students' ability to identify individuals with diabetes or chronic illness as high-risk populations remained low on the follow-up survey. In the PD Group, students' ability to identify both of these groups as high-risk populations for developing foodborne illness significantly decreased from both the pre- and post-survey.

Binomial logistic regression was used to determine the effect of course enrollment and curriculum intervention type on the likelihood of the student achieving 75% mastery-level score on the post-survey and follow-up-survey. For the regression, curriculum and course were independent variables, and mastery-level score was the dependent variable. The generated model for the post-survey was statistically significant ($p<0.001$) with a Cox and Snell R^2 equal to 0.33. The model correctly predicted whether a student mastered the post-survey content in 84% of the cases. In this study, the model's sensitivity refers to its ability to correctly predict whether a student will achieve a mastery-level score on the survey, and the model's specificity refers to its ability to correctly predict when students will not achieve a mastery-level score. For the post-survey, the model's sensitivity and specificity were 87% and 79%, respectively. The course in which students were enrolled was the only significant predictor of achieving 75% mastery on the post-survey. Students enrolled in the microbiology course were approximately 22 times more likely to achieve 75% mastery on the post-survey than students enrolled in the agriculture course. For the follow-up survey, the model was also statistically significant ($p<0.001$) with a Cox and Snell R^2 equal to 0.21. The follow-up survey's sensitivity and specificity were 84% and 61%, respectively. The course in which students were enrolled was again the only significant predictor of achieving a mastery-level score. Students enrolled in the microbiology course were approximately 7 times more likely to achieve a mastery level score compared to students enrolled in the agriculture course one year after the educational intervention.

Student Engagement

Students in both Groups agreed that the information they learned during the intervention would be useful to them (PD: 4.09, EL: 4.20) and that they would be able to apply the knowledge and skills they learned when preparing food (PD: 4.07, EL: 4.12), Table 4.4. Agriculture students were the most interested (3.55) in taking more classes related to food safety. The PD Group and the EL Group were relatively likely to recommend the food safety course in which they participated to their friends (PD: 3.74, EL: 3.90).

Table 4.4. Student evaluation of the course in which they were enrolled

Learning Format	PD Group (N=41)	EL Group (N=47)	Microbiology Students (N=59)	Agriculture Students (N=29)	Total (N=88)
The information is useful to me.	4.09 ± 0.84	4.20 ± 0.76	4.16 ± 0.82	4.13 ± 0.76	4.15 ± 0.79
I can apply the knowledge and skills I learned.	4.07 ± 0.70	4.12 ± 0.70	4.11 ± 0.69	4.06 ± 0.73	4.10 ± 0.69
I am interested in taking more food safety classes.	3.33 ± 1.04	3.39 ± 0.93	3.26 ± 0.96	3.55 ± 0.99	3.36 ± 0.98
I would recommend taking this course to my friends.	3.74 ± 1.03	3.90 ± 0.90	3.87 ± 0.92	3.74 ± 1.03	3.83 ± 0.95

When students were presented with five common methods used in classrooms to disseminate information and asked to rate how much they liked each method, most students preferred hands-on activities (88%) followed by in-class discussions where students can share their thoughts and ideas (60%) and role-playing (48%), Figure 4.2.

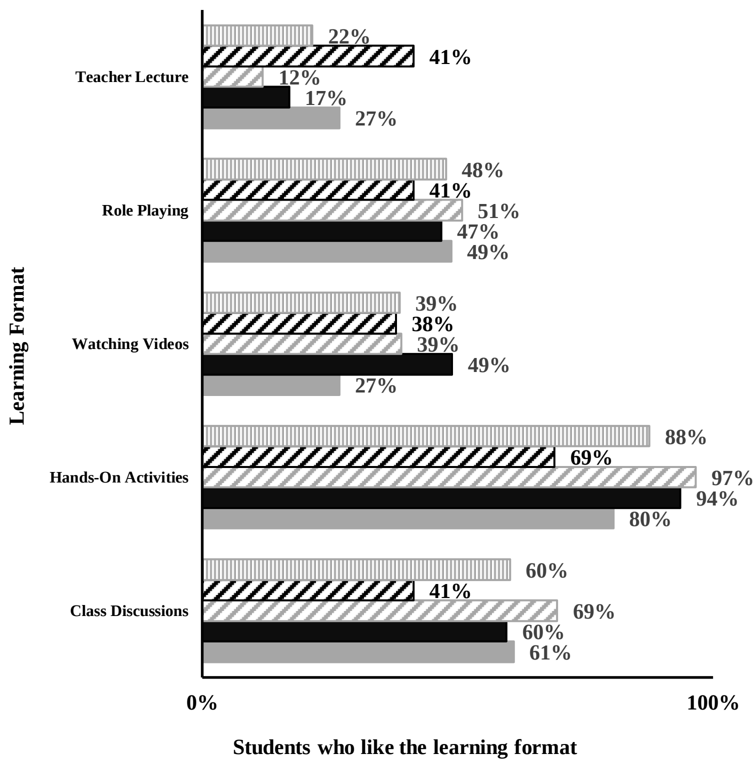


Figure 4.2. Student feedback related to how they used the food safety knowledge and skills they learned within the past year

Students reported behavior changes following the educational intervention, Table 4.5. Students described improved cleaning practices that included washing their hands more thoroughly, washing their produce, and cleaning and sanitizing surfaces. Students avoided cross-contamination from meat while shopping at the grocery store and by rearranging their home refrigerators. Three students reported using cooking thermometers when preparing food, and another student mentioned purchasing a cooking thermometer. More students began cooking after the educational intervention. One student reported that cooking his/her own food made him/her feel healthier, and other students reported trying to make healthier food choices. Four students mentioned sharing the food safety information they learned in the course with their parents to motivate their parents to practice safe food-handling. One student who was employed in the food service industry expressed how he/she used practiced safe food-handling at work.

> "I worked at Christie's on the Square, so I used the skills I learned to properly handle customers' food," stated a Microbiology Student in the EL Group.

4.4 Discussion

Student risk-perception and perceived behavioral control in both intervention groups continued to increase overtime, whereas knowledge began to attenuate one year after the intervention. In the Theory of Planned Behavior (TPB), risk-perception, perceived behavioral control, and subjective norms influence behavior intentions, and behavior intentions predict performed behaviors (Ajzen, 1991). In this study, subjective norms are individuals who students consider important and whose opinions they value. Subjective norms can include their peers, instructors, and parents. Findings from this study support the posits of the TPB model. Increased risk-perception and perceived behavioral control among students influenced students' self-reported food-handling behaviors in the year following the educational intervention. Students reported performing safer food-handling behaviors at home including cleaning, sanitizing, cross-contamination prevention, and improved food storage despite attenuating knowledge scores Findings from an observational study of high school students' food-handling behaviors suggested that parents, members of students' subjective norms, influenced what food-handling behaviors students viewed as safe (Tressie Barrett & Feng). In the present study, students reported they shared food safety information with their parents. No data was collected in this study to determine if students' food-handling recommendations to their parents changed their parents' food-handling behaviors. However, it is possible that student-parent relationships were altered such that students became part of their parents' food safety subjective norm. Few, if any, studies have evaluated youths' views of food safety and the corresponding influence on their parents' food-handling behaviors. Understanding potential changes in student-parent subjective norm relationships elicited by students' participation in food safety educational interventions could be key in understanding the sustainability of students' food safety risk-perceptions, perceived behavioral control, and ultimately, food-handling behaviors.

Prior to the intervention, the average knowledge score of each cohort was below the 75% mastery-level. Overall, students were the least familiar with concepts related to safely choosing and cooking food prior to the intervention. This reflects the findings from a longitudinal study of high school students' food safety knowledge and attitudes which indicated the majority of students did not know correct cooking temperatures (Majowicz et al., 2017). Students' lack of regular participation in food-handling activities within the home could attribute to this lack of knowledge. In the present study, many students indicated that their parents or guardians were the priamary meal preparers. Two of the main barriers parents identified for including youth in home food preparation were time constraints and youths' safety. However, experience handling food could be an important link to food safety knowledge acquisition and maintenance. A study by Sanlier (2009) found that adults and individuals with more food-handling experience are more knowledgeable about food safety than youths (Sanlier, 2009). In this study, youths were not asked whether they had received food safety education or training prior to the educational intervention nor were they asked about the types of food-handling activities in which they are engaged. Collecting this data in future research will enhance researchers' understanding of the relationship between food-handling experience and knowledge gaps among youths. This will serve as a guide for developing curriculum or food-handlers' training specific to youths' food-handling experience level. Diplock et al. (2019) suggested that food safety education should be designed to address the regularly practiced food-handling behaviors of students rather than teaching broad, generalized food safety concepts (Diplock et al., 2019).

Both Groups demonstrated a significant knowledge increase in the correct recommended endpoint cooking temperature for ground beef, and the EL Group significantly increased their knowledge of the of the correct endpoint temperature for chicken immediately following the intervention. These results could be attributed to applicability of the knowledge to the students' food-handling practices. During the study, students were asked to prepare a hamburger dish prior to and post receiving the food safety educational intervention. This activity necessitated that students use a cooking thermometer to measure the endpoint temperature to ensure their food was thoroughly cooked. Students were not asked to prepare a chicken-based dish, and therefore, did not have to directly apply the information they learned during the educational intervention sessions. Active learning activities that require students to apply their knowledge to real-life situations have exhibited improved effectiveness of students' knowledge retention post educational intervention compared to traditional teaching methods (Emke et al., 2016). However, as reflected in the present study, the benefits of active learning techniques diminished overtime as students' knowledge attenuated without further practice. On the follow-up survey, students' knowledge of the recommended

Table 4.5. Student feedback related to how they used the food safety knowledge and skills they learned within the past year

Student Feedback	Curricula and Course in which Student Participated
Risk Perception	
I have learned to cook my meats better from this experience after understanding temperature (temperature) and cross-contamination	EL Group, Microbiology Students
I used these lessons in my life to be more aware of where my food is placed, prepared, and bought. I am also more aware of how my food is prepared.	EL Group, Microbiology Students
Perceived Behavioral Control	
I was able to incorporate some of my learning into my health. When I help my mom cook I have more of an idea how to keep things clean and always remember to clean up after.**	EL Group, Microbiology Students
I know a lot more about food safety and how to prepare food at home. I now know the correct temperatures to cook food to, and how to prevent cross-contamination. I have used these skills when cooking in the last year.	PD Group, Microbiology Students
This course helped me pay closer attention to cross-contamination, since this course I would say cross-contamination in my kitchen has decreased.	PD Group, Microbiology Students
I learned where to store my food and be careful and on watch of cross-contamination. I even stop my parents before they get cross-contamination in our own household. I will now know how to be careful and to always clean in the cooking area.*	EL Group, Microbiology Students
I can cook more things than before and do it safely.	PD Group, Agriculture Students
I cook and clean for myself more now that I am older and I learned how to do it the safe way	PD Group, Agriculture Students
Subjective Norms	
I was able to share this information with my step-dad, who does the main cooking in our house.	PD Group, Microbiology Students
I helped my mother cook and used the skills I learned.	PD Group, Microbiology Students
I do not really cook as much as my mom but once we did this I went to my parents and told them all the safety things for food.	PD Group, Microbiology Students
I used the information and skills by organizing my fridge for my family and also helping my mom with the facts I was given.	EL Group, Microbiology Students
Behavior Intention	
I always tried to be very clean when cooking food.	EL Group, Agriculture Students

Table 4.5 (Continued)

I have learned to cook better and how to keep the kitchen clean whilst cooking	EL Group, Agriculture Students
I learned to properly clean the workplace, and keep food from cross contaminating	EL Group, Agriculture Students
I've tried to make sure I wash my hands before messing with food. I also try to make sure things can't cross-contaminate with each other while being in the fridge or freezer.	EL Group, Microbiology Students
I know how to keep my food safe. I know how to check and make sure I don't cross contaminate things that I have to eat. I also know how long meat should be cooked properly.	EL Group, Microbiology Students
I bought a food thermometer.	EL Group, Microbiology Students
I learned how to check the temperature of food and the best possible way to avoid contaminating it.	EL Group, Microbiology Students
I tried to eat healthy over the summer.	EL Group, Microbiology Students
Performed Behavior	
I washed my hands more thoroughly.	PD Group, Microbiology Students
I washed my hands more often to get rid of the germs.	PD Group, Agriculture Students
I washed my hands more thoroughly before helping prepare dinner.	EL Group, Microbiology Students
I always dry my hands with paper towels after learning about that in the course. I also pay attention to cross-contamination.	EL Group, Microbiology Students
I wash the fruits and vegetables better	EL Group, Microbiology Students
I've started to wash more of my produce.	EL Group, Microbiology Students
I am more careful when I prepare food. I used to not wash my produce sometimes, but I always do it now to ensure my safety.**	PD Group, Microbiology Students
I now wash all of my fruit, even though I mostly did before and I typically inform people that air dryers are less safe than paper towels, despite the environmental safety of the air dryer.	PD Group, Microbiology Students
I clean a lot better when I cook now.	EL Group, Agriculture Students
I sanitize more surfaces when cooking.	EL Group, Microbiology Students
I have used the cross-contamination material the most in my everyday life, when preparing food and buying meat from the store.	PD Group, Microbiology Students
I use thermometers whenever I cook now. I also know how to properly wash my hands and keep my station clean.	PD Group, Microbiology Students

Table 4.5 (Continued)

Use the proper temperature checking and cooking methods with my mom in the kitchen when I help her in the kitchen.	EL Group, Microbiology Students
I help my grandma cook more now.	EL Group, Microbiology Students
I have started cooking more at home and have been improving health habits around the house.	EL Group, Microbiology Students
I have started making meals more as I want to learn more about actually making the food.	EL Group, Microbiology Students
I cooked a lot more I cooked sausage and deer a lot this year instead of running to a fast food place and picking something up it made me healthier.	PD Group, Microbiology Students
Yes, I work in fast food, so we use the gloves and the meat thermometer, and the cross-contamination.	EL Group, Microbiology Students
I worked at Christie's on the Square, so I used the skills I learned to properly handle customers' food.	EL Group, Microbiology Students

**Also classified as a performed behavior endpoint temperature for ground beef significantly decreased and was within eight percentage points of the knowledge retention score for the recommended endpoint temperature for chicken. One explanation for the significant decrease in students' knowledge retention could be lack of needing to recall the information. After the intervention, students were not asked to use the information they learned in the classroom. Additionally, on the follow-up-survey, many students reported their parents were the primary meal preparer, indicating students would also not need to recall this information at home. Research suggests that long-term knowledge retention is enhanced with continued utilization of the knowledge at various time intervals compared to knowledge utilization that occurs repeatedly for short-term (Kang, 2016). Recalling information builds neural pathways, which are essential for knowledge retention, and improves the routes that are used for during memory recall, leading to more efficient recall of that information (Brown, Roediger III, & McDaniel, 2014).

Recalling specific details has proved challenging for many food-handlers. Results from a food-handler survey that utilized fill-in-the-blank style questions found that no respondents could correctly identify recommended cooking times and temperatures on four separate questions (Palak K. Panchal, 2013). Utilization of teaching methods that focus more broadly on general food safety practices rather than specific details could improve long-term knowledge recall. Similar to recommended endpoint cooking temperate knowledge, students' pre-survey scores were low for questions related to hand drying and how to determine if food is safely cooked. Students' knowledge retention for these questions significantly increased post intervention and was sustained over the course of one year. These questions required students to determine best practices from two or more choices rather than recalling a fact from memory as in the case of the endpoint recommendation temperature questions. While it is possible for students to correctly guess the answer to true/false and multiple choice questions, the high percentages of students who correctly answered these multiple-choice questions suggests that students were still able to apply the food safety concepts they learned to assess real-life scenarios one year after the intervention. Additional research is needed to better understand the contributing factors of food safety knowledge conversion into long-term memory.

Student engagement is a key factor in achieving learning outcomes. In the present study, student feedback indicated the ability to practice skills and interact with the instructor as well as peers were the most desirable learning formats. Students in both Groups preferred hands-on learning activities compared to all other presented learning formats and attributed hands-on learning to improved understanding of the presented material. A classroom instructor echoed the students' sentiments noting that hands-on learning experiences enhance students' "understanding of how things work" (Tressie Barrett, Wang, & Feng). Students also indicated they preferred learning formats that allowed social interaction with peers and instructors; students preferred discussions (60%) and role-playing (48%) compared to video-based teaching methods (39%) and standard lecture-style (22%). Hands-on learning and peer-interaction through cooperative learning have been demonstrated to be more effective at improving students' knowledge retention compared to individualized computerized learning and instructor lectures that are devoid of student-student engagement (Grechus & Brown, 2000; Tran, 2014).

In the present study, the PD model used relied extensively on student conversations with their peers and instructors to collectively achieve improved food safety knowledge, risk-perception, and perceived behavioral control outcomes. According to LeMahieu and colleagues, the PD model is most effective when the solutions are generated internally, where the individuals impacted by implementation of the new practices are decision-makers, rather than externally. Consequently, one crucial aspect of the PD model is that members of the group come to a general consensus with respect to the changes that will be implemented based on the behavioral information gained from positive deviants (LeMahieu et al., 2017). The PD model is highly sustainable because it facilitates the application of solutions already proven to work within the constraints of a given environment and encourages affected individuals to work together to achieve the desired outcome for the group (LeMahieu et al., 2017; Rose & McCullough, 2017). In the present study, students in the PD cohort demonstrated increased knowledge, risk-perception, and perceived behavioral control on the post- and follow-up-surveys compared to the pre-survey. These findings align with results from a recent study that concluded the PD model is effective at changing high school students' food safety knowledge and food-handling practices (Whited et al., 2019).

In EL teaching methods, students interact with their peers and instructor to solve challenges and answer questions. Kolb and Kolb asserted that learning is an integrated approach that allows adaptation to the world and defines learning as a process that generates knowledge through having and learning from experiences (A. Y. Kolb & Kolb, 2005). Simulations are an example of experiential learning and were used in the role-playing activities of the EL model used in this study. Simulations allow students to work together and the instructor to facilitate discussions of simulation outcomes. Simulations have been identified as a means to provide students with opportunities to explore challenges that commonly arise in the workplace that may otherwise be infeasible for students to experience and equip students to solve real-world problems (Gonczi, 2013; Rochester et al., 2012). In the present study, students in the EL cohort demonstrated significant knowledge change that was sustained one year following the educational intervention. Students' risk-perception and perceived behavioral control continued to increase overtime. Other studies using the EL model to present food safety and nutrition topics to students have resulted in improved knowledge, risk-perception, perceived behavioral control, and reported behavior changes (Taylor, Stumpos, Kerschbaum, & Inglehart, 2014; White, Sabourin, & Scallan, 2018).

Students enrolled in the microbiology course scored higher than students enrolled in the agriculture course on all three surveys. As indicated by the results from conducting binomial logarithmic regression analysis, the course in which students were enrolled was a significant predictor of whether students would achieve a mastery-level score on their post- and follow-up surveys. At the time of the study, no food-handling based courses were offered at the high school. Microbiology Students could have been exposed to topics related to food safety such as microorganisms and pathogens Agriculture Students did not encounter. Consequently, Microbiology Students could have greater potential for linking their previous knowledge to the food safety concepts disseminated through the educational intervention. Elaboration is a process that involves explaining how new information relates to information that is already known by the learner (Brown et al., 2014). Research has demonstrated that students are able to achieve deeper learning when they can link ideas or concepts they previously learned with new ideas and information, which enhances learning and improves knowledge retention (Brown et al., 2014; Granito & Chernobilsky, 2012; Liu, Grady, & Moscovitch, 2017; Xu & Shi, 2018).

Microbiology was also considered an honors-level course at the school where the study was conducted, whereas the agriculture course was not considered honors-level. While no data was collected regarding student giftedness, a higher concentration of gifted students enrolled in the honors microbiology course could account for discrepancies between knowledge gain and knowledge retention among students enrolled in the microbiology course compared to students enrolled in the agriculture course. Gifted students are typically highly proficient in acquiring knowledge and have an exceptional ability to retain information (National Society for the Gifted and Talented; Pennsylvania Association for Gifted Education & Pennsylvania State Education Association, October 2009; Singer, Sheffield, Freiman, & Brandl, 2016).

Students enrolled in the microbiology course also reported more significant changes in their risk-perception and perceived behavioral control overtime compared to students enrolled in the agriculture course. Openness to stimuli, like new ideas and information, is a common creative trait among gifted students (National Association for Gifted Children). This trait could have made students enrolled in the microbiology course more receptive to information related to foodborne illness risks and food treatment methods intended to improve food safety. Self-concept, or how students perceive themselves, has been linked to increased academic achievement among students (Huang, 2011). Peers, classroom instructors, and parents are Key Influencers who impact students' perception of their skills and value of the content being learned (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Bandura, Freeman, & Lightsey, 1999). Students personality traits, self-concept, and subjective norms could have a significant effect on students' willingness to actively practice and their perceptions of their ability to successfully perform the new skills they learned.

One key limitation in this study was the number of schools and students recruited. Data was collected from a single school; therefore, the results are not representative of the student population within the United States or Indiana. Nearly two-thirds of the students who participated in the study were enrolled in the microbiology course, which was considered an honors-level course by the school, while the remaining one-third were enrolled in an agriculture course, which was not considered an honors-level course by the school. There were more microbiology students than agriculture students who participated in the EL cohort, and vice-versa for the PD cohort. No data related to students' academic performance were collected. However, the imbalance in the number of students enrolled in an honors-level course compared to the number of students in a non-honors-level course could have impacted the evaluation of curricula effectiveness. Another study limitation was the questions used for evaluating instructor effectiveness in classroom implementation of the lessons. Students were asked to comment on the effectiveness of their instructor; however, student feedback included comments related to the effectiveness of the researcher who helped facilitate cooking activities that were part of both curricula. Therefore, students' ratings of instructor effectiveness were ambiguous as it was unclear whether students were evaluating their course instructors or the research team.

CHAPTER 5. EXPERIMENT IV: WEB-BASED SOURCES EVALUATION

5.1 Objectives

In order to enhance the understanding of potential risks and benefits to consumer health and safety, the objective of this study was to

1. evaluate the food safety messages and behaviors related to flour-handling, conveyed in blog recipes and YouTube videos.

5.2 Materials and Methods

Recipe Selection

At the time of the present study, no evaluations of food safety messages related to flour-handling in blogs and YouTube videos had been performed. Flour is a low-water-activity food that does not support pathogen growth; however, contaminated flour can be a source of foodborne illness (Syamaladevi et al., 2016). Flour contaminated or suspected to be contaminated with pathogens has incited 17 recalls since 2018 and has been responsible for multi-state foodborne illness outbreaks (Beecher, 2019; U.S. Food and Drug Administration, 2020) Many processes used to convert wheat into the flour sold to consumers do not involve steps to eliminate these pathogens because heat treatment methods increase production time and cost while altering the appearance and functionality of the flour (Beecher, 2019). As many consumers are unaware of the risks associated with handling raw flour (Feng, 2020), the FDA published consumer articles describing risks associated with raw flour and dough, emphasizing the importance of baking flour-based products, refraining from consuming raw dough, and following the manufacturers' instructions listed on packaged flour-based products (U.S. Food and Drug Administration, 2017, 2019a). The Centers for Disease Control and Prevention issued guidance for handling raw dough safely and warned consumers that raw flour can contain pathogens (U.S. Department of Agriculture, 2019). Manufacturers have also provided information on their websites and product labels to educate consumers on proper cleaning, handwashing, and flour-handling, including recommendations for using heat-treated flour (Ardent Mills; Flour; Pilsbury). Some manufactures have adopted heat treatment methods to reduce pathogen contamination risks (Beecher, 2019).

Three examples of flour-containing products were chosen for evaluation: cookie dough, cookies, and egg noodles. According to a recent study, cookie consumption has rapidly been increasing worldwide and has been touted as a preferable snack for youth (Shikha, 2018). Cookies are also ubiquitous in professional and home kitchens. Basic cookie recipes require minimal culinary skills, making them suitable for novice food-handlers, like youths. Cookie dough was chosen because it has been linked with foodborne illnesses and is a trending food-fad among U.S. consumers. Making egg noodles may require more time and culinary skill than either cookies or cookie dough, and they were consequently chosen to gain representation from food enthusiasts with more advanced culinary skill sets.

Blog Selection

Blogs were defined as online written web-content that displayed posted recipes frequently; the web content could be written by an individual or a larger entity, such as a food manufacturer (Morrison & Young, 2019). Blogs were selected using Alexa Internet to search top weblogs by category with the filters "Home" (19 sub-categories) and "Cooking" (59 sub-categories) (Morrison & Young, 2019). Five-hundred unique weblogs ranked by popularity were produced from the search, and of these, the top 17 weblogs were each searched for recipes using keyword searches (Archila, 2019; Morrison & Young, 2019). Cookie dough recipes were searched using a single keyword "cookie dough"; cookie recipes were searched using keywords "chocolate chip cookies," "sugar cookies," and "cookies"; and egg noodle recipes were searched using keywords "homemade" and "egg noodles" (Archila, 2019; Qiang, Wen, Jing, & Yue, 2011). Blogs generated from the keyword search were evaluated for compliance with three selection criteria: the blog recipes contained wheat flour, were written in English, and included the recipe for the corresponding product, either cookies, cookie dough, or egg noodles. From each of the 17 blogs, three different recipes were chosen for cookies, while a single recipe was chosen for cookie dough and egg noodles due to the low numbers of availability. A total of 51 recipes for cookies and 17 recipes for each cookie dough and egg noodles were selected for analysis. Recipes with the most consumer-interaction were selected for review. An exclusion criterion was added to the egg noodles to stipulate that the egg noodles must be "made from scratch" as many popular recipes called for dried egg noodles, which are widely available to consumers for purchase. The blog selection for cookie and cookie dough occurred during a two-month period between February and

March 2019. The egg noodle blog selection was completed in October 2019. The blogs were downloaded to preserve the content for consistent analysis.

Video Selection

YouTube was selected as the platform for video analysis due to the site's popularity. Content analyses of YouTube videos and comments were reported in previous studies about food and food safety topics (M. Li, Yan, Yang, Li, & Cui, 2019; Reddy et al., 2018; N. Zhang, 2016). In this study, videos were searched using keywords, and the resulting video lists were filtered by the number of views as a measure of video popularity. Cookies and cookie dough were searched using keywords "cookies" and "cookie dough," respectively. Egg noodles were searched using three sets of keywords and combinations thereof: "egg noodles," "recipes," and "homemade" (Qiang et al., 2011). Videos were screened by one researcher to ensure each video selected for analysis met the following inclusion criteria: the video was recorded in English or had English captions, wheat flour was used, eggs and flour was used (egg noodles only), the video had at least 200 views (egg noodles only), and the procedures were visually demonstrated. The viewership of egg noodle videos on YouTube was low; consequently, a minimum limit of 200 views was established as a selection criterion to ensure "high-impact" videos were analyzed. The top 50 viewed YouTube videos for cookies and cookie dough, and the top 46 viewed videos for egg noodles that met the selection criteria were selected for analysis. Two egg noodle videos were excluded from selection because no flour was used; these videos made alternative, nontraditional egg noodle recipes. A third egg noodle video was excluded as the link became invalid during the study period prior to downloading the videos. Cookie and cookie dough videos were searched over a two-month period from February to March 2019, and egg noodle videos were searched in June 2018. Videos were downloaded to preserve the content for consistent analysis.

Blog and Video Coding

Blog authors and video hosts were divided into two categories based on their experience levels: professional and nonprofessional. Researchers evaluated author and host experience using biographies to determine their level of cooking experience as well as visual clues, such as the use of professional kitchens and whether they wore uniforms. Professionals were defined as individuals who possessed culinary training, such as (former or current) chefs or restaurant employees. Nonprofessionals were defined as individuals who lacked formal culinary training, such as home cooks/bakers and untrained food enthusiasts.

A coding system was developed to assess the selected videos and blog recipes for general characteristics, user interactions, handling procedures, and food safety messages, including adherence to FDA- and USDA-recommended behaviors. Limited government-agency-published information is available related to cooking egg noodles, baking cookies, and preparing cookie dough. The Food and Drug Administration's (FDA) guidance for preparing flour-containing recipes to ensure safe consumption recommended baking cookies following the instructions listed on the packaged directions *(* U.S. Food and Drug Administration, 2019b*)*.

The coding system was adapted from previous blog/book content analyses (Levine, Chaifetz, & Chapman, 2017; Morrison & Young, 2019) and video content analyses (E. Rhoades, 2010; J. H. Yoo, 2012; Maughan et al., 2017; Woods, 2015). Specific information analyzed for each topic and the coding scheme for correct and incorrect behaviors is included in Table 5.1. The processing steps for making each product were reviewed, and researchers identified critical points where contamination was likely to occur. These points were included in the coding spreadsheet. Cross-contamination events resulting from direct contact with raw ingredients and hosts' contaminated hands were evaluated.

The coding system was input into a Microsoft Excel (Microsoft Corp., Redmond, WA, USA, 2016) spreadsheet to record quantitative and qualitative information. The occurrence frequency of each food-handling behavior and food safety message was recorded. Food-handling behaviors and food safety messages were classified into positive, negative, and neutral behaviors in alignment with FDA and USDA recommendations (Levine et al., 2017). The classification system used by Levine et al. was adapted to fit the scope of the products being reviewed. Actions or messages that aligned with FDA and USDA recommendations were considered positive, while those that contradicted current scientifically accepted behaviors were classified as negative. Actions or messages with mixed positive and negative information were considered neutral (Levine et al., 2017). For example, a neutral message could include the host making a positive statement that raw cookie dough should not be eaten, but then neglecting to perform proper handwashing after handling flour and prior to touching ready-to-eat foods. The list of actions and their corresponding classifications are included in Table 5.1.

Table 5.1. Topics reviewed and coded for food safety implications in videos and blogs

Overarching Category	Assessed Content	Food Safety Message Description
General Information	Video/blog identification	
	Posting date	
	Author	
	Host demographics	
	Host experience, gender, approximate age range, and ethnicity	
	User interaction	
	Number of subscribers	
	User-contributed comments	
	View count[V]	
	Rating frequency[V]	
	Approval rating (number of likes and dislikes)[V]	
	Video editing techniques[V]	
Handling Procedures	Flour handling	
	Flour storage	
	Sealed container marked with identification information for product recalls	Positive
	Original packaging that was properly sealed	Positive
	Heat treatment[CD]	
	Mentioning raw flour is not safe to consume	Positive
	Recommending unvalidated heat treatment methods	Negative
	Unintentional flour spreading	Negative
	Egg handling	
	Pasteurization	
	Mentioning the use of pasteurized eggs or egg products	Positive
	Egg shell disposal	
	Immediate disposal of shells in a waste receptacle or segregation of the shells from ready-to-eat food	Positive
Food Safety Messages	Cross-contamination	
	Flour and eggs separated from ready-to-eat foods	Positive
	Cross-contamination events from raw ingredients or unwashed hands	Negative
	Cleaning	
	Handwashing practices	
	Mentioning handwashing before food preparation	Positive

Table 5.1 (Continued)

Demonstrating or mentioning handwashing after handling raw ingredients	Positive
Environmental cleanliness	
Kitchen is visually clean	Positive
Demonstrating or mentioning cleaning work surfaces after they become contaminated	Positive
Sanitizing	
Demonstrating or mentioning sanitizing work surfaces after they become contaminated	Positive

V represents categories that were only coded for videos

CD represents categories that were only coded for cookie dough videos and blog

Researchers were trained and calibrated to use the coding system and to enter data into the spreadsheet. Two researchers reviewed and coded the videos and blog recipes, and a third researcher reconciled discrepancies between the first two reviewers using the following protocol. First, all videos and blog recipes were reviewed and coded by the first researcher. A second researcher independently reviewed five videos and five blog recipes using the coding systems. The results from the first and second coding rounds were reviewed for consistency by comparing the double-coded videos and blog recipes. Discrepancies between the researchers' coding were addressed. After recalibration, the five videos and blog recipes were re-recoded to address discrepancies, as required. By using a blind review method, the second researcher finished the second round of coding for the videos and blog recipes. A third trained researcher reviewed and resolved any final discrepancies between the coding results of the first and second researcher.

Data Analysis

The blog recipes and videos were analyzed qualitatively and quantitatively. IBM SPSS Statistics for Windows (Version 25.0. Armonk, NY: IBM Corp.) was used to conduct a descriptive analysis of the frequencies of recorded food-handling procedures and food safety messages. Qualitative assessment of the videos and blog recipes was used to classify food-handling behaviors and food safety messages into categories of positive, negative, or neutral based on the sum of the food-handling behaviors and food safety messages within each blog recipe and video (Levine et al., 2017).

5.3 Results

Fifty-one cookie recipes and 17 cookie dough and egg noodle recipes were analyzed from the 17 most popular blog sites. Nonprofessionals contributed most of the egg noodle blog recipes (88%) and half of the cookie blog recipes (55%) and cookie dough blog recipes (53%). Females were the most common authors of egg noodle (47%), cookie (49%), and cookie dough (65%) recipes, Table 5.2.

In total, 146 videos were reviewed for egg noodles (N=46), cookies (N=50), and cookie dough (N=50). Most videos were contributed by nonprofessionals across all three recipe categories: egg noodles (78%), cookies (84%), and cookie dough (92%). Females were the most frequent video host for each recipe: egg noodles (78%), cookies (68%), and cookie dough (68%). The majority of egg noodle videos were unedited (74%), while scene cuts were most common in cookies (76%) and cookie dough (98%), Table 5.2.

Table 5.2. Blog author and video host demographics

	Egg Noodle Videos (N=46) % (Number)	Cookie Videos (N=50) % (Number)	Cookie Dough Videos (N=50) % (Number)	Egg Noodle Blogs (N=17) % (Number)	Cookie Blogs (N=51) % (Number)	Cookie Dough Blogs (N=17) % (Number)
Experience						
Professional	18 (8)	16 (8)	8 (4)	12 (2)	37 (19)	41 (7)
Consumer	78 (35)	84 (42)	92 (46)	88 (15)	55 (28)	53 (9)
Gender						
Male	11 (5)	12 (6)	18 (9)	29 (5)	12 (6)	6 (1)
Female	78 (35)	68 (34)	68 (34)	47 (8)	49 (25)	59 (10)
Both	2 (1)	18 (9)	10 (5)	0 (0)	12 (6)	12 (2)

In egg noodle recipes, all blog authors (76%) and video hosts (78%) who included cooking instructions mentioned that egg noodles should be cooked in boiling liquid, such as water or chicken broth. In blog recipes and videos, recommendations for determining doneness included time (blog recipes: 18%, videos: 33%), the subjective indicator of pasta firmness (blog recipes: 6%, videos: 11%), or a combination of both (Blog recipes: 35%, Videos: 1%). All of these indicators were coded as correct. One video included pasta tasting as a subjective indicator of doneness, which was coded as incorrect. Recommended cooking times varied widely across recipes. Blog recipes' recommended cooking times for pasta ranged from 12–15 minutes to 10 seconds for "paper-thin" pasta (thickness of 0.06 inches). Video hosts provided an even greater range of recommended cooking times from as few as 30 seconds to 20–30 minutes.

On blog recipes (98%) and videos (92%), nearly all cookie recipes described baking time and oven temperature recommendations for baking cookies. These were coded as correct indicators of doneness. Only one recipe from a blog included an oven temperature without a baking time. Subjective indicators, such as color and texture, were mentioned in 63% of blog recipes and 20% of video recipes. Blog recipes and videos cited the subjective indicator of color (blog recipes: 61%, videos: 20%) as an indicator of doneness, while only blog recipes cited the subjective indicator of texture (18%). One blog recipe recommended baking the cookies until the edges were brown and crispy, and the cookie's center was raw.

Only a small percentage of blog recipes (24%) and videos (18%) recommended heat treating flour, Table 5.3. Most blog authors (75%) and video hosts (100%) who provided heat treatment

Table 5.3. Flour- and egg-handling behaviors observed in blog recipes and YouTube videos

	Egg Noodle Videos (N=46) % (Number)	Cookie Videos (N=50) % (Number)	Cookie Dough Videos (N=50) % (Number)	Egg Noodle Blogs (N=17) % (Number)	Cookies Blogs (N=51) % (Number)	Cookie Dough Blogs (N=17) % (Number)
Flour storage						
Sealed container	22 (10)	8 (4)	6 (3)	-	-	-
Original package	13 (6)	4 (2)	6 (3)	-	-	-
Unknown	11 (24)	88 (44)	88 (44)	-	-	-
Flour is heat treated						
Yes						
Bake the flour	-	-	10 (5)	-	-	12 (2)
Unspecified heat treatment	-	-	2 (1)	-	-	0 (0)
Microwave the flour	-	-	6 (3)	-	-	12 (2)
No	-	-	82 (41)	-	-	76 (13)
Unintentional flour spread, transferring						
Yes, using				-	-	-
measuring cup/similar utensil	26 (12)	30 (15)	18 (9)	-	-	-
sifter	0 (0)	6 (3)	6 (3)	-	-	-
No unintentional flour spreading	48 (22)	58 (29)	76 (38)	-	-	-
Unintentional flour spread, mixing						
Yes	24 (11)	22 (11)	32 (16)	-	-	-
No	50 (23)	58 (29)	62 (31)	-	-	-
Flour is on host's clothing						
Yes	4 (2)	8 (4)	2 (1)	-	-	-
No	37 (23)	32 (16)	76 (38)	-	-	-

Table 5.3 (Continued)

Recipe used eggs						
Yes	100 (46)	100 (50)	14 (7)	100 (17)	90 (46)	12 (2)
No	0 (0)	0 (0)	86 (43)	0 (0)	10 (5)	88 (15)
Pasteurized eggs mentioned						
Yes	0 (0)	0 (0)	10 (5)	0 (0)	0 (0)	6 (1)
No	100 (46)	100 (50)	90 (45)	100 (17)	100 (51)	0 (0)
Cracked eggshell disposal						
Immediate disposal in trash	11 (5)	0 (0)	-	-	-	-
Placed on a plate or in a bowl	7 (3)	6 (3)	-	-	-	-
Placed back in container	2 (1)	0 (0)	-	-	-	-
Placed in sink	2 (1)	0 (0)	-	-	-	-
Placed on counter	7 (3)	0 (0)	-	-	-	-

recommendations were nonprofessionals. The most commonly mentioned heat treatment methods were baking flour in the oven (50% of blog recipes, 56% videos) and microwaving flour (50% of blog recipes, 33% of videos). Among blog recipes, one recipe recommended heating the flour to 165°F, and another recipe stated flour should be heated to 180°F. Hosts in four videos mentioned heating flour to 160°F. Of the recipes that mentioned heat treating flour, only one blog recipe solely relied on color to determine if the flour was safe to use. Among recipes that did not mention heat treating flour, one blog recipe included a cautionary statement from the editor indicating that raw flour consumption may cause foodborne illness. Eighty-eight percent of cookie recipes did not contain eggs or stated that eggs could cause foodborne illness, and another 6% used a pasteurized egg product.

Video hosts unintentionally spread flour while they were transferring flour from the flour container to the mixing bowl during egg noodle (26%), cookie (30%), and cookie dough (18%) preparation, Table 5.3. Sifting flour for cookies (6%) and cookie dough (6%) recipes also resulted in video hosts unintentionally spreading flour onto work surfaces. Unintentional flour-spreading occurred during the mixing step of preparing egg noodles (24%), cookies (22%), and cookie dough (32%). Video hosts who handled eggs during the video were less likely to cross-contaminate surfaces with eggs than with flour. Only video hosts preparing egg noodles were recorded as disposing of eggshells improperly. Among egg noodle hosts, 2% placed eggs in the sink, and 7% placed eggs on the counter, Table 5.4.

None of the blog recipes or videos mentioned handwashing before preparing the recipes or after handling raw flour or eggs, Table 5.4. Two percent of blog recipes stated that the work surface should be clean prior to preparing food. However, the blog recipes did provide instructions on how to clean work surfaces. Surfaces were cleaned after contacting flour in 4% of cookie videos. During the video, hosts in two percent of egg noodle and cookie videos cleaned surfaces contacted by egg. Recommendations for sanitizing surfaces after exposure to raw flour or raw egg were absent in all blog recipes and videos.

Table 5.4. Cleaning, cross-contamination, and sanitizing practices observed or mentioned in blogs and YouTube videos

	Egg Noodle Videos (N=46) % (Number)	Cookie Videos (N=50) % (Number)	Cookie Dough Videos (N=50) % (Number)	Egg Noodle Blogs (N=17) % (Number)	Cookies Blogs (N=51) % (Number)	Cookie Dough Blogs (N=17) % (Number)
Cleaning						
Kitchen was visually clean	78 (36)	56 (28)	72 (36)	-	-	-
Flour-Handling						
Hands were washed post handling flour						
Yes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0(0)
No	33 (15)	40 (20)	94 (47)	100 (17)	51 (100)	17 (100)
Cleaned surfaces that flour contacted						
Yes	0 (0)	4 (2)	0 (0)	6 (1)	0 (0)	0 (17)
No	24 (11)	54 (27)	88 (44)	94 (16)	100 (150)	100 (17)
Egg-Handling						
Hand washing after handling egg						
Yes	0 (0)	0 (0)	-	0 (0)	0 (0)	0(0)
No	41 (19)	4 (2)	-	100 (17)	100 (51)	100 (17)
Cleaned surfaces that egg contacted						
Yes	2 (1)	2 (1)	-	0 (0)	0 (0)	0 (0)
No	15 (7)	0 (0)	-	100 (17)	100 (51)	100 (17)
Cross-contamination						
Number of videos with ≥2 cross-contamination events	28 (13)	76 (38)	16 (8)	-	-	-
Number of videos with no cross-contamination events	59 (27)	6 (3)	6 (3)	-	-	-
Sanitizing						
Shown	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mentioned	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Cross-contamination prevention activities, such as cleaning utensils, were mentioned in 2% of blog recipes: once in an egg-noodle blog recipe and once in a cookie blog recipe. However, one of the cleaning recommendations was to wipe off a spoon used in raw cookie dough before using the spoon in the ready-to-eat product, which was recorded as incorrect. In videos, the number of egg noodle videos (59%) that demonstrated no cross-contamination events was notably higher than the number of cookie (6%) and cookie dough (6%) videos that showed no cross-contamination events, Table 5.4. In all three video categories, kitchen tools were the most frequently cross-contaminated item, Figure 5.1.

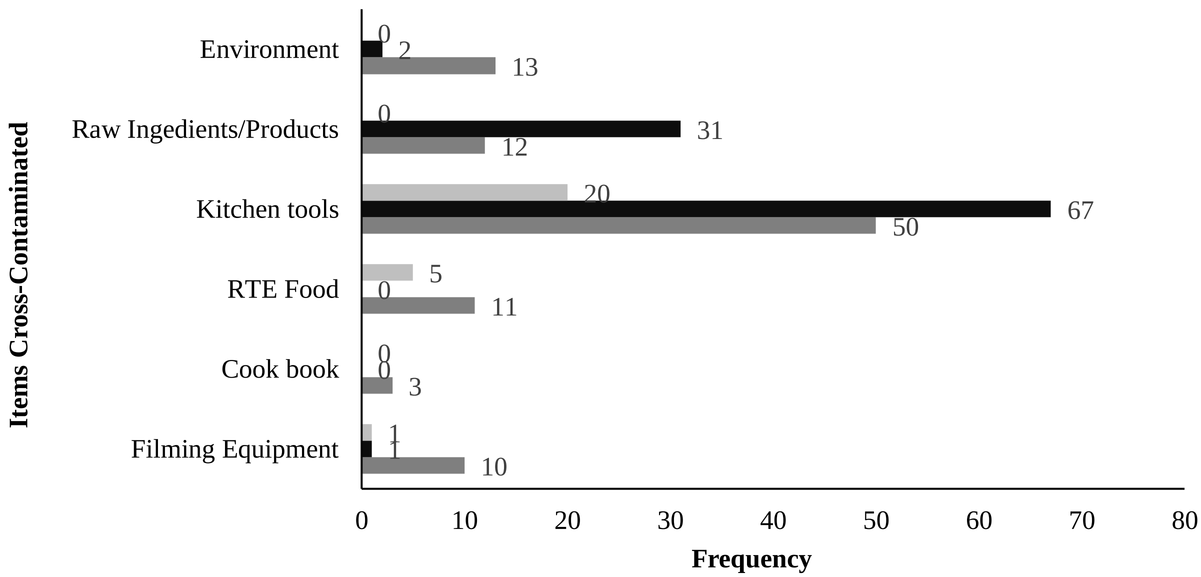


Figure 5.1 Observed cross-contamination events in YouTube videos. The light grey bars correspond to observations in cookie dough YouTube videos. Black bars correspond to observations in cookie YouTube videos. Dark grey bars correspond to observations in egg noodle YouTube videos. Cross-contamination was defined as raw flour, raw shell eggs, or hosts' contaminated hands contacting surfaces, kitchen utensils and equipment, or other ingredients. Kitchen tools had the highest frequency of being cross-contaminated.

Egg noodle and cookie recipes each had unique food-handling steps that could pose a risk to consumer health. Egg noodle recipes in blogs (47%) and videos (33%) included drying steps. Of the recipes that included drying-steps, blog recipes (13%) and videos (7%) recommended using clothing hangers. Blog authors also recommended hanging egg noodles over chair backs (25%), while video authors mentioned spreading the egg noodles across newspaper to dry (13%). In cookie recipes, raw dough consumption could lead to foodborne illness. No authors of cookie blog recipes mentioned eating raw cookie dough. However, 8% of video hosts mentioned eating raw cookie dough, and 2% of hosts consumed raw dough.

Overall, the food safety messages provided in blog recipes were positive, while videos presented a mix of positive and negative food safety messages. The only negative messages noted were the authors' recommendations to use unvalidated scientific methods to convert raw flour into ready-to-eat flour. The majority of food safety messages and food-handling behaviors communicated to consumers were positive. However, hosts were observed mishandling raw ingredients. Overall, there was one negative communication for every three positive communications in videos.

5.4 Discussion

Consumers often seek cooking advice from web-based recipes. They model what they learn from those recipes, including food-handling behaviors (Woods, 2015). Few studies have solely focused on evaluating food safety messages in popular web-based sources, such as recipes featured in blogs and on YouTube, although a few studies have evaluated food-handling in television shows. (Maughan et al., 2017; Morrison & Young, 2019; Woods, 2015). This study is the first to review flour-based recipes for food safety messages, especially messages related to flour and flour-handling practices.

Popular blog and video recipes for egg noodles, cookies, and cookie dough demonstrated a lack of general food safety information, such as recommendations for hand hygiene. No recommendations were made for consumers to wash their hands prior to meal preparation. The findings were consistent with a study by Morrison and Young (2019), who documented only one blog out of 784 that recommended handwashing prior to meal preparation. The present study reflects findings from recent studies that evaluated the food-handling behaviors of professional chefs and consumers. Two studies that reviewed professional chefs' food-handling behavior found that handwashing was omitted in 98% (N=59) of episodes, and chefs did not comply with recommended handwashing practices in 93% (N=39) of episodes (Cohen & Olson, 2016; Woods, 2015).

Most hosts in videos demonstrated techniques that caused cross-contamination, and there was no significant difference in the food-handling behaviors between professional and nonprofessional hosts. Previous observational studies of professional food-handlers such as celebrity chefs produced similar findings. In a study that reviewed 100 television shows featuring celebrity chefs, 88% of chefs did not follow, or were not shown following, handwashing recommendations after handling high-risk ingredients (Maughan et al., 2017). Other practices that reduce the risk of cross-contamination, including cleaning and sanitizing surfaces that were contacted by raw eggs or raw flour, were infrequently mentioned or demonstrated in blog recipes and videos. A similar frequency of recommendations for cleaning and sanitizing surfaces was observed by Morrison and Young (2019), who noted only one blog that mentioned cleaning and one that mentioned sanitizing.

A recent study examining adherence to recommend food-handling behaviors demonstrated that consumers who received recipes with embedded safe food-handling steps significantly outperformed consumers who received recipes containing no food safety information (Maughan, Godwin, Chambers, & Chambers IV, 2016). Along this line of research, the Partnership for Food Safety Education launched a recipe-style guide in 2019. The guide includes sample food safety prompts related to the core-four practices of cleaning, chilling, cooking, and separating that recipe writers can include to promote consumers' adherence to recommended safe food-handling behaviors (Education). Including food safety information in recipes to prompt consumers to follow recommended hand-hygiene practices prior to meal preparation and after touching raw ingredients, such as shell eggs and flour, could improve consumers' food-handling behaviors. Additional research is needed to determine if consumers following recipes found in blogs or videos will produce similar improvements in consumers' adherence to recommended safe food-handling behaviors described in prior research (Maughan et al., 2016).

Blog authors and video hosts may be viewed by consumers as role models and could influence consumers' food-handling behaviors. Results from surveys and focus groups indicated that consumers approve of celebrity chefs' food-handling behaviors and perform the behaviors demonstrated by these chefs (Woods, 2015). In the present study, the video hosts in the most popular videos had millions of subscribers to their channels; the host of the most popular video had 19 million subscribers. The number of consumers following blog authors was not available for many of the top blogs reviewed. However, popular blogs can attract nearly 5 million visitors each month (Morrison & Young, 2019). Consumers who follow blog authors and video hosts may begin to emulate the food-handling behaviors described or demonstrated in blog recipes and videos. Further research should be conducted to understand the influence blog authors and video hosts have on consumers' perception of acceptable food-handling behaviors and their performed behaviors.

Findings from this study indicated that consumers were highly aware of food safety risks related to eggs, but consumers were less aware of the food safety risks associated with flour. These findings are consistent with a recent survey of the public that was designed to be representative of the U.S. population. Researchers found that consumer awareness of flour-related food safety risks was lower than consumer awareness of the food safety risks associated with eggs (Feng, 2020). It is unsurprising, then, that blog author and video-host food-safety risk awareness was most evident in cookie dough recipes. In cookie dough recipes, eggs were omitted from almost all recipes, or pasteurized eggs were used. Conversely, around a quarter of blog recipes and a fifth of videos mentioned food safety risks associated with flour. These findings point to the critical need for effective food safety campaigns directed at raising consumer awareness of risks related to handling and consuming raw flour.

Consumers' awareness of egg-associated food safety risks may be heightened due to the prevalence of recalls (Y. Chen & Timmins, 2018; T. Li, Bernard, Johnston, Messer, & Kaiser, 2017). These outbreaks prompted the promotion of safe food-handling techniques through labels describing appropriate storage conditions and cooking instructions as mandated by 21 CFR 101.17(h) (Food and Drug Administration, 2019). At the producer level, the FDA set forth requirements to reduce the risk of *Salmonella* Enteritidis on farms and during transportation (U.S. Food and Drug Administration, 2009). Similarly, recent pathogen-related outbreaks in several flour brands' products could promote consumer awareness of food safety risks connected to raw flour. In a 2018 newsletter, Dr. Acheson, a former FDA Associate Commissioner for Foods, predicted that regulations would eventually reflect the growing number of recalls resulting and consumers' treating raw flour as a ready-to-eat product. In the newsletter, Dr. Acheson pointed out that the Canadian government has already begun advising consumers to handle raw flour with the same precautions they would use to prepare raw poultry (The Acheson Group, 2018). The U.S. Department of Health and Human Services has issued flour-handling recommendations, and some brands of flour have cautionary statements notifying consumers of food safety risks associated with consuming raw flour (Ardent Mills, 2019; North American Miller's Association, 2017). However, there are currently no federal regulations in the U.S. requiring raw flour intended for consumer use to be labeled with safe flour-handling information.

Raising consumer awareness of the risks associated with raw flour may not be sufficient to change flour-handling behaviors. As previously mentioned, blog authors and video hosts were significantly more aware of the food safety risks associated with raw shell eggs than risks associated with raw flour. Increased consumer awareness of the risks associated with raw shell eggs did translate into significant behavior differences in egg-handling compared to raw-flour-handling. Handwashing was not observed for hosts handling raw flour or raw shell eggs in any of the videos, and less than 5% of hosts handling flour or eggs promoted cleaning kitchen surfaces. This aligns with several previously conducted studies that demonstrated that consumers' food safety knowledge does not always translate into practicing recommended food-handling behaviors (Al-Shabib, Mosilhey, & Husain, 2016; Bassyouni, El-Sherbiny, Hefzy, & Wegdan, 2012; Buccheri et al., 2010; Vo, Le, Le, Minh, & Nuorti, 2015; H. Zhang, Lu, Liang, & Huang, 2015). The only exception was video hosts' prevention of environmental cross-contamination. Video hosts were eight times more likely to contaminate environmental surfaces with raw flour than they were with raw shell egg. This suggests that food safety interventions could be successful at changing consumers' interaction with raw ingredients during initial processing steps, such as ingredient addition. Food safety interventions need to be developed to translate awareness of food safety risks into practiced food-handling behaviors spanning process initiation to completion.

Videos and blog recipes presented a wide range of heat-treatment methods to render flour safe for direct consumption. Some sources provided only time and temperature recommendations or subjective indicators to measure if flour was safe to use. The blog recipes and videos that mentioned endpoint temperatures ranged from 160°F to 180°F. Blogs and videos did not specify a time for holding the flour at the recommended temperature to ensure the efficacy of the heat treatment. Heat treatment temperatures with endpoints below 165°F may be ineffective in decreasing the risk of foodborne illness from *Salmonella*, a pathogen that has incited flour recalls. Reaching a temperature of 165°F does not guarantee the elimination of the risk for developing foodborne illness from flour contaminated with *Salmonella*. Compared to high-water-activity-foods, low-water-activity foods can require 100 times as long to achieve a 6 log reduction in *Salmonella* (Bari et al., 2009; Chang, Han, Reyes-De-Corcuera, Powers, & Kang, 2010; Du, Abd, McCarthy, & Harris, 2010; Syamaladevi et al., 2016; Villa-Rojas et al., 2013). The thermal resistance of pathogens such as *Salmonella* changes as a function of a food's water activity; decreases in a food's water activity have been linked to increased *Salmonella* heat resistance (Archer, Jervis, Bird, & Gaze, 1998; Bari et al., 2009; Syamaladevi et al., 2016). There are currently no validation studies that support the home oven and microwave cooking methods or endpoint temperatures mentioned in blog recipes and videos.

In cookies and egg noodles baked or cooked before consumption, methods for determining doneness included subjective indicators like color and texture, which may not correlate with the food products reaching temperatures that could inactive pathogens. One blog recipe specifically mentioned the edges of the cookie should be golden brown, while the middle remained raw. This highlights that color changes generally associated with doneness in cookies does not guarantee the entire cookie is baked thoroughly. A generally accepted method for determining doneness of pasta and cookies is using a combination of time and temperature (U.S. Food and Drug Administration, 2019b). Consumers' reliance on time and temperature guidelines for cooking pasta and baking cookies could pose foodborne illness risks, however. Even when cookies are baked for the recommended time, variations in consumers' oven temperatures could result in internal temperatures of cookies failing to reach a temperature that can inactivate pathogens. Egg-noodle cooking instructions commonly recommended boiling the noodles in liquid for a certain amount of time. Boiling times provided in blog recipes and recipes may be inaccurate for consumers cooking at high altitudes, such as many locations in the western United States. In general, foods need to be boiled longer at higher altitudes. Consumers who do not adjust egg noodle-cooking times at high altitudes could be at increased risk for foodborne illness.

This study's findings demonstrated a need for scientifically validated methods for heat-treating flour at the manufacturer level or the consumer level. Many blog authors and video hosts treated flour as a ready-to-eat food even though not all flour available to consumers is ready-to-eat. Scientific research is currently underway to make sure that flour is heat-treated to generate ready-to-eat products and can be used as such by consumers (Roberts, 2018). As noted by Dr. Acheson, legislation requiring changes in flour manufacturing processes to provide consumers with ready-to-eat flour may require extended time to be enacted. Providing and popularizing validated methods for heat treatment methods that consumers could use at home may prove to be a viable alternative to flour that has been manufactured as a ready-to-eat product.

This study was carefully designed but still had limitations. The sample size of blog recipes and videos reviewed is small compared to the number of blog recipes and videos relative to the number of consumer-accessible food blogs and YouTube videos. Therefore, the food-handling behaviors described or observed in the blog recipes and videos may not be an accurate representation of food-handling behaviors in all blog recipes and videos. Another limitation was the lack of validated non-subjective methods for determining doneness of egg noodles, cookies, and cookie dough's heat-treated flour made it challenging to code the observed behaviors as correct or incorrect. A third limitation was the assessment of whether blog authors and video hosts were professionals or nonprofessionals. Researchers reviewed the profiles and environmental settings, when available, to assess the experience level of blog authors and video hosts. However, the use of this method may align with consumers' perceptions of blog authors and video hosts. The disproportion of professionals to nonprofessionals can generate inaccuracies in comparisons between the two groups.

Following are recommendations from the study findings.

1. Many blog authors and video hosts demonstrate a lack of risk awareness associated with handling raw flour. Authors and hosts making edible cookie dough were the most aware of raw flour-handling risks, which may be attributed to researching how to make cookie dough safe to consume. These findings point to the critical need to heighten public awareness of proper flour-handling behaviors to prevent foodborne illness.
2. This study demonstrates that campaigns focused on increasing consumer awareness of risks associated with raw ingredients have successfully increased consumer knowledge but have minimally impacted how consumers' handle these ingredients. Further research is needed to develop raw flour food safety campaigns capable of heightening consumer awareness and translating consumers' knowledge into consistently practiced behaviors. Exploring the role of web-based content, including blog recipes and videos on consumers' food-handling behaviors, could provide further insights into the best practices for developing and disseminating food safety content to consumers.
3. The relationship between blog authors' or video hosts' cooking expertise and food-safety message delivery is not well understood. Previous research highlights the need for intervention in television chefs' modeling of food-handling behaviors (Woods, 2015). The present study demonstrated that professionals and nonprofessionals model unsafe food-handling behaviors. The study also highlighted that nonprofessional authors and hosts were more likely to share raw-flour safety messages; however, the information they provided was not scientifically validated. Evaluation of the accuracy, frequency, and type of food safety messages delivered by professional and nonprofessional authors and hosts can guide

intervention strategies by identifying gaps in food safety knowledge and practiced behaviors. An understanding of which authors and hosts consumers are most likely to emulate could be provided by using big data analytical methods to analyze consumers' attitudes, opinions, and emotions related to specific blog recipes and videos. Opinion mining and sentiment analysis (OMSA) is a method being used to categorize and analyze consumers' feelings towards topics such as politics, healthcare, and service-providers using data sets from many web-based platforms, including Facebook, Twitter, and blogs (Shayaa et al., 2018). OMSA could be used to identify blog authors and video hosts who are most likely to influence consumer behavior and to develop food safety interventions targeted at these identified groups.

4. It may be impractical to train blog authors and video hosts to practice safe food-handling behaviors on the grand scale required to combat the ubiquity of food-related content conveyed to consumers. Therefore, other avenues of food safety message dissemination using popular media should be explored. For example, the use of brief food-safety advertisements demonstrating proper food-handling behaviors or promoting food safety awareness of high-risk products played between YouTube videos could be evaluated for effectiveness at changing consumers' knowledge and food-handling behaviors.

CHAPTER 6. CONCLUSIONS

Combining the findings from each experiment, I drew the following conclusions.

1. Subjective norms played a key role in shaping behavior changes during in-class learning and would likely play a similar role in learning experiences outside the classroom (Chapter 3-5).
2. In the classroom, students were influenced by the food-handling behaviors they saw modeled at home and cited methods their parents, who are Key Influencers, used when discussing how to cook food and tell when the food was safe to eat. Instructors were also Key Influencers or student behavior. Students responded to guidance from their instructors and changed their food handling behaviors to align with instructor recommendations (Chapter 3).
3. Peer-to-peer interactions demonstrated the fluidity of subjective norms; a student's thoughts and beliefs can be influenced by other students, but the student can also be a key influencer for the other students. Students began using their role as their peers' influencers and tried to affect behavior changes in others. Students who were more unsure of which behaviors were correct were more likely to be swayed by their peers than students who had strongly held beliefs (Chapter 3). This study demonstrated subjective norms between students and parents is also fluid. Students reported sharing the food safety knowledge they gained with their parents, indicating students were taking an active role in trying to influence their parents' food-handling behaviors (Chapter 4).
4. Imbalances in influencing power likely exist depending on the relationship between the individuals, Figure 6.1. Students' influencing power on changing their parents' food-handling behaviors may be weaker than their influencing power over their peers. Peer-to-peer relationships may be horizontal; students are socially on the same level. Whereas student-to-parent relationships may be more vertical as parents are at a higher social level than students. Therefore, parents exert more influencing power over the students than students exert over the parents. Students' influencing power over instructors is likely less than their influencing power over their parents. The relationship between students and instructors is again vertical, and students are less likely to have as strong of a social relationship with their instructors than with their parents. Consequently, instructor

influencing power over students is likely weaker compared to influencing power of students' parents.

5. In the case of web-based sources, students, or viewers, may never interact with authors or hosts. Even if viewers do interact with authors and hosts, their influencing power may be significantly diminished. Viewers may feel a connection to the author or host, which makes the author or host a powerful influencer over the viewers. However, authors and hosts of popular web-based content likely do not have a strong relationship with many of their viewers due to high viewership, which diminishes the influencing power of the viewer on the author or host.
6. Strong Key Influencers may be minimally influenced by individual youths or viewers; however, youths or viewers who hold the same beliefs could increase their influencing power by joining together, Figure 6.2. This collective influencing power could have greater influencing power than an individual's influencing power, Figure 6.3.
7. Influencing power imbalances, as in the case of authors or hosts compared to viewers, could make individuals with diminished influencing power more vulnerable to abandoning or incorrectly learning food-handling practices. This could be highly detrimental to youths' development of safe food-handling skills.

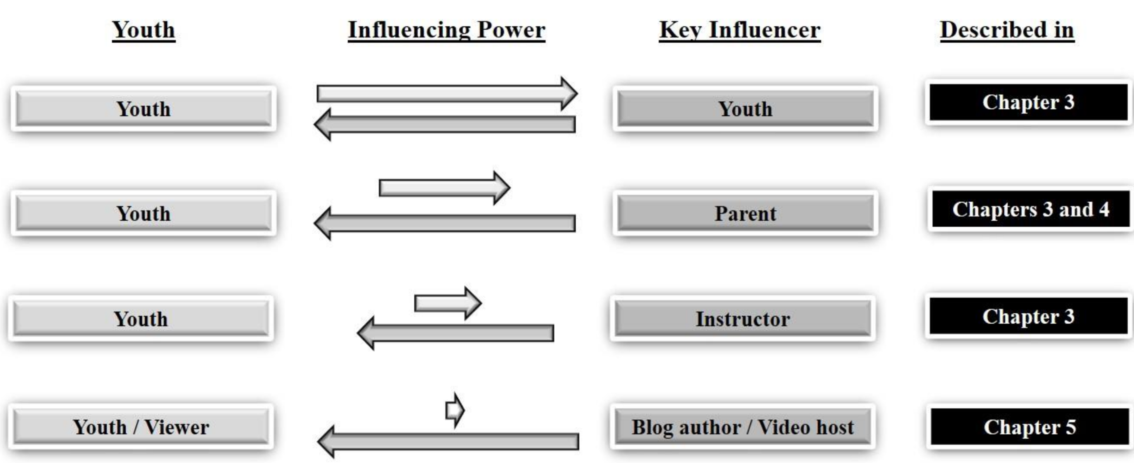


Figure 6.1. Representation of the influencing power between youths (left) and their Key Influencers (right). The arrows in the diagram are representative of each group's influencing power. Light grey arrows represent youths' influencing power, and dark grey arrows represent their Key Influencers' influencing power. Longer arrows indicate greater influencing power. There arrows are not necessarily drawn to scale.

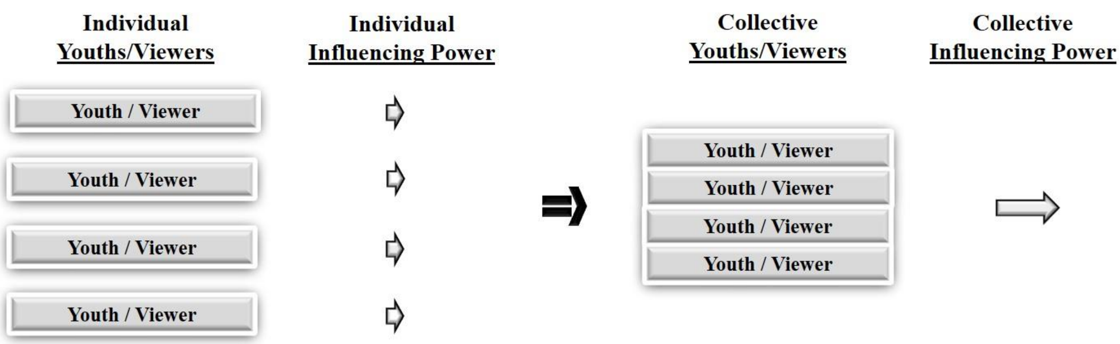


Figure 6.2. Representation of individual influencing power combined to generate collective influencing power. The arrows in the diagram are representative of each group's influencing power. Longer arrows indicate greater influencing power. There arrows are not necessarily drawn to scale.

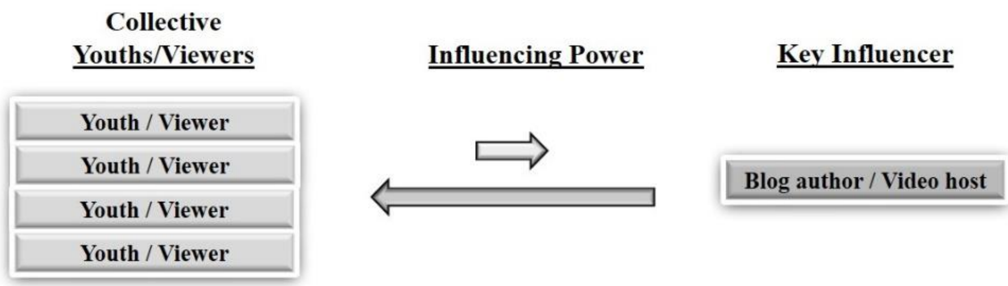


Figure 6.3. Representation of youths', or consumers', increased collective influencing power compared to their Key Influencers. The arrows in the diagram are representative of each group's influencing power. Light grey arrows represent youths', or consumers', influencing power, and dark grey arrows represent their Key Influencers' influencing power. Longer arrows indicate greater influencing power. There arrows are not necessarily drawn to scale.

CHAPTER 7. FUTURE WORK

Findings from these studies highlight the need for improved understanding of inter-relationship between behavior change factors such as subjective norms, risk-perception, and perceived behavioral control as well as the relationship between Key Influencers. Subjective norms combined with knowledge as well as behavior change factors including risk-perception and perceived behavioral control may increase the likelihood of initiating behavior change. Although the TPB model does not recognize knowledge as a determining factor of performed behaviors, students exercising their influencing power persuaded their peers to change food-handling behaviors using facts learned in the educational intervention. This suggests that knowledge combined with subjective norms could elicit behavior changes. Students also expressed their risk-perception to peers as a means of justifying their food-handling behaviors. Further study of the relationship between behavior control factors can improve understanding of youths' choices to yield to or resist food-handling recommendations, which is essential to developing effective strategies to improve and sustain correct food-handling behaviors among youth.

There is also a continued need for research related to motivation for and sustainability of food-handling behavior change in the context of in-the-classroom and outside-the-classroom learning environments. The power of subjective norms may follow a gradient depending on societal structure both in-the-classroom and outside-the-classroom and needs to be more thoroughly understood in the context of food safety. Further study of the influencing power relationship between youths and other members of their social group including peers, parents, instructors, and authors or hosts of popular web-based content can improve understanding of youths' receptivity to food-handling messages. When youths act as Key Influencers, their collective influence will likely increase. The degree of increase under different environmental conditions requires further exploration. Deeper study of these relationships can also improve understanding of the broader societal impact of food safety educational interventions and food safety messages delivered in different learning environments, thus making it possible to generate more effective food safety intervention designs with increased sustainability.

APPENDIX A. HIGH SCHOOL FOOD SAFETY CURRICULUM

For the entire curriculum package, please visit: https://ag.purdue.edu/foodsci/Fenglab/extension-articles/.

<table>
<tr><td colspan="3">[redacted]</td></tr>
<tr><td colspan="3">Before beginning the unit, have the students complete a food-safety pre-survey and participate in a cooking activity to establish a baseline of students' food-safety knowledge, attitudes, and behaviors prior to receiving food-safety education. Teach students food safety using five days of food-safety lessons, then during an additional class session, have students give presentations on what they have learned. At the end of the five-day unit and one-day presentation, have the students complete a food-safety post-survey and participate in a cooking activity to evaluate changes in students' food-safety knowledge, attitudes, and behaviors after receiving food-safety education.</td></tr>
<tr><th>Day</th><th>Principle(s)</th><th>Unit Objective(s)</th></tr>
<tr><td rowspan="3">1</td><td>Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die.

Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.</td><td>• Collect data to establish a baseline for student food-safety knowledge, attitudes, and behaviors.</td></tr>
<tr><td colspan="2">Learning Activities</td></tr>
<tr><td colspan="2">1. Activity 1: Pre-Survey Administration
1.1. Teacher/Discussion leader informs students they will be starting a new unit of study. Teacher/Leader says, "I would like to know what you already know before we start the unit, so I'm going to ask you to take a pre-survey. Remember, when you take a pre-survey, I am just looking for what you already know." If students ask if the pre-survey is graded, assure them it is ungraded and encourage them to try their best.</td></tr>
</table>

1.2. Distribute the **pre-survey.** (This is almost the same as the post-survey administered at the end of the unit.) Allow students 15 minutes to complete the pre-survey, and monitor them as they work to deter them from sharing information with one another. Collect the completed pre-surveys.

2. Activity 2: Cooking Activity

2.1. Cooking station setup:

- Label the cooking stations from 1 to 6.
- Store the temperature-sensitive ingredients (meat, cheese, vegetables, etc.) in the refrigerator. Non-temperature-sensitive ingredients may be stored on a common table or at the stations.
- Place one copy of each recipe (**Cheeseburgers** and **Zucchini Crisps**) at each station.
- Ensure that students have the necessary equipment as outlined in the materials list.

2.2. Before going to the cooking lab:

- Assign students to (or allow students to pick) their lab groups and their lab stations (1 to 6). There should be no more than 4 students per group. Teacher/Leader says, "We are going to do a cooking activity in which you will make cheeseburgers."
- Lead students to the cooking lab. Students should not bring their books or other materials to the lab unless there are places to store these items away from food-preparation areas.

2.3. In the cooking lab:

- Once in the lab, assign groups of students to cooking stations labeled 1 to 6. Group 1 should be assigned to station 1; group 2, to station 2; etc.
- When all students are at their cooking stations, the teacher/leader says, "You may begin cooking using the recipe at each of your stations. Once you are finished cooking, you may eat what you have made, but you do not have to eat the food you prepared. You will have 30 minutes to prepare your food. I will keep track of time and let you know how much time you have left to cook."
- Monitor students to ensure that they are using the kitchen equipment safely. The teacher/leader should only offer cooking advice when students are observed preparing food in a way that would result in illness. On the observation checklist, note any instances in which advice was given. Have students indicate when they are finished cooking and measure the internal temperature of the burger patties to ensure the internal temperature is 160°F. If the burger patties are not 160°F, have students continue cooking the burgers until the internal temperature is at least 160°F. In other cases where students are not properly handling food, the teacher should intervene. Any interventions should be noted on the

observation sheet. When students are finished cooking, eating, and cleaning up the kitchen for the next class, dismiss the students.

Use video recordings or the included **Student Cooking Observation Checklist** to record student food-handling behaviors. The information in the videos or checklists can be shared with students to help them identify which food-handling behaviors they are performing correctly and which behaviors require improvement. If the students' food-handling behaviors are recorded on video, the teacher/leader can have students review the footage for their group and discuss the food-handling behaviors they noticed. If students' food-handling behaviors are recorded on the checklist, teachers/leaders could have groups pair up and observe one another while cooking. For example, group 1 can watch group 2 cook and make observations during the first part of class. Group 2 can then watch group 1 cook and record observations during the second part of class. For this method, recipes requiring less cooking time are optimal as they ensure both groups will be able to prepare the meal during the class period. Alternatively, two days of cooking can be allotted for both the pre- and post-cooking sessions, with each group cooking for one class period and observing during the other class period.

Materials List

Activity 1: Pre-Survey Administration

1.1 Pre-survey

Activity 2: Cooking Activity

2.1 Cheeseburger Recipe
- 1 pound ground beef
- 1 teaspoon salt
- 1 teaspoon black pepper
- 8 slices American cheese
- 4 hamburger buns

2.2 Cheeseburger Garnishes
- Ketchup
- Mustard

<table>
<tr><td></td><td colspan="2">

Mayonnaise
Sliced tomatoes
Sliced pickles
Fresh lettuce

2.3 Zucchini Recipes

2 medium zucchinis, sliced into $^{1}/_{8}$-inch rounds
½ teaspoon salt
½ teaspoon pepper
1½ cups Parmesan cheese, grated
1 can cooking spray (enough for class)
1 roll parchment paper (enough for class)

2.4 Equipment

Food handler's gloves (enough for class)
1 Cooking thermometer
1 Skillet
1 Spatula
1 Mixing bowl
1 Baking sheet
1 Knife
1 Cutting board
Aluminum foil
Parchment paper
Plates
Paper towels

2.5 Student Cooking Observation Checklist
2.6 Optional Video Recording Devices
</td></tr>
<tr><td>Day</td><td>Principle(s)</td><td>Unit Objective(s)</td></tr>
</table>

2	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die. Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	• Students are able to apply cleaning methods to reduce or eliminate unwanted microorganisms and pathogens on hands, surfaces, and foods. • Students are able to define and identify examples of Zones 1–4 in a food-processing environment. • Students are able to develop a basic Sanitation Standard Operating Procedure (SSOP) and identify cleaning agents, disinfecting/sanitizing agents, and verification tests to use on the processing equipment and in the processing environment. • Students are able to develop a basic Good Manufacturing Practices (GMP) document for a food-processing company. • Students are able to compare and contrast cleaning and verification methods utilized in processing facilities and home kitchens.
	Suggested Pre-Knowledge	
	Basic knowledge of microbiology	
	State Standards Addressed	
	Indiana Department of Education, Advanced Life Science: Foods **Domain—Health, Safety, and Microbiology of Food** **Core Standard 5** Students conduct safe food handling, hygiene, spoilage, and quality control to understand temperature controls, species and structure of microbes, shelf-life, food-poisoning, and the socio-economic impact of the food quality. **Standards**	

ALSF-5.2 Explain techniques and procedures for the safe handling of food products

ALSF-5.3 Evaluate food product handling procedures

ALSF-5.6 Describe the effects food-borne pathogens have on food products and humans

ALSF-5.7 Explain the importance of microbiological tests in food product preparation

ALSF-5.8 Characterize the physical, chemical, and biological properties of microbes

ALSF-5.13 Develop personal food selection and food handling habits that will minimize the risk of contracting food-borne or water-borne disease (PU – FS 16100)

Core Standard 6 Students draw conclusions about food and food safety.

Standards

ALSF-6.2 Develop Sanitation Standard Operating Procedures (SSOP) for a food products and processing company

ALSF-6.3 Implement Good Manufacturing Practices (GMP) for a food products and processing company

Learning Activities

1. ***Activity 1: Building Concepts Related to Safe Food-Handling Practices: Cleaning***

1.1. Distribute the Final Project Rubric to students, and introduce the final project students will present in their groups. Tell students they will take photos to represent ideas they learn from each unit of study, then students will present these pictures to the class. During or after each unit of study, students should take a photo to include in their final project.

1.2. To open the discussion of cleaning concepts, teacher/leader asks students, “What do you think are the most common causes of foodborne illness in the United States?”

- Bacteria

1.3. Ask students to share thoughts on ways to prevent foodborne illnesses at home. Potential answers:

- Washing hands
- Thoroughly cooking meat
- Washing produce

1.4. After students answer, teacher/leader asks, “What about in a manufacturing facility? Are the ways to prevent foodborne illnesses the same as or different than in home kitchens?”

	1.5. Where are microorganisms and pathogens located in your homes or at a manufacturing facility? Potential answers: • On food handlers' hands and gloves • On reusable towels • On equipment surfaces • In ingredients • In environment 1.6. Ask students to identify how to eliminate or reduce pathogens on hands and gloves. Potential answers: • Wash hands for 20 seconds using soap and warm water. • Follow other recommended hand-washing techniques (e.g. wash the backs hands, between fingers, finger tips, thumbs, etc.) • Change gloves when they are contaminated or lose elasticity. • Wash hands between glove changes. 1.7. Ask students to identify ways to dry hands. Potential answers: • Disposable paper towels – best method because there is limited opportunity for microorganisms to grow (as with multiuse towels) or circulate (as with electric hand dryers) • Multiuse towels • Air hand dryers After students provide responses, ask them to identify the best way to dry hands and to provide justifications for their answers. *1.8. Watch the video on bacteria, hand washing, and produce washing.* 1.9. Ask students to identify ingredients that could contain pathogens and what pathogens they think could be associated. Potential answers: • Meat—*Campylobacter jejuni, E. coli* O157:H7, *Listeria monocytogenes, Salmonella* spp., *Staphylococcus aureus,* and *Yersinia enterocolitica* • Poultry—*Campylobacter jejuni, Clostridium botulinum* (canned chicken), *Clostridium perfringens, Listeria monocytogenes, Staphylococcus aureus,* and *Yersinia enterocolitica* • Seafood—*Campylobacter jejuni, Listeria monocytogenes,* and *Yersinia enterocolitica* • Eggs—*Salmonella* spp. *and Staphylococcus aureus* • Milk—*E. coli* O157:H7, *Staphylococcus aureus,* and *Yersinia enterocolitica* • Flour—*Salmonella* spp.

- Produce—*Campylobacter jejuni, Clostridium botulinum* (canned produce), *Clostridium perfringens, E. coli* O157:H7 (unpasteurized juice), *Listeria monocytogenes,* and *Salmonella* spp.
- Spices—*Clostridium perfringens* and *Salmonella* spp.
- Water—*Shigella* spp.

2. Activity 2: Applying Cleaning Concepts

2.1. Have students get in groups of four. Teacher/Leader says, "Now that you know some basics about cleaning, we have an activity to apply these concepts." Distribute the in-class activities: **In-Class Activity - Clean: Good Manufacturing Practices (GMP) Development"** and **In-Class Activity: Clean: Pete's Perfect Pretzels SSOP (Standard Operating Procedures) Development**. Teacher/Leader says, "You are going to assume the role of a Quality Assurance Team member in a pretzel production facility. You will be helping to establish some cleaning procedures for the facility. Before we start the activity, we are going to watch a video of a pretzel production facility so you will have a better understanding of what the facility and equipment look like."

2.2. *Have students watch five-minute video of pretzel production facility and record parts of the process that could be affected and why they think there is a risk at that point in the processing. https://www.youtube.com/watch?v=TQjZjF-Tcao*

2.3. After watching the video, ask students to identify equipment surfaces where pathogens might be prevalent. Answers:
- Equipment used for handling raw ingredients (e.g., belts/compartments carrying raw or uncooked ingredients/products, ingredient storage tank interior, mixers, pumps, etc.)
- Areas adjacent to processing (e.g., surfaces next to conveyor belts; control panels; handles to storage tanks and ingredient buckets; tools such as thermometers, scoops, and scrapers; etc.)

2.4. Ask students to identify some areas in a food-processing plant that could be contaminated with pathogens. Answers:
- Floors
- Drains
- Common areas, such as cafeterias
- Areas with water leaks such as from ceiling or around pipes

2.5. Have students watch Zones video that describes zones 1–4 in a processing facility.

2.6. Ask students to look at the in-class activity papers for GMP (Good Manufacturing Practices) and SSOP (Sanitation Standard Operating Procedures) development. Tell students that they are going to become members of the Quality Assurance Team for a pretzel company called Pete's Perfect Pretzels. Their job is to develop GMPs (Good Manufacturing Practices) and SSOPs (Sanitation Standard Operating Procedures) for the pretzel production facility.

- Instruct students to assemble in assigned groups and to take out their **In-Class Activity—Clean: Good Manufacturing Practices (GMP) Development** worksheet. Read aloud the instructions, and give the students 5 minutes to complete the worksheet. At the end of 5 minutes, ask each group to contribute ideas to the class GMP policy for Pete's Perfect Pretzels.
- While still in their groups, have students take out their **In-Class Activity—Clean: Pete's Perfect Pretzels SSOP (Sanitation Standard Operating Procedures) Development** worksheet. Read aloud the instructions, and give students 20 minutes to complete the worksheet. Have students identify where the ingredient statement can be found on a bag of pretzels and then list pretzel ingredients that could contain pathogenic microorganisms. Provide students with a list of microorganisms and pathogens commonly associated with food processing, common cleaning agents, and methods for verifying cleaning. At the end of 10 minutes, ask each group to contribute ideas to the class SSOP for Pete's Perfect Pretzels.

3. ***Activity 3: Take-Home Activity to Assess Student Comprehension***

3.1. Tell students they are going to continue their exploration of clean food-handling practices at home. Distribute **Take-Home Activity—Clean** and ask students to complete the information based on what they learned in class today. Explain that students will be asked to answer two questions comparing and contrasting food-processing facilities and home kitchens. Also, explain that they need to develop a Good Kitchen Practices policy and Kitchen Sanitation Standard Operating Procedures (SSOP). Instruct students to turn in the assignment at the next class period, and remind students to take a photo to represent something they learned during this unit and to work on their final project.

Materials List

Activity 1: Building Concepts Related to Safe Food-Handling Practices: Cleaning

- Video: Bacteria, hand washing, and produce washing

Activity 2: Applying Cleaning Concepts

- Video: https://www.youtube.com/watch?v=TQjZjF-Tcao
- Video: Zones
- In-Class Activity—Clean: Good Manufacturing Practices (GMP) Development worksheet
- In-Class Activity—Clean: Pete's Perfect Pretzels SSOP (Sanitation Standard Operating Procedures) Development worksheet
- Pathogen References for Students

Activity 3: Take-Home Activity to Assess Student Comprehension

- Take-Home Activity—Clean worksheet

Note: Students will need a camera or other technology to take pictures for their final presentation. If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia department technology is available for students who do not have a cell phone, students can make posters using markers or computer-generated pictures to illustrate pictures of what they have learned.

Day	Principle(s)	Unit Objective(s)
3	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die. Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	• Students are able to identify environmental factors required by microorganisms to survive and multiply, and to explain how these factors can be controlled to reduce or prevent the survival and growth of microorganisms. • Students are able to identify the temperature at which chicken, beef, pork, and leftovers should be cooked in order to kill pathogens as well as the temperature at which refrigerators and freezers should be kept. • Students are able to explain heat transfer through a product and can explain how surface-area-to-volume ratios and heat-transfer rates relate to cooking and cooling foods. • Students are able to identify where foods should be stored.

- Students are able to identify and justify alternative methods for ensuring food is safe for consumers when taking internal food temperatures is impractical or unfeasible.
- Students are able to differentiate between safe and unsafe food-handling and storage practices and to propose solutions to correct unsafe practices.

Suggested Pre-Knowledge

Basic knowledge of microbiology and chemistry
Basic knowledge of mathematics to calculate surface area, volume, and ratios

State Standards Addressed

Indiana Department of Education, Advanced Life Science: Foods

Domain—Health, Safety, and Microbiology of Food

Core Standard 5 Students conduct safe food handling, hygiene, spoilage, and quality control to understand temperature controls, species and structure of microbes, shelf-life, food-poisoning, and the socio-economic impact of the food quality.

Standards

ALSF-5.2 Explain techniques and procedures for the safe handling of food products

ALSF-5.3 Evaluate food product handling procedures

ALSF-5.4 Describe the importance of performing quality-assurance tests on food products

ALSF-5.8 Characterize the physical, chemical, and biological properties of microbes

ALSF-5.12 Explain the role of chemical reactions, enzymes, and microorganisms in food spoilage, food preservation, and food-borne disease (PU – FS 16100)

	ALSF-5.13 Develop personal food-selection and food handling habits that will minimize risk of contracting food-borne or water-borne disease (PU – FS 16100)
	Learning Activities
	1. Activity 1: Introduction of Concepts Related to Safe Food-Handling Practices: Chilling, Cooking, and Food Preparation 1.1. Teacher/Leader introduces the unit with the cabbage juice activity. Setup for **Cabbage Juice Activity:** • At each station, set out (or have available) the following items: ○ Three 5-ounce containers of red cabbage juice ○ 0.5 ounce (15 ml) vinegar ○ 1 teaspoon (3.5 g) baking soda ○ Tow stirring rods 1.2. Instruct students to assemble in their groups of four. Have students add 0.5 ounce of vinegar to one of the 5-ounce containers of red cabbage juice and 1 teaspoon of baking soda to another one of the 5-ounce containers of red cabbage juice. Students may need to stir the baking soda mixture. 1.3. Ask students to note their observations and why they thought the color change occurred. **Answer:** Caused by pH changes. When students mention pH, respond that the color change did happen due to changes in pH. Ask students what each color represents. **Answer:** Vinegar added to the cabbage turned pink and is acidic, and baking soda added to cabbage turned green and is basic. When students respond that the solutions represent acidic and basic solutions, distribute the pH strips. Ask students to verify their answers by measuring the pH using the pH strips. Cabbage juice is the pH indicator in this experiment and should have a pH of around 7. 1.4. Ask students what role pH plays in food safety. When students respond that it prevents bacteria growth, ask students which solution(s) would prevent bacterial growth. When students respond with acids (specifically, pH 4.6 and below for high-acid foods), ask them what other methods can be used to decrease, slow, or prevent bacterial growth. Answers may include: • Cooking • Refrigerating • Freezing • Water activity

Allow students to guess and justify their responses for 2 minutes. Tell students that temperature/time (cooling and cooking), moisture, and nutrients also affect bacterial growth rates.

1.5. Ask students how they know if their food is being cooled to the correct temperature in the refrigerator or freezer. Answers may include:
- Thermometer indicates temperature inside the refrigerator or freezer.
- Contents in the refrigerator are cold.
- Air in the refrigerator feels cold.

1.6. Ask students how they know if their food is safe to eat. For example, how do they know if their chicken, hamburger, and leftovers are safe to eat? Answers may include:
- By cooking the food at the correct temperature for the recommended time (correct)
- By cooking until juices run clear (incorrect)
- By checking the color (incorrect)
- By checking the texture (incorrect)
- By using a cooking thermometer (incorrect)

1.7. *Have students watch a video on key conditions for bacterial growth.*

1.8. Ask students about methods for checking pH, moisture, and nutrients. Teacher/leader says, “Why are these methods not used frequently?” Answers may include:
- These things are difficult to measure at home.
- People do not have correct equipment at home.

2. Activity 2: Building Concepts—Heat Transfer

2.1. Teacher/Leader distributes the color-changing dough. *Note: The dough should be kept chilled until right before use. Instruct students to minimize dough handling because the heat from their hands can cause the color to change. Equipment (e.g., plastic knives) can be used to help separate the dough and minimize handling. The dough will need to be chilled to below 54°F before use in subsequent labs.*

2.2. Have students divide the dough into four pieces. One piece should be the reference piece. The second piece should be approximately half the size of the reference piece along all dimensions. The third piece should have the same mass as the reference piece but should be pressed flat. The fourth piece should be of the same size and shape as the reference piece. Tell the students the dough changes color when its temperature reaches 54°F. Have the students place the dough on a sheet of foil on the hot plate. Heat the dough pieces on the hot plate. Dough pieces 1, 2, and 3 should be heated without flipping, and dough piece 4 should be flipped when the dough has changed color approximately half-way up the side of the dough. Have students note how the heat travels through the dough, indicated by the dough changing color. Temperature change should gradually occur vertically through the dough. For each method, have students calculate the surface-area-to-volume ratios they used and record the time it took for heat to transfer through the dough (students will explain how they determined when heat transfer was complete). Have students briefly share their results with the class. Remind students the color change represents heat transfer, not the color change of the food being cooked. The color of the food being cooked does not indicate if the food is cooked thoroughly.

Alternative Activity: Students can design the experiment themselves. Instead of telling the students what sizes and shapes they should make the dough, have the students design an experiment to demonstrate how cooking times differ for different dough geometries. Have students perform the calculations for surface-area-to-volume ratios and record the time it took for heat to transfer through the dough. As a class, discuss the different experiments students tried and their results.

2.3. Teacher/Leader asks students what implications the different surface-area-to-volume ratios and heating methods have for cooking food. Answers may include:
- Thin food (higher surface-area-to-volume ratios) heats faster.
- Smaller pieces cook faster when the shape is the same.
- Flipping the food to cook both sides increases the cooking rate.

2.4. Show the students the Temperature Control video.Teacher/Leader asks students how their observations of heating food relate to cooling food. Answers may include:
- Thin layers of food cool faster than thick layers of food.
- Exposing food to cooler temperatures above/below/on the sides of containers will increase the rate of cooling.

3. Activity 3: Ingredient Storage and Product Testing

3.1. Teacher/Leader will have the students work in their groups on the **In-Class Activity—Chill: Dessert Pretzels** and **In-Class Activity—Cook: Is It Safe to Eat?** handouts. Tell students they will have the remaining class time (about 20 minutes) to complete the activity, and the class will discuss the answers to this activity at the start of the next class. Have groups complete the worksheets based on the table below. For the Ingredient Identification activity, each group will work on their own worksheet, but two groups will be working on the same question.

Activity	Groups 1 and 2	Groups 3 and 4	Groups 5 and 6
Ingredient Identification	Pete's Dark Chocolate Peanut Butter Pretzel Bites	Milk chocolate caramel-dipped pretzel rods	Dessert trail mix
Warehouse Inspection	All questions		
Quality Measurements			

4. ***Activity 3: Take-Home Activity to Assess Student Comprehension***
   4.1. Teacher/Leader explains to students they will continue their exploration of food-handling practices related to following chilling and cooking practices at home. Distribute **Take-Home Activity—Chill, Cook, and Food Preparation** and instruct students to answer the questions on the worksheet based on what they learned in class today. Remind students that they will turn in the homework at the next class period. Remind students to take a photo to represent something they learned during this unit and to work on their final project.

3

Materials List

Activity 1: Introduction of Concepts Related to Safe Food-Handling Practices: Chilling, Cooking, and Food Preparation

- 5-ounce containers of red cabbage juice
- 0.5 ounce (15 ml) distilled, white vinegar
- 1 teaspoon (3.5 g) baking soda
- 2 stirring rods
- 3 pH test strips
- Video: Bacterial growth

Activity 2: Building Concepts—Heat Transfer

Color-changing dough. 1 batch yields enough dough for approximately 3 groups of 4 students.

- 4 cups flour
- 1½ cups salt
- 2 tablespoons oil
- 1 cup water
- 5–10 grams color-changing powder (add until the desired color is reached)
- 1 hot plate (per group)
- Optional: Plastic knives for dividing dough

Activity 3: Ingredient Storage and Product Testing

- **In-Class Activity—Chill: Dessert Pretzels**
- **In-Class Activity—Cook: Is It Safe to Eat?**

Activity 4: Take-Home Activity to Assess Student Comprehension

- Take-Home Activity—Chill, Cook, and Food Preparation

Note: Students will need a camera or other technology to take pictures for their final presentation. If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia department technology is available for students who do not have a cell phone, students can make posters using markers or computer-generated pictures to illustrate pictures of what they have learned.

Resources

Red Cabbage Chemistry, Steve Spangler Science, https://www.stevespanglerscience.com/lab/experiments/red-cabbage-chemistry/

Fight BAC!® by Chilling Out, U.S. Department of Agriculture, http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/fighting-bac-by-chilling-out/CT_Index

	Go 40 or Below, Fight BAC!®, Partnership for Food Safety Education, http://www.fightbac.org/food-safety-education/40-or-below/ Color of Cooked Ground Beef as It Relates to Doneness, USDA Food Safety Inspection Service, https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/meat-preparation/color-of-cooked-ground-beef-as-it-relates-to-doneness/ct_index Your Gateway to Food Safety Information, U.S. Department of Health and Human Services, www.foodsafety.gov Food Safety, Teens Health, Nemours Foundation, http://kidshealth.org/teen/food_fitness/nutrition/food_safety.html Food Safety for Your Family, Kids Health, Nemours Foundation, http://kidshealth.org/parent/firstaid_safe/home/food_safety.html National Cattlemen's Beef Association, www.beef.org Free Resources, Fight BAC!®, Partnership for Food Safety Education, www.fightbac.org https://www.extension.iastate.edu/foodsafety/ten-steps-safe-kitchen Thermy^{TM} Campaign, USDA Food Safety and Inspection Service, https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/teach-others/fsis-educational-campaigns/thermy	
Day	**Principle(s)**	**Unit Objective(s)**
4	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die. Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	• Students define and distinguish between cross-contamination and cross-contact. • Students explain ways to prevent cross-contamination and/or cross-contact. • Students are able to evaluate the food-handling practices of others and identify cross-contamination and/or cross-contact events and other unsafe food-handling practices. • Students are able to collect and synthesize data and reach conclusions based on collected data.
	Suggested Pre-Knowledge	

Basic knowledge of microbiology and microbial pathogens

State Standards Addressed

Indiana Department of Education, Advanced Life Science: Foods

Domain—Health, Safety, and Microbiology of Food

Core Standard 5 Students conduct safe food handling, hygiene, spoilage, and quality control to understand temperature controls, species and structure of microbes, shelf-life, food-poisoning, and the socio-economic impact of the food quality.

Standards

ALSF-5.2 Explain techniques and procedures for the safe handling of food products

ALSF-5.3 Evaluate food product handling procedures

ALSF-5.8 Characterize the physical, chemical, and biological properties of microbes

ALSF-5.13 Develop personal food selection and food handling habits that will minimize risk of contracting food-borne or water-borne disease (PU – FS 16100)

Core Standard 6 Students draw conclusions about food and food safety

Standards

ALSF-6.6 Demonstrate an ability to critically evaluate the validity of information that commonly appears in newspapers, magazines, radio, and television (PU – FS 16100)

Learning Activities

1. ***Activity 1: Building of Concepts Related to Safe Food-Handling Practices: Wrap-Up of*** **In-Class Activity-Chill: Dessert Pretzels** and **In-Class Activity—Cook: Is It Safe to Eat?** ***(15 minutes)***
   1.1. Teacher/Leader asks students to take out their **In-Class Activity—Chill: Dessert Pretzels** and **In-Class Activity—Cook: Is It Safe to Eat?** worksheet from the previous day. Have Groups 1 and 2 share their ideas for

ingredient storage conditions, concerns, and justification of their choices. Then have Groups 3 and 4 share their ideas, followed by Groups 5 and 6. Work to generate consensus among students.

1.2. After sufficient discussion or students reach an agreement, have each group share feedback for Decadent Dipped Desserts and suggestions related to the warehouse observations. Work to generate consensus among students.

1.3. Ask students to share their quality-control answers. Work to generate consensus among students.

2. ***Activity 2: Building of Concepts Related to Safe Food-Handling Practices: Cross-Contamination***

2.1. Teacher/Leader tells students they will now learn about cross-contamination. Ask students to define cross-contamination based on their current understanding of the term.

2.2. Ask if cross-contamination is the same as cross-contact. Answer: Cross-contact involves unintentionally spreading allergens from one surface to another, whereas cross-contamination involves spreading bacteria from one surface to another.

2.3. Ask students to identify items in their kitchen that could cause cross-contamination or cross-contact. Possible answers may include:

- Cutting boards
- Knives
- Dish towels
- Dish clothes
- Counter

2.4. Ask students how they prevent cross-contamination. Possible answers may include:

- Washing the surface with soap and water
- Using a disinfectant

2.5. Ask students if they wash salt and pepper shakers, refrigerator handles, oven-door handles, sink faucets, or raw meat. Facilitate a discussion and promote correct cleaning and food-handling practices.

2.6. Have students watch the Don’t Wash Your Chicken! Germ – Vision Animation

2.7. https://www.youtube.com/watch?v=JZXDotD4p9c

3. ***Activity 3: Practice Identifying Cross-Contamination and Other Unsafe Food-Handling Behaviors***

3.1. Teacher/Leader tells students they will watch a video of a professional chef preparing a dish. Show students the Bobby Flay’s “Throwdown” Burger video (https://www.youtube.com/watch?v=H_9oM1Y60lU). Ask students to record the cross-contamination/cross-contact events and any other unsafe food-handling practices they see while watching the video.

3.2. After students watch the video, ask them to share their observations. Facilitate the discussion and work to generate consensus among students related to food-safety practices.

4. ***Activity 4: Cross-Contamination Investigation***

4.1. Teacher/Leader distributes **In-Class Activity—Cross-Contamination: Pete's Perfect Pretzels P.I.'s (Pretzel Investigators)** and says, "Now you will conduct an investigation to determine the source of a cross-contamination event. You will investigate a series of customer complaints received by Pete's Perfect Pretzels. To conduct the investigation, you will need to learn information from different Pete's Perfect Pretzel employees. I have information from employees in the following departments: Sanitation, Quality Assurance, Processing, Packaging, Warehouse, and Record Retention. Two groups at a time may come up and ask me for that information. Please record any information you receive on your worksheet. Groups who are not speaking to me about the information provided by the employees should discuss the current information they have and determine which employees they still need information from. Remember, it might not be necessary to get information from all of the employees in order to determine the contamination source." (Use the provided **Teacher's Notes** for this activity to respond to the students' requests for information.)

4.2. Allow students to work for the remaining class time on identifying the source of contamination. Toward the end of the class period, inform the students that the FDA has issued a recall for black pepper. If students are not familiar with the FDA, explain that "FDA" stands for "Food and Drug Administration". The FDA is responsible for regulating the production of certain food items. The FDA publishes guidance documents to disseminate information to producers and manufacturers related to safe food processing, transporting, and storage. When food is suspected to be unsafe, the FDA issues recalls to notify the public of the potential hazard and conducts an investigation to determine the source of the problem.

4.3. Tell students you will discuss their investigation results at the start of the next class period. If students have trouble determining the source, remind students about the different sources of contamination, including an object in the facility, a person, or an ingredient.

5. ***Activity 5: Take-Home Activity to Assess Student Comprehension***

5.1. Teacher/Leader explains to students that they are going to continue their exploration of food-handling practices related to cross-contamination at home. Distribute the **Take-Home Activity—Cross-Contamination** worksheet and ask students to answer the questions based on what they learned in class today. Instruct students to turn in this worksheet at the next class period. Remind students to take a photo to represent something they learned during this unit and to work on their final project.

Materials List

Activity 1: Building of Concepts Related to Safe Food-Handling Practices: Wrap-Up of **In-Class Activity-Chill: Dessert Pretzels** and **In-Class Activity—Cook: Is It Safe to Eat?** ***(15 minutes)***

- Completed In-Class Activity—Chill: Dessert Pretzels from the previous class period

Activity 2: Building of Concepts Related to Safe Food-Handling Practices: Cross-Contamination

- Video: *Don't Wash Your Chicken! Germ – Vision Animation*, https://www.youtube.com/watch?v=JZXDotD4p9c

Activity 3: Practice Identifying Cross-Contamination and Other Unsafe Food-Handling Behaviors

- Video: Bobby Flay's "Throwdown" Burger Video, https://www.youtube.com/watch?v=H_9oM1Y60lU

Activity 4: Cross-Contamination Investigation

- In-Class Activity—Cross-Contamination: Pete's Perfect Pretzels P.I.'s (Pretzel Investigators)
- Teacher's Notes for In-Class Activity—Cross-Contamination: Pete's Perfect Pretzels P.I.'s (Pretzel Investigators)

Activity 5: Take-Home Activity to Assess Student Comprehension

- Take-Home Activity—Cross-Contamination

Note: Students will need a camera or other technology to take pictures for their final presentation. If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia department technology is available for students who do not have a cell phone, students can make posters using markers or computer-generated pictures to illustrate pictures of what they have learned.

Day	Principle(s)	Unit Objective(s)

<table>
<tr>
<td rowspan="7">5</td>
<td>Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die.

Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.</td>
<td>• Students are able to identify and describe methods for treating food to reduce or eliminate unwanted microorganisms.
• Students can choose foods that may decrease their chances of contracting a foodborne illness.
• Students are able to develop a hypothesis and design an experiment to test their hypothesis.
• Students analyze data from different sources to reach a conclusion and are able to justify their conclusion.
• Students learn to judge the credibility and identify potential biases of different information sources.</td>
</tr>
<tr><td colspan="2">Suggested Pre-Knowledge</td></tr>
<tr><td colspan="2">Basic knowledge of microbiology and plating techniques</td></tr>
<tr><td colspan="2">State Standards Addressed</td></tr>
<tr><td colspan="2">Indiana Department of Education, Advanced Life Science: Foods

Domain—Health, Safety, and Microbiology of Food

Core Standard 5 Students conduct safe food handling, hygiene, spoilage, and quality control to understand temperature controls, species and structure of microbes, shelf-life, food-poisoning, and the socio-economic impact of the food quality.

Standards

ALSF-5.1 Discuss the issues of safety and environmental concerns about foods and food processing

ALSF-5.2 Explain techniques and procedures for the safe handling of food products

ALSF-5.3 Evaluate food product handling procedures</td></tr>
</table>

ALSF-5.7 Explain the importance of microbiological tests in food product preparation

ALSF-5.8 Characterize the physical, chemical, and biological properties of microbes

ALSF-5.9 Explain reasons for detecting microbes and identify sources of microbes

ALSF-5.13 Develop personal food selection and food handling habits that will minimize risk of contracting food-borne or water-borne disease (PU – FS 16100)

Core Standard 6 Students draw conclusions about food and food safety.

Standards

ALSF-6.4 Articulate a personal set of values related to your decisions pertaining to selection of food products for both your personal and your family's consumption (PU – FS 16100)

Learning Activities

1. ***Activity 1: Discussion of Concepts Related to Safe Food-Handling Practices: Wrap-Up of Cross-Contamination (10 minutes)***
   1.1. Teacher/Leader asks students to take out their In-Class Activity—Cross-Contamination: Pete's Perfect Pretzels P.I.'s (Pretzel Investigators) worksheets and has each group to share with the class the source of contamination they identified and their justification. If groups reached different conclusions, try to reach a consensus. Allow 10 minutes for discussion.

2. ***Activity 2: Discussion of Concepts Related to Safe Food-Handling Practices: Chose Safe Foods***
   2.1. Show the students 3–7 food products processed by ultra-high temperature (UHT), such as salad dressing, guacamole, yogurt, fruit jams, pasteurized juice, and soup. Ask students what these items have in common. If students do not guess that the similarity is in processing methods, tell the students these foods are commonly processed using ultra-high temperature (UHT).
   2.2. *Show students the* What is UHT Milk? *video describing UHT* (https://www.youtube.com/watch?v=wFkVefQJpfg).

	2.3. Ask students what other ways they think food can be handled or treated to reduce or limit bacterial growth. Potential answers: • Canning food • Dehydrating food • Choosing foods without blemishes or defects 2.4. After students contribute answers, ask them why they think those methods make foods safer for consumption. Potential answers: • Reduced water activity • Heat treatment to kill bacteria • pH below 4.6, • 149Modified oxygen content inside the product package 2.5. Show students videos covering various foods and making choices that decrease their risk of foodborne illness. • Raw milk, https://www.drink-milk.com/common-questions/raw-milk/ • Food Safety in the Produce Aisle, https://www.youtube.com/watch?v=Zy_QuxLkr7c • Using Nuclear Science in Food Irradiation, https://www.youtube.com/watch?v=pe6AKh_tLys (start at 0:55 seconds) 2.6. Tell students it is their turn to prove or disprove that pasteurized juice is safer than unpasteurized juice. Have students assemble in their lab groups. Distribute **In-Class Activity—Choose: Experiment Design**. Provide each group with pasteurized apple juice, unpasteurized apple juice, five sterile swabs, two beakers, two stirring rods, parafilm, nitrile gloves, and five sterile petri dishes containing nutrient agar. (Note: Students can pour the juice they need from larger containers into beakers and transport these back to their lab stations.) Have students develop a hypothesis about which juice(s) is safe to consume and design an experiment to test their hypothesis. Allow students 15 minutes to answer lab questions, develop a hypothesis, design the experiment, and complete the experiment. Have students incubate their petri dishes for a maximum of 1 to 2 days, depending on their experimental procedure. Students will make observations about what they see on their petri dishes when they remove them from the incubator. 2.7. While still in their groups, ask students if food manufacturing facilities also need to make safe food choices. Ask students how they think manufacturers make safe food choices. Allow students to propose answers for a few minutes. Answers may include: • Using ingredients that are properly treated to mitigate associated with pathogens

- Choosing reputable suppliers
- Testing incoming ingredients for pathogens or to ensure the product meets the standard of identity

3. ***Activity 3: Using Collected and Experimental Data to Decide if Spices should be used in Pretzel Production***

   3.1. Relate the discussion back to the cross-contamination investigation activity. Remind students that the pretzel seasoning was the source of pathogens. Ask students to determine what a safe seasoning choice would be for Pete's Perfect Pretzels by completing the **In-Class Activity—Choose: Are Spices Safe?** as a group. Allow students to complete the exercise in the remaining class time (approximately 15 minutes). Distribute 5 salt-and-pepper pretzels (e.g., Snack Factory® Pretzel Crisps Sea Salt and Cracked Pepper) to each group to represent the product produced by Pete's Perfect Pretzels. This will be the control. Distribute 5 salt pretzels to each group (e.g., Snack Factory® Pretzel Crisps Original). Make oleoresins or essential oil available to students at a common station. Instruct the students to NOT EAT the oleoresins or essential oils. Allow students to experiment with the pretzels and oleoresin or essential oil to determine their formulation and to answer questions on the corresponding worksheet. Ask students to be prepared to discuss their answers at the beginning of the next class period.

4. ***Activity 4: Take-Home Activity to Assess Student Comprehension***

   4.1. Teacher/Leader explains to students that they will continue their exploration of food-handling practices related to Chose Safe Food at home. Distribute **Take-Home Activity—Choose: Scavenger Hunt** and ask students to answer the questions on the worksheet based on what they learned in class today. Instruct students to turn in this worksheet at the next class period. Remind students to take a photo to represent something they learned during this unit and to work on their final project.

Materials List

Activity 1: Discussion of Concepts Related to Safe Food-Handling Practices: Wrap-Up of Cross-Contamination (10 minutes)

- Completed In-Class Activity – Cross-Contamination: Pete's Perfect Pretzels P.I.'s (Pretzel Investigators) from previous class period

Activity 2: Discussion of Concepts Related to Safe Food-Handling Practices: Chose Safe Foods

- Three to seven food products processed with UHT
  - Fruit jams
  - Guacamole
  - Pasteurized juice
  - Salad dressing
  - Soup
- Raw milk, https://www.drink-milk.com/common-questions/raw-milk/
- Food Safety in the Produce Aisle, https://www.youtube.com/watch?v=Zy_QuxLkr7c
- Using Nuclear Science in Food Irradiation, https://www.youtube.com/watch?v=pe6AKh_tLys (start at 0:55 seconds)
- In-Class Activity—Choose: Experiment Design
  - Growth media
  - Pasteurized apple juice (2-3 fl oz. for the class)
  - Unpasteurized apple juice (2-3 fl oz. for the class)
  - 5 Sterile swabs
  - 2 Beakers
  - 2 Stirring rods
  - Parafilm
  - Nitrile gloves
  - 5 sterile petri dishes containing nutrient agar
- In-Class Activity—Choose: You Decide: Are Spices Safe?
  - 5 Salt pretzels
  - 5 Salt-and-pepper pretzels
  - Food-/ Pharmaceutical-grade black pepper oleoresin (or substitute black pepper essential oil)
  - Droppers to dispense the oleoresin

Activity 3: Take-Home Activity to Assess Student Comprehension

- Take-Home Activity—Choose: Scavenger Hunt

	Note: Students will need a camera or other technology to take pictures for their final presentation. If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia department technology is available for students who do not have a cell phone, students can make posters using markers or computer-generated pictures to illustrate pictures of what they have learned.

Day	Principle(s)	Unit Objective(s)
6	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die. Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	• Students define HACCP and can identify the seven principles of HACCP. • Students can recall four hazard categories to be considered when conducting a hazard analysis, provide examples of hazards in each hazard category, and list equipment/procedures used to mitigate identified hazards. • Students are able to develop a basic process flow diagram to describe a process from initiation to completion. • Students are able to conduct a basic hazard analysis.
	Suggested Pre-Knowledge	
	Basic knowledge of microbiology and chemistry	
	State Standards Addressed	
	Indiana Department of Education, Advanced Life Science: Foods **Core Standard 6** Students draw conclusions about food and food safety. **Standards** ALSF-6.5 Implement a Hazard Analysis and Critical Control Point (HACCP) program for a food products and processing facility	
	Learning Activities	

	1. Activity 1: Discussion of Concepts Related to Safe Food-Handling Practices: Wrap-Up of Chose Safe Foods (10 minutes) 1.1. Teacher/Leader leads student in discussion of answers to In-Class Activity – Choose: Are Spices Safe? worksheet from the previous class period. Have students share whether they would use spices or oleoresins and ask them to provide justification for their choice(s). Allow 10 minutes for discussion. ***2. Activity 2: Discussion of Concepts Related to Safe Food-Handling Practices: Begin HACCP*** 2.1. Teacher/Leader tells students they will apply all the concepts they have learned to create a Hazard Analysis Critical Control Point (HACCP) plan. Tell students they will watch two videos to learn about the seven principles of HACCP and about different hazards related to foods. Distribute the **Hazard Analysis Critical Control Point (HACCP) Video Notes** in-class activity, and instruct students to use it to take notes on the details of the HACCP principles and hazards. These notes can be used later during their own HACCP analysis. • Show students the Hazard Analysis & Critical Control Points (HACCP)_Fulton County video (https://www.youtube.com/watch?v=X2kw40KyVnY). • HACCP Food Safety Hazards video (https://www.youtube.com/watch?v=lEZbSaikBTw). 2.2. After the videos, have students brainstorm methods to prevent the hazards listed in each category (i.e., biological, chemical, physical, and radiological). Answers may include: • Using metal detectors • Using X-ray machines • Checking for chemical residue(s) • Having policies that prohibit employees from bringing medication into production areas • Choosing ingredient sources to minimize exposure to radiological hazards 2.3. Review hazard analysis examples with students. ***3. Activity 3: HACCP In-Class Activity***

3.1. Distribute the **In-Class Activity: Pete's Perfect Pretzels Hazard Analysis Critical Control Point (HACCP)** worksheet. Review the simplified process flow diagram of Pete's Perfect Pretzels with students. Begin walking students through the HACCP examples on the **Hazard Analysis Critical Control Point (HACCP) Video Notes** in-class activity. After talking through the examples, ask students to work as a class to begin filling in Table 1, Hazard Analysis, on the in-class worksheet for Pete's Perfect Pretzels using the examples as guides. Facilitate movement through processing steps, identification of critical control points (CCPs), and methods to control the identified CCPs. Students may review the pretzel production facility shown during the Clean unit to recall the process and equipment used.

4. ***Activity 4: Take-Home Activity to Assess Student Comprehension***

4.1. Teacher/Leader explains to students they will continue their exploration of food-handling practices related to HACCP at home. Distribute the **Take-Home Activity—HAACP** worksheet and ask students to answer the questions based on what they learned in class today. Instruct students to turn in the worksheet at the next class period. Remind students to take a photo to represent something they learned during this unit and to work on their final project. If students are working with a food product involving produce, they may want to reference the following resources for additional information about hazards:

- *Food Safety for Fruit and Vegetable Farms,* Purdue Extension/University of Illinois Extension, https://www.extension.purdue.edu/extmedia/GP/GP-1-W.pdf
- Integrated Pest Management, G.A.P (Good Agricultural Practices) in Action, GLOBALG.A.P., https://www.youtube.com/watch?v=7qQCLMFjRew
- Good Agricultural Practices on the Farm and in Your Home Garden, College of Tropical Agriculture and Human Resources, University of Hawai'I-Mānoa, https://www.youtube.com/watch?v=wO5miD90wMQ

Materials List

Activity 1: Discussion of Concepts Related to Safe Food-Handling Practices: Wrap-Up of Chose Safe Foods (10 minutes)

- Completed **In-Class Activity – Choose: Are Spices Safe?** from the previous day

Activity 2: Discussion of Concepts Related to Safe Food-Handling Practices: Begin HACCP

- Handout: Hazard Analysis Critical Control Point (HACCP) Video Notes
- Video: Hazard Analysis & Critical Control Points (HACCP)–Fulton County [Georgia], https://www.youtube.com/watch?v=X2kw40KyVnY
- Video: HACCP Food Safety Hazards, https://www.youtube.com/watch?v=lEZbSaikBTw

Activity 3: HACCP In-Class Activity

- In-Class Activity—Pete's Perfect Pretzels Hazard Analysis Critical Control Point (HACCP)

Activity 4: Take-Home Activity to Assess Student Comprehension

- Take-Home Activity—HAACP
- *Food Safety for Fruit and Vegetable Farms,* Purdue Extension/University of Illinois Extension, https://www.extension.purdue.edu/extmedia/GP/GP-1-W.pdf
- Integrated Pest Management, G.A.P (Good Agricultural Practices) in Action, GLOBALG.A.P., https://www.youtube.com/watch?v=7qQCLMFjRew
- Good Agricultural Practices on the Farm and in Your Home Garden, College of Tropical Agriculture and Human Resources, University of Hawai'i–Mānoa, https://www.youtube.com/watch?v=wO5miD90wMQ

Note: Students will need a camera or other technology to take pictures for their final presentation. If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia department technology is available for students who do not have a cell phone, students can make posters using markers or computer-generated pictures to illustrate pictures of what they have learned.

Day	Principle(s)	Unit Objective(s)
7	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die.	• Students present their final projects and explain to the class what they have learned by participating in the food-safety education units.

Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	

Suggested Pre-Knowledge

N/A

State Standards Addressed

Indiana Department of Education, Advanced Life Science: Foods

Core Standard 8 Students validate the necessity of leadership skills development in conjunction with participation in the national FFA Organization (FFA) and/or Family, Career and Community Leaders of America (FCCLA) as a critical component of the course.

Standards

ALSF-8.1 Acquire and demonstrate communication skills such as writing, public speaking, and listening while refining oral, written, and verbal skills

Learning Activities

1. ***Activity 1: Discussion of Concepts Related to Food-Handling Practices: Evaluate Petri Dishes from Choose Experiment***

   1.1. Teacher/Leader instructs students to check the petri dishes from the experiment they designed in the Choose unit. Have students record their results on their **In-Class Activity—Choose Experiment Design**. Allow students 5–10 minutes to record their results, answer the questions on the handout, and clean up. After students have had time to review and record results, ask them to share their experimental design, their results, and their conclusions. Discuss strengths of their designs and what could be improved. Allow 10–15 minutes for class discussion.

2. ***Activity 2: Final Project Presentations***

2.1. Teacher/Leader tells students to begin presentations. Each group presentation should be 5 to 6 minutes long, depending on the number of groups and the length of the class period. Have each group present their projects. Allow time for the class to ask questions of each group. Teachers may choose to grade students using the **Final Project Rubric** included with this curriculum.

Materials List

Activity 1: Discussion of Concepts Related to Food-Handling Practices: Evaluate Petri Dishes from Choose Experiment

- Streaked petri dish from In-Class Activity: Choose Experiment Design
- In-Class Activity: Choose Experiment Design for students to complete

Activity 2: Final Project Presentations

- Student-prepared presentations
- Camera or other technology for students to take pictures
  Note: If students have a camera on their cell phones, they could use their personal camera. If no classroom or multimedia depart technology is available for students who do not have a cell phone, students can make posters using markers or computer-gene pictures to illustrate pictures of what they have learned.
- Projection equipment for electronic presentations

Day	Principle(s)	Unit Objective(s)
8	Each year in the United States, an estimated 48 million people are affected by foodborne illnesses. Of those affected, approximately 128,000 will be hospitalized and approximately 3,000 will die. Practicing safe food-handling techniques can help reduce the risk of foodborne illnesses among consumers.	• Collect data to evaluate changes in student food-safety knowledge, attitudes, and behaviors after participating in this unit.

Learning Activities

1. ***Activity 1: Post-Survey Administration***
   1.1. Teacher/Leader informs students they will conclude the food-safety unit with a post-survey and final cooking activity. Teacher/Leader says, "I would like for you to complete a post-survey to help determine how much you have learned from our study of food safety." If students ask if the post-survey is for a grade, assure them it is ungraded and encourage them to try their best.
   1.2. Distribute the **post-survey**. Allow students 15 minutes to complete the post-survey, and monitor them as they work to deter them from sharing information with one another. Collect the completed post-surveys.

2. ***Activity 2: Cooking Activity***
   2.1. Set up cooking stations as noted in Activity 2 from the Day 1 Learning Activities. Tell students they will be preparing the cheeseburger recipe using different seasonings and topping ingredients.
   2.2. Lead students to the cooking lab. Students should not bring their books or other materials to the lab unless there are places to store these items away from food-preparation areas. In the lab, students should be assigned to the same groups and cooking stations as before. Group 1 should be assigned to station 1; Group 2, to station 2, etc.
   2.3. When all students are at their cooking stations, the teacher/leader says, "You may begin cooking using the recipe at each of your stations. Once you are finished cooking, you may eat what you have made, but you do not have to eat the food you prepared. You will have 30 minutes to prepare your food. I will keep track of time and let you know how much time you have left to cook."
   2.4. Monitor students to ensure that they are using the kitchen equipment safely. The teacher/leader should only offer cooking advice when students are observed preparing food in a way that would result in illness. On the observation checklist, note any instances in which advice was given. Have students indicate when they are finished cooking and measure the internal temperature of the burger patties to ensure the internal temperature is 160°F. If the burger patties are not 160°F, have students continue cooking the burgers until the internal temperature is at least 160°F. In other cases where students are not properly handling food, the teacher should intervene. Any interventions should be noted on the observation sheet. When students are finished cooking, eating, and cleaning up the kitchen for the next class, dismiss the students.
   2.5. Use either video recordings or the included **Student Cooking Observation Checklist** to record the students' food-handling behaviors. Observations from Cooking Lab 1 and Cooking Lab 2 can be used to evaluate student growth and to help students identify areas of competency and improvement.

Materials List

Activity 1: Post-Survey Administration

- Post-survey

Activity 2: Cooking Activity

2.1 Cheeseburger Recipe

- 1 pound ground beef
- ¼ cup mild or spicy nacho cheese sauce
- ½ teaspoon salt
- ½ teaspoon pepper
- hamburger buns, split and toasted

2.2 Cheeseburger Garnishes

- Shredded lettuce
- 4 green onions, sliced

2.3 Salsa

- 2 large plum tomatoes, diced (yields 1 cup)
- $^{1}/_{8}$ cup white onion, chopped
- 1½ tablespoons fresh cilantro, chopped
- 1 teaspoon jalapeño, minced (remove seeds for lower heat)
- ¾ teaspoon fresh lime juice
- ¼ teaspoon kosher salt (or to taste)
- Tortilla chips (for serving salsa)

2.4 Equipment

- Food handler's gloves (enough for class)
- 1 Cooking thermometer
- 1 Skillet
- 1 Spatula
- Mixing bowls
- 1 Spoon

	• 1 Knife • 1 Cutting board 2.5 Student Cooking Observation Checklist 2.6 Optional Video Recording Devices

REFERENCES

Aaron Smith, S. T., Patrick Van Kessel. (2018). Many turn to YouTube for children's content, news, how-to lessons. *An analysis of videos suggeted by the site's recommendation engine finds that users are directed toward progressively longer and more popular content*: Pew Research Center.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179-211.

Al-Shabib, N. A., Mosilhey, S. H., & Husain, F. M. (2016). Cross-sectional study on food safety knowledge, attitude and practices of male food handlers employed in restaurants of King Saud University, Saudi Arabia. *Food Control, 59*, 212-217.

Archer, J., Jervis, E. T., Bird, J., & Gaze, J. E. (1998). Heat resistance of Salmonella weltevreden in low-moisture environments. *Journal of Food Protection, 61*(8), 969-973.

Archila, J. (2019). Flour handling behaviors: Evaluation of self-reported US consumer data and content analysis of popular recipes on YouTube and Cooking Blogs. Retrieved from http://hdl.handle.net/11036/6484.

Ardent Mills. Food safety. Retrieved from https://ardentmills.com/how-we-can-help/food-safety/

Ardent Mills. (2019). Flour food safety. Retrieved from https://www.ardentmills.com/media/1090/ardent_mills_flour_food_safety_white_paper.pdf

Balasubramaniam, S. M., Bhargava, S., Agrawal, N., Asif, R., Chawngthu, L., Sinha, P., . . . Sood, B. (2018). Blending virtual with conventional learning to improve student midwifery skills in India. *Nurse Education in Practice, 28,* 163-167.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206.

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman and Company, New York, NY.

Bari, M. L., Nei, D., Sotome, I., Nishina, I., Isobe, S., & Kawamoto, S. (2009). Effectiveness of sanitizers, dry heat, hot water, and gas catalytic infrared heat treatments to inactivate Salmonella on almonds. *Foodborne Pathogens and Disease, 6*(8), 953-958.

Barrett, T., & Feng, Y. *Observational evaluation of food safety curricula on high school students' behavior change* [Manuscript in preparation]. Department of Food Science, Purdue University.

Barrett, T., Wang, H.-H., & Feng, Y. *Food safety in the classroom: using the Delphi Technique to evaluate researcher-developed food safety curriculum aligned to state academic standards* [Manuscript in preparation]. Department of Food Science, Purdue University.

Bassyouni, R. H., El-Sherbiny, N., Hefzy, E. H., & Wegdan, A.-A. (2012). Perception of food safety and prevalence of Staphylococcus aureus and Salmonella species carriers among Fayoum University food handlers. *Life Science Journal, 9*(4), 2934-2940.

Beecher, C. (2019). Consumers need wake-up call about potential dangers of flour. Retrieved from https://www.foodsafetynews.com/2019/08/consumers-need-wake-up-call-about-potential-dangers-of-flour/

Bermudez-Millan, A., Perez-Escamilla, R., Damio, G., Gonzalez, A., & Segura-Perez, S. (2004). Food safety knowledge, attitudes, and behaviors among Puerto Rican caretakers living in Hartford, Connecticut. *Journal of Food Protection, 67*(3), 512-516.

Boud, D., & Feletti, G. (2013). *The challenge of problem-based learning*: Routledge.
Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick*: Harvard University Press.
Brown, R. (1999). The complete facilitator's handbook. *Training Journal*, 9.
Buccheri, C., Mammina, C., Giammanco, S., Giammanco, M., La Guardia, M., & Casuccio, A. (2010). Knowledge, attitudes and self-reported practices of food service staff in nursing homes and long-term care facilities. *Food Control, 21*(10), 1367-1373.
Bureau of Labor Statistics. (2019, June 13). *Occupational outlook handbook*. Food and beverage serving and related workers. Retrieved from https://www.bls.gov/ooh/food-preparation-and-serving/food-and-beverage-serving-and-related-workers.htm#tab-3
Burke, A., & Dworkin, M. (2015). How knowledgeable are high school students about food safety? Results from a predominantly minority Chicago charter school. *British Food Journal, 117*(6), 1737-1752.
Byrd-Bredbenner, C., Abbot, J. M., & Quick, V. (2010). Food safety knowledge and beliefs of middle school children: Implications for food safety educators. *Journal of Food Science Education, 9*(1), 19-30.
Cañigueral, R., & Hamilton, A. F. d. C. (2019). Effects of being watched on self-referential processing, self-awareness and prosocial behaviour. *Consciousness and Cognition, 76*, 102830.
Cates, S. C., Carter-Young, H. L., Durocher, B. L., Williams, C., & Conley, S. (2002). Thermometer usage messages and delivery mechanisms for parents of young children. Research Triangle Park, NC: Research Triangle Institute.
Centers for Disease Control and Prevention. (2018, November 5). *Estimates of foodborne illness in the United States.* Burden of foodborne illness: findings. Retrieved from https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html
Cepeda, N. J., Vul, E., Rohrer, D., Wixted, J. T., & Pashler, H. (2008). Spacing effects in learning: A temporal ridgeline of optimal retention. *Psychological Science, 19*(11), 1095-1102.
Chang, S. S., Han, A., Reyes-De-Corcuera, J., Powers, J., & Kang, D. H. (2010). Evaluation of steam pasteurization in controlling Salmonella serotype Enteritidis on raw almond surfaces. *Letters in Applied Microbiology, 50*(4), 393-398.
Chen, D.-F., Wu, T.-C., Chen, C.-H., Chang, S.-H., Yao, K.-C., & Liao, C.-W. (2016). Developing an industry-oriented safety curriculum using the Delphi technique. *International Journal of Injury Control and Safety Promotion, 23*(3), 302-316.
Chen, Y., & Timmins, C. (2018). How consumers respond to food safety crisis: A study of peanut butter and egg recalls on consumer behavior. *Economic Research Initiatives at Duke (ERID)* [Manuscript in preparation]. Department of Economics, Duke University.
Choukas-Bradley, S., Giletta, M., Cohen, G. L., & Prinstein, M. J. (2015). Peer influence, peer status, and prosocial behavior: An experimental investigation of peer socialization of adolescents' intentions to volunteer. *Journal of Youth and Adolescence, 44*(12), 2197-2210.
Chow, S., & Mullan, B. (2010). Predicting food hygiene. An investigation of social factors and past behaviour in an extended model of the Health Action Process Approach. *Appetite, 54*(1), 126-133.
Christou, C., Eliophotou-Menon, M., & Philippou, G. (2004). Teachers' concerns regarding the adoption of a new mathematics curriculum: An application of CBAM. *Educational Studies in Mathematics, 57*(2), 157-176.

Clayton, D. A., & Griffith, C. J. (2008). Efficacy of an extended Theory of Planned Behaviour model for predicting caterers' hand hygiene practices. *International Journal of Environmental Health Research*, *18*(2), 83-98.

Cohen, N. L., & Olson, R. B. (2016). Compliance with recommended food safety practices in television cooking shows. *Journal of Nutrition Education and Behavior, 48*(10), 730-734. e731.

Conner, M., & Norman, P. (2005). *Predicting Health Behaviour Research and Practice with Social Cognition Models*, (2nd ed.). Maidenhead: Open University Press.

Corso, M. J., Bundick, M. J., Quaglia, R. J., & Haywood, D. E. (2013). Where student, teacher, and content meet: Student engagement in the secondary school classroom. *American Secondary Education*, 50-61.

Cunningham-Sabo, L., & Lohse, B. (2013). Cooking with kids positively affects fourth graders' vegetable preferences and attitudes and self-efficacy for food and cooking. *Childhood Obesity, 9*(6), 549-556.

Cuomo, M. T., Tortora, D., Festa, G., Giordano, A., & Metallo, G. (2017). Enablers for end-user entrepreneurship: An investigation on Italian food bloggers. *Psychology & Marketing, 34*(12), 1109-1118.

Dajani, J. S., Sincoff, M. Z., & Talley, W. K. (1979). Stability and agreement criteria for the termination of Delphi studies. *Technological Forecasting and Social Change, 13*(1), 83-90.

Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: A scoping review. *Health Psychology Review, 9*(3), 323-344.

De Boeck, E., Mortier, A., Jacxsens, L., Dequidt, L., & Vlerick, P. (2017). Towards an extended food safety culture model: Studying the moderating role of burnout and jobstress, the mediating role of food safety knowledge and motivation in the relation between food safety climate and food safety behavior. *Trends in Food Science & Technology, 62*, 202-214.

DeKeyser, R. (2007). Skill Acquisition Theory. In B. VanPatten & J. Williams (Eds.), *Theories in second language acquisition: An introduction* (pp 94-107). New York, NY: Routledge.

Dickinson, K. M., Watson, M. S., & Prichard, I. (2018). Are clean eating blogs a source of healthy recipes? A comparative study of the nutrient composition of foods with and without clean eating claims. *Nutrients, 10*(10), 1440.

Diplock, K. J., Dubin, J. A., Leatherdale, S. T., Hammond, D., Jones-Bitton, A., & Majowicz, S. E. (2018). Observation of high school students' food handling behaviors: Do they improve following a food safety education intervention? *Journal of Food Protection, 81*(6), 917-925.

Diplock, K. J., Jones-Bitton, A., Leatherdale, S. T., Rebellato, S., Hammond, D., & Majowicz, S. E. (2019). Food safety education needs of high-school students: Leftovers, lunches, and microwaves. *Journal of School Health, 89*(7), 578-586.

Dreibelbis, R., Kroeger, A., Hossain, K., Venkatesh, M., & Ram, P. K. (2016). Behavior change without behavior change communication: Nudging handwashing among primary school students in Bangladesh. *International Journal of Environmental Research and Public Health, 13*(1), 129.

Du, W.-X., Abd, S. J., McCarthy, K. L., & Harris, L. J. (2010). Reduction of Salmonella on inoculated almonds exposed to hot oil. *Journal of Food Protection, 73*(7), 1238-1246.

Edwards, C. M., Rule, A. C., & Boody, R. M. (2017). Middle school students' mathematics knowledge retention: Online or face-to-face environments. *Journal of Educational Technology & Society, 20*(4), 1-10.

Elshahat, S., Woodside, J. V., & McKinley, M. C. (2019). Meat thermometer usage amongst European and North American consumers: A scoping review. *Food Control, 106,* 106692.

Emke, A. R., Butler, A. C., Larsen, D. P., Emke, A. R., Butler, A. C., Larsen, D. P., . . . Larsen, D. P. (2016). Effects of team-based learning on short-term and long-term retention of factual knowledge effects of team-based learning on short-term and long-term retention of factual knowledge. *Medical Teacher, 38*(3), 306-311.

Evans, E. W., & Redmond, E. C. (2018). Behavioral observation and microbiological analysis of older adult consumers' cross-contamination practices in a model domestic kitchen. *Journal of Food Protection, 81*(4), 569-581.

Fan, C. K., & Cheng, C. L. (2006). A study to identify the training needs of life insurance sales representatives in Taiwan using the Delphi approach. *International Journal of Training and Development, 10*(3), 212-226.

Farland, M. Z., Franks, A. S., Barlow, P. B., Rowe, A. S., & Chisholm-Burns, M. (2015). Assessment of student learning patterns, performance, and long-term knowledge retention following use of didactic lecture compared to team-based learning. *Currents in Pharmacy Teaching and Learning, 7*(3), 317-323.

Feng, Y. (In press). Consumer Flour Survey. *Journal of Food Protection*.

Feng, Y., & Bruhn, C. M. (2019). Motivators and barriers to cooking and refrigerator thermometer use among consumers and food workers: A review. *Journal of Food Protection, 82*(1), 128-150.

Feng, Y., Bruhn, C. M., Elder, G., & Boyden, D. (2019). Assessment of knowledge and behavior change of a high school positive deviance food safety curriculum. *Journal of Food Science Education, 18*(2), 45-51.

Ferreira, J. J., Maguta, L., Chissaca, A. B., Jussa, I. F., & Abudo, S. S. (2016). Cohort study to evaluate the assimilation and retention of knowledge after theoretical test in undergraduate health science. *Porto Biomedical Journal, 1*(5), 181-185.

Food and Drug Administration. (2019). *21 CFR 101.17 (h)*. Retrieved from https://www.govinfo.gov/content/pkg/CFR-2019-title21-vol2/xml/CFR-2019-title21-vol2-sec101-17.xml.

Glanz, K., Rimer, B. K., & Viswanath, K. (2015). *Health behavior: Theory, research, and practice*. San Francisco, CA: Jossey-Bass.

Godwin, S., Maughan, C., & Chambers, E. (2016). Food safety: Recommendations for determining doneness in consumer egg dish recipes and measurement of endpoint temperatures when recipes are followed. *Foods, 5*(3), 45.

Goldstein, C. M. (2012). *Creating consumers: Home economists in twentieth-century America*. Chapel Hill, NC: University of North Carolina Press.

Gommans, R., Sandstrom, M. J., Stevens, G. W., ter Bogt, T. F., & Cillessen, A. H. (2017). Popularity, likeability, and peer conformity: Four field experiments. *Journal of Experimental Social Psychology, 73*, 279-289.

Gonczi, A. (2013). Competency-based approaches: Linking theory and practice in professional education with particular reference to health education. *Educational Philosophy and Theory, 45*(12), 1290-1306.

Gould, L. H., Walsh, K. A., Vieira, A. R., Herman, K., Williams, I. T., Hall, A. J., & Cole, D. (2013). Surveillance for foodborne disease outbreaks—United States, 1998–2008. *Morbidity and Mortality Weekly Report: Surveillance Summaries*, *62*(2), 1-34.

Granito, M., & Chernobilsky, E. (2012). The effect of technology on a student's motivation and knowledge retention. *NERA Conference Proceedings 2012*. Retrieved from https://opencommons.uconn.edu/nera_2012/17.

Grechus, M., & Brown, J. (2000). Comparison of individualized computer game reinforcement versus peer-interactive board game reinforcemen on retention of nutrition label knowledge. *Journal of Health Education, 31*(3), 138-142.

Heiko, A. (2012). Consensus measurement in Delphi studies: Review and implications for future quality assurance. *Technological Forecasting and Social Change*, *79*(8), 1525-1536.

Hendryx, M., Guerra-Reyes, L., Holland, B. D., McGinnis, M. D., Meanwell, E., Middlestadt, S. E., & Yoder, K. M. (2017). A county-level cross-sectional analysis of positive deviance to assess multiple population health outcomes in Indiana. *BMJ Open, 7*(10), e017370.

Her, E., Seo, S., Choi, J., Pool, V., & Ilic, S. (2019). Assessment of food safety at university food courts using surveys, observations, and microbial testing. *Food Control, 103*, 167-174.

Herington, M. J., & van de Fliert, E. (2018). Positive deviance in theory and practice: A conceptual review. *Deviant Behavior, 39*(5), 664-678.

Huang, C. (2011). Self-concept and academic achievement: A meta-analysis of longitudinal relations. *Journal of School Psychology, 49*(5), 505-528.

Humphrey-Murto, S., Varpio, L., Gonsalves, C., & Wood, T. J. (2017). Using consensus group methods such as Delphi and Nominal Group in medical education research. *Medical Teacher, 39*(1), 14-19.

Jonassen, D. H., & Hung, W. (2015). All problems are not equal: Implications for problem-based learning. In A. Walker, H. Leary, & C. Hmelo-Silver. (Eds.), *Essential readings in problem-based learning*, (pp. 17-41). West Lafayette, IN: Purdue University Press.

Kang, S. H. (2016). Spaced repetition promotes efficient and effective learning: Policy implications for instruction. *Policy Insights from the Behavioral and Brain Sciences, 3*(1), 12-19.

Karakos, H. L. (2014). Positive peer support or negative peer influence? The role of peers among adolescents in recovery high schools. *Peabody Journal of Education, 89*(2), 214-228.

Kendall, P. A., Elsbernd, A., Sinclair, K., Schroeder, M., Chen, G., Bergmann, V., . . . Medeiros, L. C. (2004). Observation versus self-report: Validation of a consumer food behavior questionnaire. *Journal of Food Protection, 67*(11), 2578-2586.

King Arthur Flour. Flour safety. Retrieved from https://www.kingarthurflour.com/about/products/docs/flour-safety#

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education, 4*(2), 193-212.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. Upper Saddle River, NJ: Pearson Education, Inc.

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2001a). Experiential learning theory: Previous research and new directions. In R. J. Sternberg & L. Zhang (Eds.), *Perspectives on Thinking, Learning, and Cognitive Styles* (pp. 227-247). New York, NY: Routledge.

Krijtenburg-Lewerissa, K., Pol, H., Brinkman, A., & van Joolingen, W. (2019). Key topics for quantum mechanics at secondary schools: A Delphi study into expert opinions. *International Journal of Science Education, 41*(3), 349-366.

Kuh, G., Schneider, C., & Association of American Colleges Universities. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Washington, DC: Association of American Colleges and Universities.

Kwiatkowska, M. (2016, May). Measuring the difficulty of test items in computing science education. *Western Canadian Conference on Computing Education.* Paper presented at 2016 Proceedings of the 21st Western Canadian Conference on Computing Education, Kamloops, BC, Canada.

Leachman, M., Masterson, K., & Figueroa, E. (2017). A punishing decade for school funding. *Center on Budget and Policy Priorities*. Retrieved from https://www.cbpp.org/research/state-budget- and-tax/a-punishing-decade-for-school-funding

Lee, O., & Brophy, J. (1996). Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 33*(3), 303-318.

LeMahieu, P. G., Nordstrum, L. E., & Gale, D. (2017). Positive deviance: Learning from positive anomalies. *Quality Assurance in Education*, *25*(1), 109-124.

Levine, K., Chaifetz, A., & Chapman, B. (2017). Evaluating food safety risk messages in popular cookbooks. *British Food Journal*, *119*(5), 1116-1129.

Li, M., Yan, S., Yang, D., Li, B., & Cui, W. (2019). YouTube™ as a source of information on food poisoning. *BMC Public Health*, *19*(1), 952.

Li, T., Bernard, J. C., Johnston, Z. A., Messer, K. D., & Kaiser, H. M. (2017). Consumer preferences before and after a food safety scare: An experimental analysis of the 2010 egg recall. *Food Policy, 66*, 25-34.

Lindsey, R. V., Shroyer, J. D., Pashler, H., & Mozer, M. C. (2014). Improving students' long-term knowledge retention through personalized review. *Psychological Science, 25*(3), 639-647.

Liu, Z.-X., Grady, C., & Moscovitch, M. (2017). Effects of prior-knowledge on brain activation and connectivity during associative memory encoding. *Cerebral Cortex*, *27*(3), 1991-2009.

Löfmark, A., & Mårtensson, G. (2017). Validation of the tool assessment of clinical education (AssCE): A study using Delphi method and clinical experts. *Nurse Education Today, 50*, 82-86.

Majowicz, S. E., Diplock, K. J., Leatherdale, S. T., Bredin, C. T., Rebellato, S., Hammond, D., . . . Dubin, J. A. (2015). Food safety knowledge, attitudes and self-reported practices among Ontario high school students. *Canadian Journal of Public Health, 106*(8), 520-526.

Majowicz, S. E., Hammond, D., Dubin, J. A., Diplock, K. J., Jones-Bitton, A., Rebellato, S., & Leatherdale, S. T. (2017). A longitudinal evaluation of food safety knowledge and attitudes among Ontario high school students following a food handler training program. *Food Control*, *76*, 108-116.

Mari, S., Tiozzo, B., Capozza, D., & Ravarotto, L. (2012). Are you cooking your meat enough? The efficacy of the Theory of Planned Behavior in predicting a best practice to prevent salmonellosis. *Food Research International*, *45*(2), 1175-1183.

Masud, T., Blundell, A., Gordon, A. L., Mulpeter, K., Roller, R., Singler, K., . . . Stuck, A. (2014). European undergraduate curriculum in geriatric medicine developed using an international modified Delphi technique. *Age and Ageing*, *43*(5), 695-702.

Matvienko, O., Lewis, D. S., & Schafer, E. (2001). A college nutrition science course as an intervention to prevent weight gain in female college freshmen. *Journal of Nutrition Education, 33*(2), 95-101.

Maughan, C., Chambers IV, E., & Godwin, S. (2017). Food safety behaviors observed in celebrity chefs across a variety of programs. *Journal of Public Health, 39*(1), 105-112.

Maughan, C., Godwin, S., Chambers, D., & Chambers IV, E. (2016). Recipe modification improves food safety practices during cooking of poultry. *Journal of Food Protection, 79*(8), 1436-1439.

Mazengia, E., Fisk, C., Liao, G., Huang, H., & Meschke, J. (2015). Direct observational study of the risk of cross-contamination during raw poultry handling: Practices in private homes. *Food Protection Trends, 35*(1), 8-23.

McConchie, J., Hite, B. J., Blackard, M. B., & Cheung, R. C. M. (2019). With a little help from my friends: Development and validation of the positive peer influence inventory. *Applied Developmental Science*, 1-20.

Melnick, S. A., & Meister, D. G. (2008). A comparison of beginning and experienced teachers' concerns. *Educational Research Quarterly, 31*(3), 39-56.

Mo, Y. (2008). *Opportunity to learn, engagement, and science achievement: Evidence form TIMSS 2003 Data* (Doctoral dissertation). Retrieved from http://hdl.handle.net/10919/29564.

Mohr-Schroeder, M., Jackson, C., Schroeder, D. C., and Wilhelm, J. (2019). Developing a STEM education teacher preparation program to help increase STEM literacy among preservice teachers. In P. M. Jenlink, Jenlink, K. E. (Eds.), *The next generation of STEM teachers: An interdisciplinary approach to meet the needs of the future* (pp. 93-112). Lanham, Maryland: Rowman & Littlefield.

Morrison, E., & Young, I. (2019). The Missing Ingredient: Food Safety Messages on Popular Recipe Blogs. *Food Protection Trends, 39*(1), 28-39.

Mullan, B., Allom, V., Sainsbury, K., & Monds, L. A. (2015). Examining the predictive utility of an extended Theory of Planned Behaviour model in the context of specific individual safe food-handling. *Appetite, 90,* 91-98.

Mullan, B. A., Wong, C., & Kothe, E. J. (2013). Predicting adolescents' safe food handling using an extended Theory of Planned Behavior. *Food Control, 31*(2), 454-460.

Mullan, B. A., & Wong, C. L. (2009). Hygienic food handling behaviours. An application of the Theory of Planned Behaviour. *Appetite, 52*(3), 757-761.

National Association for Gifted Children. Traits of giftedness. Retrieved from https://www.nagc.org/resources-publications/resources/my-child-gifted/common-characteristics-gifted-individuals/traits

National Science Foudnation. (2013). International household germ study. Retrieved from https://www.nsf.org/newsroom_pdf/2013_germ_study_FOR-WEB-ONLY.pdf

National Society for the Gifted and Talented. (n.d.) Giftedness defined - NSGT. Retrieved from https://www.nsgt.org/giftedness-defined/

Nauta, M. M., Kahn, J. H., Angell, J. W., & Cantarelli, E. A. (2002). Identifying the antecedent in the relation between career interests and self-efficacy: Is it one, the other, or both? *Journal of Counseling Psychology, 49*(3), 290.

North American Miller's Association. (2017). Grain milling industry releases new consumer educational food safety video for wheat flour: Proper handling and baking of flour eliminates food safety risk. Retrieved from https://www.namamillers.org/wp-content/uploads/2017/09/NAMA-News-Release-Grain–Milling-Industry-Releases-New–Consumer-Educational-Food-Safety-Video-for-Wheat-Flour-09-7-17.pdf.

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education, 37*(7), 1067-1088.

Ovca, A., Jevšnik, M., & Raspor, P. (2018). Food safety practices of future food handlers and their teachers, observed during practical lessons. *British Food Journal, 120*(3), 531-548.

Palak K. Panchal, P. B., Mark. S. (2013). Food safety knolwedge among restaurant food handlers in Neuchatel, Switzerland. *Food Protection Trends, 33*, 133-144.

Partnership for Food Safety Education. The Core Four Practices. Retrieved from http://www.fightbac.org/food-safety-basics/the-core-four-practices/

Partnership for Food Safety Education. New Tool Launched to Improve Consumer Food Safety at Home. Retrieved from https://www.saferecipeguide.org/news/

Pennsylvania Association for Gifted Education, & Pennsylvania State Education Association. (2009, October). Understanding and challenging the gifted. Retrieved from https://www.psea.org/globalassets/for-members/professional-practice/special--gifted-education/files/understandingandchallengingthegifted.pdf.

Pillsbury. Flour safety: What you need to know. Retrieved from https://www.pillsburybaking.com/flour-safety

Prestwich, A., Webb, T. L., & Conner, M. (2015). Using theory to develop and test interventions to promote changes in health behaviour: Evidence, issues, and recommendations. *Current Opinion in Psychology, 5*, 1-5.

Qiang, L., Wen, L., Jing, W., & Yue, D. (2011). Application of content analysis in food safety reports on the Internet in China. *Food Control, 22*(2), 252-256.

Quick, V., Byrd-Bredbenner, C., & Corda, K. (2011). Kitchen Ninja to the rescue: development and formative evaluation of a food safety education game targeting middle school youth. *Journal of Nutrition Education and Behavior, 43*(4), S37-S38.

Reddy, K., Kearns, M., Alvarez-Arango, S., Carrillo-Martin, I., Cuervo-Pardo, N., Cuervo-Pardo, L., . . . Schroer, B. (2018). YouTube and food allergy: An appraisal of the educational quality of information. *Pediatric Allergy and Immunology, 29*(4), 410-416.

Redmond, E., Griffith, C., McCurdy, S. M., Takeuchi, M. T., Edwards, Z. M., Edlefsen, M., . . . Hillers, V. N. (2006). Food safety education initiative to increase consumer use of food thermometers in the United States. *British Food Journal, 108*(9), 775-794.

Rhoades, E. & Ellis, J. D. (2010). Food tube: Coverage of food safety issues through video. *Journal of Food Safety, 30*(1), 162-176.

Rhodes, M. T., & Kuchler, F. (2020). The influence of time use, risk factors and occupation on meal preparers' use of food thermometers. *Food Protection Trends, 40*(1), 16-28.

Rochester, S., Kelly, M., Disler, R., White, H., Forber, J., & Matiuk, S. (2012). Providing simulation experiences for large cohorts of 1st year nursing students: Evaluating quality and impact. *Collegian, 19*(3), 117-124.

Ronto, R., Ball, L., Pendergast, D., & Harris, N. (2017). What is the status of food literacy in Australian high schools? Perceptions of home economics teachers. *Appetite, 108*, 326-334.

Rose, A. J., & McCullough, M. B. (2017a). A practical guide to using the positive deviance method in health services research. *Health Services Resesearch, 52*(3), 1207-1222.

Ruby, G. E., Abidin, U. F. U. Z., Lihan, S., Jambari, N. N., & Radu, S. (2019). Predicting intention on safe food handling among adult consumers: A cross sectional study in Sibu district, Malaysia. *Food Control, 106*, 106696.

Sanlier, N. (2009). The knowledge and practice of food safety by young and adult consumers. *Food Control, 20*(6), 538-542.

Schrempft, S., van Jaarsveld, C. H., & Fisher, A. (2017a). Exploring the potential of a wearable camera to examine the early obesogenic home environment: Comparison of SenseCam images to the home environment interview. *Journal of Medical Internet Research, 19*(10), 332.

Schroeder, M., Yang, L., Eifert, J., Boyer, R., Chase, M., & Nieto-Montenegro, S. (2016). Evaluation of how different signs affect poultry processing employees' hand washing practices. *Food Control, 68*, 1-6.

Scott, E. (2003). Food safety and foodborne disease in the 21st century. *Canadian Journal of Infectious Diseases and Medical Microbiology, 14*(5), 277-280.

Seagle, E., & Iverson, M. (2002). Characteristics of the turfgrass industry in 2020: A Delphi study with implications for agricultural education programs. *Journal of Southern Agricultural Research, 52*(1), 1-13.

Sharman, N., Wallace, C. A., & Jespersen, L. (2020). Terminology and the understanding of culture, climate, and behavioural change–Impact of organisational and human factors on food safety management. *Trends in Food Science & Technology, 96*, 13-20.

Shayaa, S., Jaafar, N. I., Bahri, S., Sulaiman, A., Wai, P. S., Chung, Y. W., . . . Al-Garadi, M. A. (2018). Sentiment analysis of big data: Methods, applications, and open challenges. *IEEE Access, 6*, 37807-37827.

Shikha, R. S & Yadav, MPS. (2018). Effects of whey supplementation on physico-chemical evaluation of developed cookies. *International Journal of Home Science, 4*(2), 130-132.

Shoulders, T. L., & Krei, M. S. (2015). Rural high school teachers' self-efficacy in student engagement, instructional strategies, and classroom management. *American Secondary Education, 44*(1), 50.

Sibley, J., & Ostafichuk, P. (2014). *Getting started with team-based learning*. Sterling, VA: Stylus Publishing, LLC.

Simmonds, S., Roux, C., & Avest, I. t. (2015). Blurring the boundaries between photovoice and narrative inquiry: A narrative-photovoice methodology for gender-based research. *International Journal of Qualitative Methods, 14*(3), 33-49.

Singer, F. M., Sheffield, L. J., Freiman, V., & Brandl, M. (2016). *Research on and activities for mathematically gifted students*. AG Switzerland: Springer International Publishing.

Soon, J. M. (2019). Finger licking good? An observational study of hand hygiene practices of fast food restaurant employees and consumers. *British Food Journal, 121*(3), 697-710.

Sourani, A., & Sohail, M. (2015). The Delphi method: Review and use in construction management research. *International Journal of Construction Education and Research, 11*(1), 54-76.

Syamaladevi, R. M., Tadapaneni, R. K., Xu, J., Villa-Rojas, R., Tang, J., Carter, B., . . . Marks, B. (2016). Water activity change at elevated temperatures and thermal resistance of Salmonella in all purpose wheat flour and peanut butter. *Food Research International, 81*, 163-170.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*(6), 1273-1296.

Tahir, S., Chowdhury, D., Legge, M., Hu, H., Whiteley, G., Glasbey, T., . . . Vickery, K. (2019). Transmission of Staphylococcus aureus from dry surface biofilm (DSB) via different types of gloves. *Infection Control & Hospital Epidemiology, 40*(1), 60-64.

Taylor, G. W., Stumpos, M. L., Kerschbaum, W., & Inglehart, M. R. (2014). Educating dental students about diet-related behavior change: Does experiential learning work? *Journal of Dental Education, 78*(1), 64-74.

The Acheson Group. (2018). Are You Producing an RTE Food … and Don't Realize It? Retrieved from https://www.achesongroup.com/post/are-you-producing-an-rte-food-and-don-t-realize-it

Tran, V. D. (2014). The effects of cooperative learning on the academic achievement and knowledge retention. *International Journal of Higher Education, 3*(2), 131-140.

Umberson, B. & Roberts, J. (2018). Validating Heat-Treated Flour. *Food Quality & Safety Farm to Fork Safety, 25*(1), 3.

United States Department of Agriculture. (n.d.) Employment opportunities for college graduates in food, agriculture, renewable natural resources, and the environment. Retrieved from https://www.purdue.edu/usda/employment/

United States Department of Agriculture. (2019). Say no to raw dough! Retrieved from https://www.cdc.gov/features/no-raw-dough/index.html

United States Food and Drug Administration. (2009). Production, storage, and transportation of shell eggs. Retrieved from https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfCFR/CFRSearch.cfm?CFRPart=118

United States Food and Drug Administration. (2017). Raw dough's a raw deal and could make you sick. Retrieved from https://www.fda.gov/consumers/consumer-updates/raw-doughs-raw-deal-and-could-make-you-sick

United States Food and Drug Administration. (2019a). Handling flour safely: What you need to know. Retrieved from https://www.fda.gov/food/buy-store-serve-safe-food/handling-flour-safely-what-you-need-know

United States Food and Drug Administration. (2019b). Holiday Food Safety. Retrieved from https://www.fda.gov/food/buy-store-serve-safe-food/holiday-food-safety

United States Food and Drug Administration. (2020, February 15). Recalls, Market Withdrawals, & Safety Alerts. Retrieved from https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts

United States, & Food Safety Inspection Service. (1998). *Focus groups on barriers that limit consumers' use of thermometers when cooking meat and poultry products: Phase one: Final report*. Washington D.C.: The Dept.

Uçar, F. M., & Sungur, S. (2017). The role of perceived classroom goal structures, self-efficacy, and engagement in student science achievement. *Research in Science & Technological Education, 35*(2), 149-168.

Villa-Rojas, R., Tang, J., Wang, S., Gao, M., Kang, D.-H., Mah, J.-H., . . . Lopez-Malo, A. (2013). Thermal inactivation of Salmonella Enteritidis PT 30 in almond kernels as influenced by water activity. *Journal of Food Protection, 76*(1), 26-32.

Vo, T. H., Le, N. H., Le, A. T. N., Minh, N. N. T., & Nuorti, J. P. (2015). Knowledge, attitudes, practices and training needs of food-handlers in large canteens in Southern Vietnam. *Food Control, 57*, 190-194.

Wenger, M. (2009). *A social theory of learning.* New York, NY: Routledge.
White, A. E., Sabourin, K. R., & Scallan, E. (2018). The foodborne outbreak challenge—using experiential learning to foster interdisciplinary training among students on foodborne disease outbreak investigations. *Journal of Food Scence Education, 17*(2), 60-65.
Whited, T., Feng, Y., & Bruhn, C. M. (2019). Evaluation of the high school food safety curriculum using a positive deviance model. *Food Control, 96*, 324-328.
Woods, R. D. (2015). *Television celebrity chefs as role models for consumer's safe food handling in the home* (Master's thesis). Retrieved from https://search.proquest.com/docview/1695282777?accountid=13360
Worsley, A., Wang, W., Yeatman, H., Byrne, S., & Wijayaratne, P. (2016). Does school health and home economics education influence adults' food knowledge? *Health Promotion International, 31*(4), 925-935.
Xu, Z., & Shi, Y. (2018). Application of Constructivist Theory in flipped classroom—Take college English teaching as a case study. *Theory and Practice in Lanuage. Studies, 8*(7), 880-887.
Yiannas, F. (2015). *Food safety = behavior: 30 proven techniques to enhace employee compliance.* New York, NY: Springer.
Yoo, J. H. & Kim, J. (2012). Obesity in the new media: A content analysis of obesity videos on YouTube. *Health Communication, 27*(1), 86-97.
York, V. K., Brannon, L. A., Shanklin, C. W., Roberts, K. R., Barrett, B. B., & Howells, A. D. (2009). Intervention improves restaurant employees' food safety compliance rates. *International Journal of Contemporary Hospitality Management, 21*(4), 459-478.
Young, I., Reimer, D., Greig, J., Turgeon, P., Meldrum, R., & Waddell, L. (2017). Psychosocial and health-status determinants of safe food handling among consumers: A systematic review and meta-analysis. *Food Control, 78*, 401-411.
Young, I., Thaivalappil, A., Greig, J., Meldrum, R., & Waddell, L. (2018). Explaining the food safety behaviours of food handlers using theories of behaviour change: A systematic review. *International Journal of Environmental Health Research, 28*(3), 323-340.
Zhang, H., Lu, L., Liang, J., & Huang, Q. (2015). Knowledge, attitude and practices of food safety amongst food handlers in the coastal resort of Guangdong, China. *Food Control, 47*, 457-461.
Zhang, N. (2016). *Public Perceptions Of Genetically Modified Food On Social Media: A Content Analysis Of Youtube Comments On Videos* (Master's thesis). Retrieved from https://scholarcommons.sc.edu/etd/3981.