Implementing food science-based instruction in career technical education courses

Jasmine D. Hendrix

Mississippi State University, jdhendrix16@gmail.com

Follow this and additional works at: https://scholarsjunction.msstate.edu/td

Part of the Agricultural Education Commons, Curriculum and Instruction Commons, Educational Assessment, Evaluation, and Research Commons, Food Chemistry Commons, Food Microbiology Commons, Food Processing Commons, Other Food Science Commons, Other Teacher Education and Professional Development Commons, Secondary Education Commons, Secondary Education and Teaching Commons, and the Vocational Education Commons

Recommended Citation

Hendrix, Jasmine D., "Implementing food science-based instruction in career technical education courses" (2021). Theses and Dissertations. 5321.
https://scholarsjunction.msstate.edu/td/5321

This Dissertation - Open Access is brought to you for free and open access by the Theses and Dissertations at Scholars Junction. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of Scholars Junction. For more information, please contact scholcomm@msstate.libanswers.com.
Implementing food science-based instruction in career technical education courses

By

Jasmine D. Hendrix

Approved by:

M. Wes Schilling (Co-Major Professor)
David R. Buys (Co-Major Professor)
Laura Hall Downey (Minor Professor)
Juan L. Silva (Committee Member)
Shecoya White (Committee Member)
Wen-Hsing Cheng (Graduate Coordinator)
Scott T. Willard (Dean, College of Agriculture and Life Sciences)

A Dissertation
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
in Food Science and Technology
in the Department of Food Science, Nutrition, and Health Promotion

Mississippi State, Mississippi

December 2021
Students are exposed to food concepts in agriculture-based career technical education (CTE) courses which provide a gateway for students to become more aware of food science career pathways. Professional development for Mississippi (MS) CTE teachers is needed to effectively implement food science-based instruction since there is not a food science curriculum framework adopted in MS. The objective of this study was to assess a food science professional development training for MS CTE teachers that would increase their self-perceived knowledge of food science, self-perceived ability to conduct food science skills, and their self-efficacy to implement food science-based instruction. Thirty-one teachers participated in a 2-h professional development (PD) training that provided teachers an experiential learning opportunity to learn and apply food science concepts. Results indicated that the food science PD training was effective at increasing teachers’ self-perceived knowledge and ability to conduct food science skills. Post training, more than 77% of the participating teachers were more confident in their ability to teach food science concepts. Overall, teachers were satisfied with the food science PD training.
After participating in the food science PD training, teachers were asked to implement food science-based instruction in their CTE courses. A pilot test was conducted to examine MS CTE teachers’ (N=4) perception of implementing food science-based instruction that was provided to them. Post implementation, each teacher participated in a semi-structured interview to capture each teacher’s detailed experience pertaining to the implementation of the food science-based instruction. A conventional content analysis was used to analyze teacher responses. Research findings indicated that MS CTE teachers were interested in teaching food science to increase student knowledge of food science and to enhance student performance on the Future Farmers of America food science career development event. All teachers noted that they had a positive experience implementing the food science toolkit and that they intend to use the food science-based instruction in the future. MS CTE teachers perceived that the food science toolkit increased student exposure to, engagement in, and interest in food science academic and career pathways.

Key words: teaching toolkit, secondary education, curriculum, implementation, career pathways, academic pathways, self-perceived knowledge, self-efficacy
DEDICATION

To my husband, Denzel, who amazingly supported and encouraged me along this PhD journey. In your words, “We ball TOGETHER, and we win TOGETHER!”

Forever my Always
ACKNOWLEDGEMENTS

First and most importantly, ALL honor and praise belong to my Lord and Savior Jesus Christ who has orchestrated every aspect of my PhD journey! As John 15:5 states, He is the vine, and I am simply a branch. If I abide in Him and He in me, I can bear much fruit, but apart from Him I can’t do anything. This dissertation was developed by my connection and relationship with the "True Vine". I encourage all to get connected to Christ - it's simple- Admit. Believe. Confess and walk in the abundant life Christ gives.

To my wonderful professor, Dr. Schilling, thanks for supporting me and believing in me as we've journeyed down this food science and education path. Your encouragement, motivation, and prayers will always be greatly appreciated.

To my committee members, Drs. Buys, Downey, Silva, White, and Jagger, thanks for making the ideas become a reality through your advisement, edits and feedback on manuscripts, and for your willingness to promote food science in Mississippi high schools.

To the Muscle Foods and Sensory Laboratory (The Awesome Lab), words can't express my gratitude towards the support you've provided me through this journey! To each of you that helped develop lessons, recorded instructional videos, set up and implemented the food science lessons, and/or followed any of my education/recruiting madness - I salute you!

To the wonderful teachers and school districts that partnered with us to conduct our research study. Your help is greatly appreciated and valued.
To my beautiful and supportive family and friends, thanks for the love and support along this journey. I truly appreciate all the prayers, encouragement, shoulders to cry on, time to listen to me vent, and the list can go on and on. Specifically to my sister, Glenda - you have heard a million times before how grateful I am for you. Thank you for the “G.I. Jane” conversations that pushed me to complete this dissertation.

Finally, to my strong man, Denzel – thank you for your sacrificial love through this journey. You were a rock through the late nights writing and studying and the best at celebrating me when I was in the depths of many valleys and screaming from the mountain top. You are a true inspiration and joy in my life.
# TABLE OF CONTENTS

DEDICATION ....................................................................................................................... ii

ACKNOWLEDGEMENTS .................................................................................................... iii

LIST OF TABLES ............................................................................................................... viii

LIST OF FIGURES .......................................................................................................... ix

CHAPTER

## I. INTRODUCTION ........................................................................................................... 1

- Statement of Problem .................................................................................................... 3
- Purpose and Significance of Study ................................................................................. 4
- Research Objectives and Questions ............................................................................... 5
  - The delivery and evaluation of a food science professional development training for
    Mississippi career technical education teachers ......................................................... 5
  - Mississippi career and technical education teachers’ perception toward
    implementing a food science toolkit designed to increase food science
    curriculum use in MS ................................................................................................. 5
- Definitions ..................................................................................................................... 6

## II. LITERATURE REVIEW ............................................................................................ 8

- Food Science Defined ..................................................................................................... 8
- Food Science Profession ................................................................................................. 8
- Recruitment and Retention in Food Science .................................................................. 9
- Food Science at the Secondary Education Level .......................................................... 11
  - A two-pronged approach to promote food science in U.S. high schools .................... 12
  - Using food science demonstrations to engage students of all ages in science,
    technology, engineering, and mathematics (STEM) .................................................. 12
  - FoodMASTER middle grades: Development and pilot evaluation of an integrative
    food-based science curriculum ................................................................................. 12
  - Food4Thought provides students STEM opportunities in food science ................... 13
  - Evaluating the effectiveness of integrating food science lessons in high school
    biology curriculum in comparison to high school chemistry curriculum .................. 13
- Career and Technical Education Programs .................................................................. 14
- Agriculture Education in CTE Programs ..................................................................... 16
- Mississippi CTE Programs .......................................................................................... 18
Food Science CTE Programs in MS..................................................................................19
Need for Teacher Professional Development in Food Science ...........................................21
Professional Development ..................................................................................................21
  Science content courses: Workshop in food chemistry for 4th grade school teachers ........23
  Training teachers to use food to teach science .................................................................23
  Process evaluation of FoodMASTER middle grades: An integrative approach to nutrition education in the science classroom ..............................................................24
Conceptual Framework ......................................................................................................25

III. DELIVERY AND EVALUATION OF A FOOD SCIENCE PROFESSIONAL
DEVELOPMENT TRAINING FOR MISSISSIPPI CAREER TECHNICAL EDUCATION TEACHERS .................................................................................................30

Abstract .............................................................................................................................30
Introduction .......................................................................................................................31
Materials and Methods .....................................................................................................33
  Agricultural food science and technology curriculum ......................................................33
  Intervention: Food science professional development training ......................................33
  Participants .....................................................................................................................37
  Instrumentation .............................................................................................................38
  Experimental design and data analysis ..........................................................................40
Results and Discussion .....................................................................................................40
  Teachers’ self-perceived knowledge and ability to conduct food science skills ..............40
  Participants’ self-efficacy and satisfaction ......................................................................43
Conclusions .......................................................................................................................47

IV. MISSISSIPPI CAREER AND TECHNICAL EDUCATION TEACHERS’
PERCEPTION TOWARD IMPLEMENTING A FOOD SCIENCE TOOLKIT
DESIGNED TO INCREASE FOOD SCIENCE CURRICULUM USE IN MS ........55

Abstracts ...........................................................................................................................55
Introduction .......................................................................................................................56
Materials and Methods .....................................................................................................58
  The development of the food science teaching toolkit ......................................................58
  The food science toolkit .................................................................................................59
  Implementation procedures and participants ..................................................................60
  Measurements ................................................................................................................61
  Statistical analysis ........................................................................................................62
Results and Discussion .....................................................................................................62
  Research question one: Why are Mississippi career and technical education teachers interested in teaching food science in secondary CTE career and technical education courses? ........................................................................63
  Research question two: How do Mississippi CTE teachers characterize their experiences implementing food science educational resources in their secondary career and technical education courses? ......................................................65
Research question three: What were the perceptions of the CTE teachers towards the quality of the food science educational resources and implementation process? .................................................................69

Research question four: Why would CTE teachers continue to use these food science educational resources? .................................................................72

Conclusions ..............................................................................................................74
Implications for Future Practice .................................................................................75
Recommendations for Future Work ...........................................................................76

V. CONCLUSIONS, IMPLICATIONS FOR FUTURE PRACTICES, AND RECOMMENDATIONS .................................................................................................83

Conclusions ..............................................................................................................83
Delivery and evaluation of a food science professional development training for Mississippi career technical education teachers ..............................................83
Mississippi career and technical education teachers’ perception toward implementing a food science toolkit designed to increase food science curriculum use in MS ....................................................................................84
Implications for Future Practice .................................................................................84
Limitations ..................................................................................................................86
Recommendations .....................................................................................................86

REFERENCES ............................................................................................................88

APPENDIX

A. FOOD SCIENCE LESSON PLAN OVERVIEW ..................................................96

B. SUPPLEMENTAL TEACHING RESOURCES .................................................106

Supplemental Teaching Resources ............................................................................107
PowerPoint slides .......................................................................................................107
Activity guide/student handouts ................................................................................108

C. FOOD SCIENCE PROFESSIONAL DEVELOPMENT ....................................110

D. TEACHER TRAINING SURVEY INSTRUMENT ..........................................132

E. INTERVIEW PROTOCOL AND QUESTIONS ...............................................137
LIST OF TABLES

Table 2.1 Agricultural food science technology course outline .................................................28
Table 3.1 Topics of each food science lesson and associated training activity .........................48
Table 3.2 Average teachers’ self-perceived knowledge before and after completing the food science professional development training (n=28). ........................................50
Table 3.3 Average teachers’ self-perceived ability to conduct food science skills before and after completing the food science professional development training. ...............51
Table 3.4 Teachers’ self-disclosed responses to open-ended survey questions. .......................52
Table 3.5 Teachers’ level of agreement (%) of their self-efficacy to teach food science post food science professional development training (n=31) ........................................53
Table 3.6 Teachers’ level of agreement (%) to instruction and satisfaction post food science professional development training (n=30). ..................................................54
Table 4.1 Food science toolkit lesson objectives and sample food science lesson activities and toolkit supplies. .................................................................77
Table 4.2 Career and technical education teacher’s interest in teaching food science in Mississippi career and technical education courses ........................................79
Table 4.3 Mississippi career and technical education teacher’s experience implementing food science educational resources ..............................................................80
Table 4.4 Mississippi career and technical education teachers’ perception of food science educational resources ...............................................................81
Table 4.5 Career and technical education teachers’ intended continued use of the food science educational resources .............................................................82
LIST OF FIGURES

The Self-efficacy Theory (Bandura, 1977) ........................................................................................................29
CHAPTER I
INTRODUCTION

Food science is a multidisciplinary field in which agriculture, science, technology, engineering, and math concepts are used to ensure the maintenance of a safe and sustainable food supply. Food science career pathways offer diverse opportunities in areas such as food engineering, processing, manufacturing, and quality control. As a thriving and expanding industry, job growth in food science is projected to increase 9% by 2030 in the United States (U.S.) (U.S. Bureau of Labor Statistics, 2021). As a result, approximately 37,400 positions will be available for agriculture and food scientists in 2030 (U.S. Bureau of Labor Statistics, 2021). However, Fernandez et al. (2019) anticipated that positions available for food scientists will be partially filled due to the decline in the number of students enrolling in food science and agriculture university programs.

It is important to incorporate food science-based instruction on the secondary education level to increase the number of students that enroll in university food science programs. High school students’ lack of awareness, interest, and knowledge of the field of food science is a primary challenge that is associated with increasing the enrollment and number of university graduates in food science programs (Peacock, 2007). Many students are either never exposed to food science concepts or are not exposed to these concepts until they enter college (Lang, 2007). Incorporating food science-based instruction into high school classrooms has the potential to
increase the number of students that choose food science as a major and potentially enter the food industry.

Incorporating food science-based instruction in secondary Career Technical Education (CTE) provides a gateway for students to become more aware, interested, and knowledgeable of various food science academic and career pathways. Lekes et al. (2007) stated that CTE programs are geared to provide students with rigorous, diverse course instruction that offers a comprehensive approach to education. Students are generally exposed to food science-based instruction in CTE courses housed under the Agriculture, Food, and Natural Resources (AFNR) career cluster in U.S. CTE programs. Under the AFNR career cluster, students can explore career pathways such as Agribusiness Systems and Food Products and Processing (Advance CTE, 2021a). Within these courses, however, there is limited to no exposure to a diverse view of food science principles and professional opportunities in the field due to limited instructional time allotted to teach food science concepts.

In Mississippi (MS), there is not currently an adopted food science curriculum, which contributes to the lack of awareness and promotion of food science as a career pathway among MS high school students. However, a collaboration among Mississippi State University’s Research Curriculum Unit (RCU), food science professionals, and MS CTE agriculture teachers addressed this need by developing a food science curriculum framework, Agricultural Food Science and Technology, to be presented to the MS Department of Education for adoption as a formal curriculum. Adopting the Agricultural Food Science and Technology curriculum framework in MS has the potential to increase the number of secondary education students exposed to food science, who would potentially select food science as an academic or career pathway.
To effectively adopt and implement food science curricula in secondary CTE programs, it is essential for teachers to demonstrate knowledge, skills, and self-efficacy to teach food science in their classrooms. Food science consists of interdisciplinary concepts that may not directly correspond to the teacher's educational background, which potentially creates challenges during curriculum implementation. Therefore, there is a need to establish food science professional development (PD) for high school teachers. Several studies examining food science-based PD and its impact on teacher knowledge gain and self-efficacy have described that teachers with a strong self-efficacy are more willing to implement innovative instructional strategies to further enhance students’ learning experiences (Liceaga et al., 2014; Stein & Wang, 1988; Tschannen-Moran et al., 2001). Providing CTE teachers with opportunities can increase awareness of food science career pathways among students and teachers (Schaich-Rogers, 2007; Roseno et al., 2017; Johnson, 2020; Hendrix et al., 2021).

**Statement of Problem**

There are limited food science PD experiences offered to MS CTE teachers to expand student exposure to academic and career opportunities in food science. Food science consists of concepts derived from a variety of disciplines that may not directly correspond to the teacher's educational and technical background. In literature describing interviews with food science teachers, it was expressed that the teachers perceived that they were not knowledgeable of food science concepts and had low confidence in their abilities and/or were apprehensive to teach food science concepts without support (Liceaga et al., 2014). Adequately and professionally training MS CTE teachers to implement food science-based curricula as part of their current CTE curricula can increase the presence of food science-based instruction in MS CTE courses and
further support efforts to increase the number of students exposed to food science academic and career pathways.

The lack of an official curriculum framework for MS teachers to teach food science contributes to the lack of awareness and promotion of food science as a career pathway among MS high school students. To support curriculum development and adoption of the MS Agricultural Food Science and Technology curriculum framework, there is a need to provide MS CTE teachers with food science educational resources and examine teachers’ experiences and their perceptions of implementing food science-based instruction in their classrooms. Teachers’ perceptions towards curriculum implementation can provide evidence on how curriculum design impacts the implementation of educational resources and potential ideas on improving curriculum design. Research findings in this area can offer advances in curriculum development and design of the MS Agricultural Food Science and Technology curriculum and support the adoption of the curriculum by the Mississippi Department of Education.

**Purpose and Significance of Study**

The purpose of this research study was to determine the effects of a food science focused PD experience on MS CTE teachers’ knowledge, skills, and self-efficacy to teach food science on the secondary education level, and to explore teachers’ perceptions of implementing food science-based instruction in their CTE courses. Data reported via a post-training evaluation survey determined MS CTE teachers’ self-perceived knowledge of specific food science concepts, their self-perceived ability to conduct food science activities, and their self-efficacy to teach food science in their CTE courses. MS CTE teachers’ perceptions of implementing food science-based instruction in CTE courses will provide insights on how to further food science
focused PD opportunities for MS teachers and support food science curriculum development and adoption in MS.

**Research Objectives and Questions**

This study was divided into two parts: 1) Delivery and evaluation of a food science professional development training for Mississippi career technical education teachers and 2) Mississippi career and technical education teachers’ perception toward implementing a food science toolkit designed to increase food science curriculum use in MS.

**The delivery and evaluation of a food science professional development training for Mississippi career technical education teachers**

The research objectives were to:

1. Identify and compare the self-perceived knowledge and self-perceived ability to conduct specific food science skills among MS high school teachers before and after food science professional development training.
2. Determine teachers’ self-efficacy and satisfaction after completing the food science professional development training.

**Mississippi career and technical education teachers’ perception toward implementing a food science toolkit designed to increase food science curriculum use in MS**

The research questions were:

1. Why are Mississippi CTE teachers interested in teaching food science in secondary career and technical education courses?
2. How do Mississippi CTE teachers characterize their experiences implementing food science educational resources in their secondary career and technical education courses?
3. What were the perceptions of the CTE teachers towards the quality of the food science educational resources and implementation process?

4. Why would CTE teachers continue to use the food science educational resources?

Definitions

Constitutive terms for this study are defined as follows:

*Food Science*: The Institute of Food Technologists defines food science as the study of the physical, biological, and chemical components of food, and it focuses on food deterioration and the principles of food processing (Institute of Food Technologists [IFT], 2019).

*Career and Technical Education*: A field of education that prepares secondary and postsecondary students with academic and technical skills for a variety of career pathways (Association for Career and Technical Education [ACTE], 2021c)

*Self-perceived Knowledge*: Career Technical Education teacher personal thought of learning gains from the food science professional development measured by a Likert-type scale within a retrospective survey.

*Self-perceived Skills*: Career Technical Education teacher personal thought of their ability to conduct specific skills of food science after participating in a food science professional development measured by a Likert-type scale within a retrospective survey.

*Self-efficacy*: Bandura (1977) defines self-efficacy as ones’ belief about the skills and competencies of performing a specific task. Specifically, this study examines teachers’ belief about how they teach food science in MS high school CTE courses.

*Satisfaction*: Career Technical Education teacher’s rate of how pleased they were with the overall food science professional development training measured by a five-point Likert-
type scale of agreement to nine items that assessed the teacher’s satisfaction with the food science professional development training instructor, the materials delivered in the training, and the impact of the training.

*Professional Development:* The comprehensive, sustained, and systematic learning experiences that are based on identified needs of teachers and result in improved instructional effectiveness and increased student achievement and performance outcomes. (National Research Center for Career and Technical Education [NRCCTE], 2010)

*Food Science Professional Development:* A 2-hour training session for MS Agriculture CTE teachers to learn food science concepts and practice food science activities presented by Mississippi State University food science professionals.
CHAPTER II
LITERATURE REVIEW

Food Science Defined
The Institute of Food Technologists (IFT) describes food science as the study of the physical, biological, and chemical components of food, and it focuses on food deterioration and the principles of food processing (IFT, 2019). Food scientists apply principles of chemistry, engineering, microbiology, and nutrition to improve the safety of food, develop methods to process, preserve, package, and distribute food effectively and efficiently (IFT, 2019). In the text, Principles of Food Science, Ward (2013) also defined food science as “the study of the nature of food, the cause of deteriorations, the principles underlying good processing, and the improvement of foods for the consuming public.” Additionally, food science is a multidisciplinary field which scientists use an array of disciplines including agriculture, engineering, chemistry, biology, microbiology, and statistics to solve food related problems (Floros et al., 2010; IFT, 2019).

Food Science Profession
As a career path, food science offers diverse opportunities in areas such as food engineering, processing, manufacturing, and quality control. As reported by the FDA, there are approximately 44,000 food processors and 113,000 food warehouses in the United States, which contributes to the food industry being one of the largest manufacturing industries in the country (IFT, 2019). The United States Department of Agriculture reported that the foodservice and food
Retail industries supplied approximately $1.69 trillion of food even with a 16.9% decline in 2020 due to the COVID-19 pandemic (USDA, 2021). As a thriving and expanding industry, job growth in food science is projected to increase 9% by 2030 in the U.S., resulting in approximately 37,400 positions available for agriculture and food scientists in 2030 (U.S. Bureau of Labor Statistics, 2021). However, it is anticipated that there will be more annual job openings than the number of graduates in food and agriculture-related fields to fill these positions (Fernandez et al., 2019). Consequently, there is a need to understand factors that influence students’ academic and career pathway selection, and to determine strategies to recruit and retain students in food science.

**Recruitment and Retention in Food Science**

The vision of the IFT’s Feeding Tomorrow Foundation is to increase awareness of careers in the science of food by promoting efforts to recruit the best and brightest students to the field of food science. To increase awareness and the number of graduates that enter the field of food science and technology, organizations like IFT as well as food science and agricultural-related university programs should revise their strategies that are used to recruit students to the field. In previous studies, Wildman and Torres (2001) stated that recruitment is based on researchers’ knowledge of the student population and identification of the influences impacting their decision-making process when selecting a college major. Previous studies have identified several prominent factors that impact students’ selection of a college major: 1) previous exposure in agriculture and career opportunities in agriculture fields (Donnermeyer and Kreps, 1994; Rawls et al., 1994; Wildman & Torres, 2001); 2) family, friends, and mentors (i.e., teachers and counselors) (Fisher & Griggs, 1995; Wildman & Torres, 2001; Bowen & Rumberger, 2002); 3)
agricultural-related university programs’ recruitment activities (Donnermeyer and Kreps, 1994; Rawls & Bekkum, 1995; Rocca and Washburn, 2005; Rayfield et al., 2013).

There are several significant factors that influence students’ decisions to select agriculture-related majors such as prior exposure to agriculture and teacher influences; however, it is essential to use an integrative approach when revamping and/or developing recruiting strategies (Wildman & Torres, 2001; Rayfield et al., 2013). Past studies have revealed that providing students educational and technical training on the secondary education level can render increased interest and selection of agriculture as their college major (Rawls & Bekkum, 1995; National Research Council, 1996; Peacock, 2007). At the 7th and 8th grade level, students are required to explore various career opportunities of interest; therefore, it is important for students to be exposed to various programs, curricula, and/or trainings to make a sound decision on which academic and/or career path they choose to pursue.

To raise awareness and interest in food science and/or related disciplines among secondary education students, an important recruiting strategy is to provide students with experiential learning opportunities in food science. This strategy allows students to gain experience in food science as well as offers teachers educational resources to showcase real-life application of science concepts in their courses (McEntire & Rollins, 2007). Chikthimmah and Floros (2007) discovered that teachers’ commitment to incorporate food science-based instruction in their high school curriculum plays a significant role in increasing the number of high school students interested in food science. Food science university programs can also support this strategy by developing and disseminating food science educational resources to further increase students’ exposure to the field (National Research Council, 1996; Peacock, 2007).
Food Science at the Secondary Education Level

If food science-based instruction is implemented in K-12 schools, it is generally introduced at the secondary education level, and it has the potential to increase students’ interest and knowledge of academic and career opportunities in the field. McEntire and Rollins (2007) stated that implementing food science-based instruction in high school courses can provide students with positive perspectives of the field, which aids in the selection of food science as their college major. Generally, secondary education students are already familiar with food products and are naturally interested in food; therefore, food science concepts can conveniently be integrated at the secondary education level (Schmidt et al., 2012).

Past studies have demonstrated how food science was implemented in secondary education courses to teach within and across various subject areas. Ward (2004) created a secondary education food science course that showcased principles that were centered around food processing, preservation, and packaging via the application of core concepts such as English, science, and writing. Food product development concepts were applied by students in the development of new food options for their school lunch menu (Lindquist, 2004). Food science-based instruction was also used to teach K-12 mathematics and science principles (Duffrin et al., 2005). In addition, the science behind fast food was used to investigate chemistry principles in an 8th grade physical science class (Davis et al., 2007).

Literature also includes the efforts of other researchers and organizations that have explored the integration of food science education resources among secondary education students to increase their awareness of food science. A synopsis of each study follows:
A two-pronged approach to promote food science in U.S. high schools

IFT collaborated with Discovery Education and created food science promotion materials in 2006. The food science career guidance and promotional materials were distributed to 18,000 high schools in the U.S. The kits included science kits and counselor material to increase the students’ awareness of food science in secondary education classrooms. Nearly 1,000 schools responded to the study survey indicating that 97% of survey respondents intend to use the food science resources that were provided. The resources were considered useful by kit recipients, but long-term metrics, such as increased enrollment in food science-related university majors were not included and should be examined in subsequent research (McEntire and Rollins, 2007).

Using food science demonstrations to engage students of all ages in science, technology, engineering, and mathematics (STEM)

Researchers developed six demonstrations using food science to enhance interest in STEM fields. They included liquid nitrogen ice cream, sensory descriptions, whipped cream, chocolate sweetness, burning calories, and cross-linking learning activities in culinary. It was determined that the demonstrations can be adapted to various age groups and science standards. However, there were no surveys or interviews conducted to measure the effectiveness of the demonstrations (Schmidt et al., 2012).

FoodMASTER middle grades: Development and pilot evaluation of an integrative food-based science curriculum

In a poster abstract delivered to the Journal of Nutritional Education and Behavior, the authors presented feedback on IFT’s FoodMASTER program for middle grade students. This program covers 12 units and includes 25 interactive learning labs. The program was conducted in five 7th grade classrooms in North Carolina. The program was well received, and teachers
reported a high willingness to repeat the course and would recommend it to others (Carraway-Stage et al., 2014).

**Food4Thought provides students STEM opportunities in food science**

The Food4Thought program builds on the 2006 efforts by IFT and Discovery Education to increase exposure to food science via STEM disciplines. The Food4Thought program includes three main points of focus: 1) educate students in food science, 2) engage students in food science pilot programs, and 3) empower students through learning resources. There were no variables directly measured in this study; however, authors showcased IFT’s collaboration with Girls, Inc. and Chapman University to help students view the academic and career outlook for food science. Participants were enrolled in a Food 101 college course, engaged with university faculty and students, and had an opportunity to attend IFT’s 2013 Annual Meeting and FoodExpo® (Wagner, 2015).

**Evaluating the effectiveness of integrating food science lessons in high school biology curriculum in comparison to high school chemistry curriculum**

Research conducted by Stringer et al. (2018) contributed to food science education research by determining whether eight basic food science principles (water activity and food spoilage, proteins, lipids, carbohydrates, dairy, preservation, enzymes, and sensory evaluation) could be comprehended by high school students in a biology class without a chemistry background versus students enrolled in a chemistry class. The study assessed baseline knowledge of high school students, determined the effect of food science-based lessons on baseline knowledge and level of understanding, and determined the effect of food science-based lessons on students’ awareness of and interest in food science. When evaluated, baseline knowledge and awareness of food science was low; however, implementing food science-based instruction
resulted in higher post-test scores for knowledge and awareness of food science among students. Results indicated that there were no differences in students’ knowledge base and level of understanding between biology and chemistry classes and supported the idea of further incorporating a food science curriculum into high school biology (Stringer et al., 2018).

There are general shared objectives across the programs observed above: 1) it is essential for student to learn food and nutrition science concepts, 2) secondary education learning environments are suitable for enhancing student knowledge in food science, and 3) it is necessary to evaluate the students’ knowledge that is retained from the programs. However, only a few of the programs offer 1) active experiential learning experiences for students via demonstrations, hands-on activities, etc., 2) food science taught from a multidisciplinary approach (e.g. Family and Consumer Sciences students exposure to food science concepts), 3) lessons that align with national and state education standards, and 4) training to properly integrate food science curriculum into existing curricula (Hovland et al., 2013; Schmidt et al., 2012). Despite the drive to increase the student exposure to food science, these educational programs have faced implementation challenges and these challenges should be addressed.

**Career and Technical Education Programs**

Secondary CTE programs provide students with rigorous, life applicable curriculum designs that offers students hands-on learning opportunities in various career fields. Brand (2008) stated that CTE courses prepare students to pursue studies and educational trainings at and beyond the postsecondary level by helping them identify the connections between their interest and the career that would like to pursue in the future. The purpose of secondary CTE programs is to inspire high school students to pursue and transition to college and careers (Lekes et al., 2007). Current CTE programs acknowledge that most secondary education students need
to be engaged in high-quality and progressively advanced curriculum (Lekes et al., 2007). Therefore, current CTE programs strive to encourage student engagement by helping students see the relationship between their academic and career goals which affirms the hypothesis that “once students understand the relevance of their education, they will be motivated to stay in high school and improve their academic performance, so college becomes a realistic option” (Lekes et al., 2007; Lynch, 2000; Bragg, 2001)

CTE programs are geared to provide students with rigorous, diverse course instruction that offers a comprehensive approach to education (Lekes et al., 2007). The Association for Career and Technical Education (ACTE) (2021a) reported that 6 out of 10 CTE students planned to pursue a career pathway related to the CTE course they participated in on the secondary education level. High school students who are active in one or more CTE courses have developed problem-solving, research, time management, and critical thinking skills while participating in high school CTE courses (Lekes et al., 2007; ACTE, 2021a). In addition, Brand (2008) also expressed that CTE courses afford students the opportunity to network and interact with career specific practitioners and professionals that can help them be both more skilled and qualified for positions. Due to the advantageous effects on secondary education students’ transition into academic and career pathways, it is important to examine how CTE programs and specific curriculum instruction is implemented at the secondary education level.

CTE programs are conducive to the implementation of food science-based instruction. Currently, CTE programs are categorized into 16 career clusters; however, career clusters offered in U.S. schools vary (Advance CTE, 2021b). Students are currently exposed to food science concepts in agriculture based CTE courses such as Agriculture, Food, and Natural Resources and Hospitality and Tourism. Hence, implementing food science-based instruction in high school
CTE courses that focuses on agriculture education provides a gateway for students to become more aware and knowledgeable of food science and the associated academic and career pathways.

**Agriculture Education in CTE Programs**

Agriculture education CTE programs are structured into a three-circle model that offers student development in the classroom, hands-on experiences outside of the classroom, and in student organizations (i.e., Future Farmers of America (FFA) and The National Young Farmer Education Association) (National Association of Agriculture Educators [NAAE], 2021). Agriculture education CTE programs promote academic success and advanced career preparation among students.

In agriculture education, classroom instruction can be conducted in diverse settings. Teachers and students experience innovative agricultural science techniques and concepts in a variety of learning environments such as class laboratories, barns, and on farms. Agriculture CTE programs seek to provide students with quality instruction that utilizes an experiential learning approach and consists of learning activities that weave in core academic subjects such as math, reading, and social studies into each course (NAAE, 2021).

A supervised agricultural experience (SAE) allows students to apply content learned in the classroom to a real-life scenario. SAEs are supervised by agriculture educators that consist of planned activities that are conducted outside classroom instruction time. Within these SAEs, learning is extended beyond the classroom which students gain new learning experiences through hands-on activities. SAEs also offer students the opportunity to engage in community-based learning settings that aid in their development of individual career-based competencies such as effective oral and written communication (The National Council for Agricultural Education,
All students are encouraged to complete a SAE when enrolled in an agriculture CTE program. This allows them to explore a variety of career pathways, while learning professionalism in the workplace and ways to apply academic skills in a professional environment. Food science SAEs allow students to work in a food distribution center, gaining experiences in food safety while working in food inspection services, and job shadowing at a food company (Explore SAE, 2021). Through the SAE experiential learning approach, students are exposed to current technologies, connected them to industry professionals, and provides skills and experiences to help and prepare them to transition into college (The National Council for Agricultural Education, 2012).

Student professional development via student organizations is the third focus of the three-circle model of agriculture CTE programs. FFA is the leading agriculture-based student organization that offers leadership development, student competitions, scholarships, and community service. The National FFA Organization exposes students to agriculture career pathways and builds leadership skills through agriculture education. Since 1947, FFA has hosted many Career Development Events (CDE), where students can showcase and apply their knowledge and skills pertaining to a variety of academic and career topics (National FFA Organization, 2019a). FFA CDEs are local, state, and national competitive events and are an “outgrowth of classroom and laboratory instruction, and skills gained through supervised agriculture experiences” (Morgan et al., 2013).

The FFA Food Science and Technology (FST) CDE supports students’ learning by requiring students to solve problems via their understanding of food product development, food safety issues, and sensory evaluation skills (National FFA Organization, 2019b). The Food Science and Technology CDE is comprised of both individual and team activities. Student
individual activities consist of an exam with 50 multiple choice questions that measures each student’s knowledge of food science concepts. Students also individually conduct two sensory practicums. The team component of the FFA FST CDE is comprised of a food safety and sanitation team activity and a food product development project. Students work together to respond to a marketing scenario where the team formulates a new food product with product specifications included in the marketing scenario. The FFA FST CDE was designed to expose students to food science career pathways such as research and development, sensory science, and food safety and sanitation (National FFA Organization, 2019b).

Mississippi CTE Programs

Mississippi (MS) is a predominantly agricultural state that sends most of its farm crops to food companies in other states for added value processing. MS is in the top 20 in the production of a variety of agriculture commodities such as poultry and eggs (no. 1), soybeans (no. 2), catfish (no. 7), corn (no. 5), rice (no. 9), and sweet potatoes (no. 11) (MDAC, 2021). However, state residents have become distant from their food supply, and approximately 90% of the food consumed in the MS is sourced outside of the state (Meter & Goldenberg, 2014).

In 2018, the Bureau of Labor Statistics reported that MS only employs 30 to 70 food scientists and technologists with most of the job opportunities available in the northwest part of the state (U.S. Bureau of Labor Statistics, 2018). In recent years, companies have either expanded or have been established in MS. The job market is continuously growing as depicted through Peco Foods, Inc. efforts to bring 300 jobs to Mississippi’s Clay County and these positions should be filled by qualified, skilled, and trained workers. Education in food science at the K-12 level will help train students for jobs in the food industry as well as to promote living healthier lives. This will contribute to the production of a trained workforce so that food
companies have greater opportunities and incentives to open added value food plants in Mississippi. Agriculture CTE programs, specifically focused on food science, can help increase the number of students that pursue career pathways related within the agriculture and food industry.

The Mississippi Department of Education stated that CTE programs are widely available across the state that students can enroll in at the secondary and postsecondary level (Mississippi Department of Education [MDE], 2021). According to the National Association of Agricultural Educators, MS has over 7700 students actively enrolled in agriculture, food, and natural resources courses. There are 62 MS counties that have agriculture programs and there are approximately 140 agriculture teachers in the state. The state has 166 reported FFA chapters consisting of over 3400 FFA members (NAAE, 2021).

**Food Science CTE Programs in MS**

In MS, there is not an adopted food science curriculum which teachers can implement food science-based instruction. Not having an official curriculum framework for MS teachers to teach food science contributes to the lack of awareness and promotion of food science as a career pathway among MS high school students. MS has adopted a Food Products curriculum that focuses on meat processing. The food products pathway is housed under the agriculture, food, and natural resources career cluster (MSU-RCU, 2021) and is designed to reach students who are interested in meat cutting, packing, and processing professions. Although the food products pathway is offered in MS, the curriculum framework only offers a limited view of food processing by targeting meat processing and does not provide students with a broad view of food science. There is also no literature or official documentation that confirms implementation and/or evaluation of the MS Food Products curriculum framework.
Food science-based instruction is currently incorporated in MS CTE programs such as Agriculture, Food, and Natural Resources. However, there is limited exposure to a diverse view of food science and professional opportunities in the field due to limited instructional time to teach subject area content. In 2018, Mississippi State University’s Research Curriculum Unit (RCU) combated the lack of an official food science curriculum to be offered in the state by drafting a curriculum framework for teaching food science and technology.

The Agricultural Food Science and Technology curriculum was developed by a collaboration among MS agriculture teachers, Mississippi State University food science professionals, and RCU’s curriculum and instruction specialists. The curriculum is designed to be a one credit course and includes competencies in food chemistry, composition and analysis, the science of food processing, sensory evaluation and product development. The main course objectives are: 1) to learn basic roles and functions of food scientists and 2) to gain skills essential for an entry-level food scientist position. The curriculum is comprised of ten food science units that require 140 instructional contact hours (Table 2.1). The Agricultural Food Science and Technology curriculum framework will be presented to the Mississippi Department of Education to be adopted in the state and made available for MS teachers to implement in MS public schools.

Adopting the Agricultural Food Science and Technology curriculum framework in MS would assist in increasing the number of secondary education students exposed to food science and who would potentially select food science as an academic or career pathway. However, offering and implementing the Agricultural Food Science and Technology curriculum in MS would be at the discretion of MS teachers. To successfully teach food science-based instruction, it is recommended that teachers have a comprehensive background in food, nutrition, and food
technology as well as are knowledgeable in the application of core subject areas (i.e., math, science, reading) (Johnson, 2020).

**Need for Teacher Professional Development in Food Science**

Based on the diversity of subject area content presented in agriculture-based curriculum that CTE teachers implement, agriculture CTE teachers are qualified to teach food science. However, food science consists of interdisciplinary concepts that may not directly correspond to the teacher’s educational background and potentially create challenges during curriculum implementation. Liceaga et al. (2014) also reported that many educators: (1) did not have necessary resources to teach food science concepts, (2) had low self-efficacy and/or were intimidated to teach food science concepts, and/or (3) were not knowledgeable of food science concepts and could not effectively teach food science theories to their students without support. Therefore, there is a need to supply teachers with professional development (PD) opportunities and tools to implement food science-based instruction in their classrooms in effort to increase student exposure and knowledge of food science.

**Professional Development**

Professional development for CTE is needed to effectively implement food science curriculum in secondary education courses. PD opportunities for CTE teachers can increase awareness of food science academic and career pathways among students (Schaich-Rogers, 2007; Roseno et al., 2017; Johnson, 2020; Hendrix et al., 2021). Professional development is described as the “comprehensive, sustained, and systematic learning experiences that are based on identified needs of teachers and result in improved instructional effectiveness and increased student achievement and performance outcomes” (NRCCTE, 2010). Teachers can be presented
PD opportunities through a variety of methods and on various platforms. In literature describing why professional development matters, Mizell (2010) stated that PD can be conducted in a formal (i.e., conferences or training workshops) and informal (i.e., observations of researchers’ work or dialogue between colleagues) settings.

Teachers receive opportunities for continuing education through PD to stay up to date on the most current technologies and information in various subjects. The Carl D. Perkins Career and Technical Education Act of 2006 was reauthorized in 2018 and showcased the importance of PD in CTE. Within the Act, PD in CTE was described as follows: 1) PD in CTE should provide educators with knowledge and skills that are necessary to empower students to be successful in CTE programs, 2) PD activities are to be designed to be sustained, intensive, and collaborative for teachers to improve and increase their knowledge of academic and technical subjects, 3) PD should enhance educators ability to analyze student work and achievement in academic and technical subjects, and 4) PD should afford educators various methods on how to adjust instructional strategies, assessments, and materials based on student performance analyses (Strengthening Career and Technical Education for the 21st Century Act, 2018).

To effectively expose students to food science-based curricula, teachers need to be actively engaged in food science focused PD opportunities to ensure that students are retaining and applying learned food science concepts. After reviewing literature and through personal communication with representatives who oversee PD for CTE teachers in MS, as of 2019, there were no formal food science focused PD offered to MS teachers (P. Stafford and G. Fortenberry, personal communication, July 11, 2019; Hendrix et al., 2021). However, there are several studies in literature that showcases the impact of providing teachers with food science PD. Brief summaries of these studies are reviewed below:
**Science content courses: Workshop in food chemistry for 4th grade school teachers**

Chaiyapechara and Dong (2004) examined a PD opportunity that was offered to 4th grade teachers that were employed by the Seattle School District. The PD experience was structured as a 4-day workshop that was offered in the summer from 1999 to 2001. The workshop was designed to increase the knowledge of food science among participating teachers, to exhibit food science experiments that could be implemented in 4th grade classrooms, and to assist teachers to become more familiar with the scientific method. The researchers reported that several participants implemented several experiments that were showcased during the workshop in their classrooms. It was also reported that the material provided during the PD workshop made teachers more confident to conduct food science experiments and lead discussions about the subject with their students (Chaiyapechara & Dong, 2004).

**Training teachers to use food to teach science**

In 2006, IFT K-12 Career Guidance Committee conducted a teacher training session at the national IFT Annual Meeting and Food EXPO®. There were 20 science teachers from areas near Orlando, Florida who participated in a 3-hour training session featuring food science activities that demonstrated physics, chemistry, and biology concepts. IFT’s K-12 Career Guidance Committee and Food Science Ambassadors participated in the training sessions to help teachers become proficient in conducting and administering the food science experiments and to help expose teachers to the application of food science in the industry via tours of the Food EXPO®. The researchers used a training evaluation survey to measure the effectiveness of the teacher training. The teacher training was successful in increasing awareness about food science, and the teachers rated the food science resources that were provided as very helpful. Also, participating teachers indicated that they intend to use the food science resources that were
provided in the future as well as implement the experiments in their classrooms (Schaich-Rogers, 2007).

**Process evaluation of FoodMASTER middle grades: An integrative approach to nutrition education in the science classroom**

There were 9 8th grade science teachers in eastern North Carolina who implemented the FoodMASTER curriculum during the 2013-2014 school year. Authors conducted a process evaluation to examine the implementation process of the FoodMASTER program by teachers. Prior to implementation, teachers participated in a 6-hour professional development workshop hosted by the North Carolina Association for Biomedical Research. The workshop provided teachers with an overview of the FoodMASTER laboratory activities and offered teachers an in-depth review of carbohydrates, proteins, and lipids/oils. During the workshop, teachers were placed in a 2-3 member team and were guided through hands-on laboratory activities. Teachers became familiar with the laboratory activities and were able to link science and nutrition concepts for effective implementation. Post the food science workshop, teachers were provided resources and tools to implement the FoodMASTER curriculum. Results of this study indicated the usefulness of the FoodMASTER curriculum and the intended continued use of the curriculum by the teachers. The findings of this study also revealed how high school students were highly engaged during implementation which can be attributed to the impactful teacher training hosted prior to the implementation of the FoodMASTER curriculum (Roseno, et al., 2017).

As the food science industry and educational system innovatively changes, so should the implementation of food science-based instruction on the secondary education level. It is essential for teachers to continually learn through food science-based PD opportunities; however, food
science-based PD experiences must be made available to teachers, specifically in MS. Providing teachers professional training and tools to implement food science curriculum will support teachers’ knowledge, skills, and self-efficacy to teach food science.

**Conceptual Framework**

The guiding conceptual framework for this study was based on the Self-Efficacy Theory presented by Bandura (1977). Bandura (1977) defines self-efficacy as a person’s belief about their ability to perform or conduct a task. Within the Self-efficacy Theory, Bandura (1977) expressed that a person’s self-efficacy is directly related to a person’s achievement of goals via personal choices, motivations and emotional reactions. Bandura (1977) also believed that a person develops self-efficacy via four sources of influence: performance outcomes, vicarious experience, verbal persuasion, and emotional arousal (Figure 2.1).

**Performance Outcomes.** Bandura (1977) expressed that the most influential source of self-efficacy results from a person’s past accomplished or failed experiences. An increase in self-efficacy is observed when someone takes on a new challenging task and overcomes the presented obstacle. When a person masters the tasks with high self-efficacy, the individual feels confident to continuously perform the task. However, Bandura (1977) also stated that when a person fails to accomplish a new task, their self-efficacy is lowered, and they feel as if they are incapable of performing the task.

**Vicarious Experience.** Vicarious experiences entail seeing other people model success when completing tasks. Bandura (1977) believed that observing role models (i.e., friends, counselors, family members) or people with similar characteristics or interest succeed provides increased confidence in the observer and in their beliefs that they too are capable achieving their goals.
Verbal Persuasion. Self-efficacy is affected by the positive or negative feedback that is received while someone is performing a task (Bandura, 1977). Bandura (1977) explained that a person feels more confident and capable to perform tasks when they receive positive feedback about their performance. In contrast, when a person receives discouraging feedback, their self-efficacy decreases, and it may deter them from accomplishing set tasks.

Emotional Arousal. This component of the Self-Efficacy Theory showcases how the emotional and physiological state of a person can influence their self-efficacy towards their performance or behavior. For example, when a person is in a stressful and intense situation, it is increasingly challenging for that person to perform or behave well. In addition, it is difficult to increase self-efficacy when a person is experiencing hardship and feels that they are incapable of performing successfully (Bandura, 1982). However, Bandura (1977) states, “it is not the sheer intensity of emotional and physical reactions that is important but rather how they are perceived and interpreted. People who have a high sense of efficacy are likely to view their state of affective arousal as an energizing facilitator of performance, whereas those who are beset by self-doubts regard their arousal as a debilitator.” Therefore, it is essential for someone to learn how to manage stressors and improve their emotional state when they are facing difficult circumstances to ultimately help improve their self-efficacy (Bandura, 1982).

In connection to teacher self-efficacy, Tschannen-Moran et al. (1998) used Bandura’s Self-Efficacy Theory to define teacher self-efficacy as the teacher’s belief in their ability to create a plan of action to successfully carry out specific teaching tasks. A teacher’s positive and strong personal belief in their ability to perform tasks renders them more receptive to learning and performing new concepts and tasks. Literature revealed that teachers with a strong self-efficacy are also more willing to implement new instructional strategies to further enhance
student learning experiences (Liceaga et al., 2014; Stein & Wang, 1988; Tschannen-Moran et al., 2001).

Through the guiding framework of Bandura’s Self-efficacy Theory (Bandura, 1977), interactive PD experiences for MS CTE teachers can properly train them to implement food science in their courses which leads to increased confidence in their ability to teach specified course content. When teachers’ self-efficacy is increased, positive results are rendered in the classroom; hence, knowledge transfer is enhanced, and effective and accurate application of knowledge by students is commonly increased (Ambrose et al., 2010). The review of literature sets a foundation to examine the effects of PD on teachers’ self-perceived knowledge, skills, and self-efficacy to teach food science in MS CTE courses.
Table 2.1  Agricultural food science technology course outline

<table>
<thead>
<tr>
<th>Unit Number</th>
<th>Unit Name</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Food Science</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Safety and Sanitation in Food Science</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Food Chemistry</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Food Composition and Analysis</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Food Microbiology</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>The Science of Food Processing</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Sensory Evaluation of Food Products</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Product Development</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Careers and Professionalism in Food Science</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Current Issues and Trends in Food Science</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>140</td>
</tr>
</tbody>
</table>

Note: Referenced from Mississippi CTE Proposed 2018 Agricultural Food Science and Technology Curriculum Framework, Mississippi State University Research Curriculum Unit
Figure 2.1  The Self-efficacy Theory (Bandura, 1977)
CHAPTER III
DELIVERY AND EVALUATION OF A FOOD SCIENCE PROFESSIONAL
DEVELOPMENT TRAINING FOR MISSISSIPPI CAREER TECHNICAL
EDUCATION TEACHERS

Abstract

Professional development for Career Technical Education (CTE) is needed to effectively implement food science curricula in secondary education courses. Providing CTE teachers with professional development training supports increased awareness of food science academic and career pathways among students. The goal of this study was to assess a food science professional development training for Mississippi CTE teachers that would increase their self-perceived knowledge, self-perceived ability to conduct specific food science skills, and self-efficacy to implement food science-based instruction.

Thirty-one teachers participated in the 2-h professional development training that provided teachers an experiential learning opportunity to learn and apply food science concepts. Results indicated that the food science professional development training was effective at increasing teachers’ self-perceived knowledge and ability to conduct food science skills since the average scores (five-point Likert-type scale, n = 28) in all statements increased (p < 0.001) post training. For example, teachers self-perceived knowledge of the five D’s of food product development at pre-survey (M = 2.00 ± 0.94) increased (p < 0.001) after the training (M = 4.29 ± 0.60). In addition, teachers’ self-perceived ability to employ the five D’s of food product development before the training (M = 0.31 ± 0.54, three-point scale) significantly increased
(p < 0.05) post training (M = 1.72 ± 0.53). Post training, more than 77% of the teachers “agreed” or “strongly agreed” to six out of nine self-efficacy statements which affirmed their belief to teach food science concepts. Overall, teachers were satisfied with the food science professional development training.

Key words: academic pathways, career pathways, self-perceived knowledge, self-efficacy

**Introduction**

Food science is a multidisciplinary field that utilizes agriculture, science, technology, engineering, and math concepts to ensure the maintenance of a safe, high-quality, and sustainable food supply. As a career path, food science offers diverse career opportunities in areas such as food engineering, processing, manufacturing, and quality control. There are 35,600 annual positions that are currently available for agriculture and food scientists and the positions are partially filled due to the decline in the number of students enrolling in food and agriculture university programs (Goecker et al., 2015).

High school students’ lack of awareness, interest, and knowledge of the field of food science is a primary challenge that is associated with increasing the enrollment and number of university graduates in food science programs (Peacock, 2007). Many students are either never exposed to food science concepts or are not exposed to these concepts until they enter college (Lang, 2007). Incorporating food science-based instruction into high school classrooms has the potential to increase the number of students that choose food science as a major and potentially enter the food industry.

Students are exposed to food concepts in agriculture-based career technical educational (CTE) courses which provides a gateway for students to become more aware, interested, and
knowledgeable of various career pathways. However, in Mississippi (MS), there is not an adopted food science curriculum, which contributes to the lack of awareness and promotion of food science as a career pathway among MS high school students.

To effectively integrate or implement food science curricula in high schools, it is essential for teachers to demonstrate knowledge, skills, and self-efficacy to teach food science in their classroom. Since food science consists of interdisciplinary concepts that may not directly correspond to the teacher's educational background and potentially create challenges during curriculum implementation, there is a need to establish food science professional development training for high school teachers. In addition, Liceaga et al. (2014) reported that many educators: (1) lacked necessary resources to teach food science concepts, (2) had a low confidence level and/or were intimidated to teach food science concepts, and/or (3) were unfamiliar with the material and could not effectively teach food science theories to their students without support. Therefore, there is a need to supply teachers with training and tools to implement food science-based instruction in their classrooms to increase student exposure and knowledge of the field of food science.

A professional development training was designed for MS high school CTE teachers to increase their self-perceived knowledge, self-perceived ability to conduct specific food sciences skills, and self-efficacy to implement food science-based instruction in their courses. The specific objectives of this study were to:

1. Identify and compare the self-perceived knowledge and self-perceived ability to conduct specific food science skills among MS high school teachers before and after food science professional development training.
2. Determine teachers’ self-efficacy and satisfaction after completing the food science professional development training.

**Materials and Methods**

**Agricultural food science and technology curriculum**

The Mississippi State University Research Curriculum Unit, Mississippi agriculture teachers, and Mississippi State University food science professionals identified the lack of secondary education curriculum to promote food science career pathways and responded to this need by developing an Agricultural Food Science and Technology career technical curriculum. The curriculum was designed as a one-credit course and includes competencies in food chemistry, composition, and analysis, food processing, sensory evaluation, and product development. The curriculum framework consists of 10 food science units that requires a minimum of 140 instructional contact hours (Table 2.1) to deliver curriculum objectives. Seven introductory food science lessons were developed by the research team to support curriculum development and the future adoption of the Agricultural Food Science and Technology curriculum by the Mississippi Department of Education.

**Intervention: Food science professional development training**

The food science professional development training was developed to enhance high school CTE teachers’ self-perceived knowledge, self-perceived ability to conduct specific skills of food science, and their self-efficacy to teach food science in MS high school CTE courses. The research team consisting of faculty, staff, and students in food science, human sciences, and agricultural and extension education collaborated with the Mississippi State University Research Curriculum Unit to plan and deliver the food science professional development training at the
Mississippi Association for Career and Technical Education (MS ACTE) Summer 2019 Conference. The food science professional development training lasted 2 hours and was led by a member of the research team who has acquired educational and training experiences in agricultural and extension education, programing, and evaluation in a PhD program in food science with a minor in agricultural education.

Incorporating principles adapted from the experiential learning theory (Kolb, 1984), the training was designed to examine teachers as the learner. This approach aimed for further understanding of the concepts and use of hands-on pedagogical strategies to teach food science in high school CTE courses and to increase their self-efficacy to teach food science concepts. During the training, teachers (1) were introduced to each lesson by the training instructor, (2) were specifically trained on how to conduct recommended “ice breakers” for each lesson to formatively assess current knowledge of food science topics among students, (3) were instructed on how to implement the main learning activity of each food science lesson to scaffold upon current food science knowledge and skills, and (4) were informed of teaching tools available to implement the food science lessons and activities.

Teachers were provided guided and independent practice sessions as they participated in individual and group food science activities. The training instructor observed teachers’ application of learned food science knowledge and skills to correct misconceptions, misconduct of food science topics, and/or application of practiced food science activities. Teachers were also encouraged to openly discuss among their peers to reflect and understand their experiences gained during the training.
Seven introductory food science lessons and activities showcasing topics such as food chemistry, food safety, food product development, and other food science related topics were reviewed and/or practiced during the training and are described below (Table 3.1).

*Discover food science*—This module defines food science, investigates various disciplines and career opportunities of the food science industry. Ice breaker—Teachers were provided a chocolate coated candy and were asked “have they ever wondered why the chocolate coated candy melts in their mouth and not in their hand.” Within an open-ended discussion on melting points of chocolates, teachers explored how food science and technologies are used to formulate and produce food products. Focus Activity—Teachers were introduced to various disciplines (e.g., food chemistry and quality control) within food science via a training presentation and interactive discussion that were led by a member of the research team.

*Food product development*—This module describes the main principles of food product development such as identifying the target audience, creating a product description, and developing a prototype of the product. Ice breaker—Teachers participated in a short role play scenario where the teacher was instructed to imagine their grocery shopping experiences. After being presented with a food product, the teachers were directed to discuss their main thoughts and/or concerns when they are shopping for a food product. The training provided follow up discussion on various ideas and concepts involved in developing the product. Focus Activity—Teachers participated in a hands-on 5-to-6-member group session with participants acting as a food scientist product development team that was tasked to create and develop a prototype of an ice cream product comprising of a product label, the specific target audience, and so on.

*Food chemistry*—This module examines components found in food products, which include water, carbohydrates, proteins, and lipids and their functionality. Ice breaker—Teachers
were tasked to determine the name of a product from a list of ingredients presented and to share in a guided discussion on the functionality of each ingredient. Focus Activity–The training instructor presented a short lecture on ingredient functionality of an ice cream product.

*Food safety*– This module describes the importance of food safety and explores the seven principles of a Hazard Analysis Critical Control Point (HACCP) plan and its importance for maintaining a safe food supply. Ice breaker–The training instructor provided a demonstration of the Glo Germ Handwashing toolkit. Focus Activity–Teachers participated in a guided discussion on identifying biological, chemical, and physical hazards in a processing facility. A picture of improper techniques used in a food processing facility was presented to the teachers, and they were trained on how to determine what corrective actions were needed to reduce or eliminate the risk of the identified hazard(s).

*Food processing*– This module explores different types of food processes, including refrigeration, freezing, canning, and fermentation and how these processes are important in developing diverse food products that can improve health outcomes. Ice breaker–Teachers contributed to a guided discussion on various presented food products and the food processing techniques used to develop the products (i.e., freezing, freeze drying, fermenting). Focus Activity–The training instructor demonstrated the fermentation process via the inflation of balloons by the gasses produced when yeast, sugar, and water are mixed.

*Sensory evaluation*– This module explains the importance of sensory evaluation and describes a sensory evaluation test. Ice breaker–The training instructor led a discussion on the definition of sensory evaluation and how our senses are used when eating food products such as potato chips. Focus Activity–Teachers completed an aroma test demonstration where they practiced how to properly conduct an aroma analysis and identify various aroma samples.
**Food packaging**—This module explores the main functions of food packaging and describes the components required on the principal display panel of food products. Ice breaker—Teachers participated in a food packaging/marketing trivia game which they had to answer various questions based on limited information given on the packaging and marketing practices for various food products. Focus Activity—Teachers explored the main functions of food products (i.e., containment, protection, etc.) and identified the various components needed on the principal display panel of a food product.

Promotional flyers and a promotional presentation were used to promote the food science professional development training at the FFA State Convention teachers meeting that was hosted 1 month prior to the conference. An invitation to attend the food science professional development training was extended via email to Mississippi agriculture teachers that had expressed interest in attending the training and implementing food science lesson and activities. Continuing education units were offered to help meet the teachers’ professional development requirements.

**Participants**

Participants in this study consisted of CTE teachers employed by various public school districts in MS. There were 31 teachers (42% male and 58% female) who attended the food science professional development training and completed all components of the training. Participants’ teaching experience ranged from 0 to 30 years, and all teachers fell in the range of teaching 8th–12th grade career technical courses.
Instrumentation

A 20-min retrospective survey adapted from Mississippi State University's Extension Services included sections on teachers’ demographics, satisfaction with training and instruction, teachers’ self-perceived knowledge of food science, self-perceived ability to conduct specific food sciences skills, and their self-efficacy to teach food science. The use of a retrospective survey to evaluate the training is appropriate to evaluate changes in knowledge because it allows the participants to make a more meaningful comparison of their level of understanding and experience before and after the training once they are exposed and aware of new knowledge (Rockwell & Kohn, 1989).

Teachers were asked how much they perceived and knew about food science concepts before and after the training on a five-point scale with response options of 1—Very little, 2—Little, 3—Some, 4—Much, 5—Very much (Table 3.2). The scale for measuring teachers' self-perceived knowledge of food science had a high level of internal consistency, which was determined by the Cronbach's alpha of 0.87. Additionally, teachers were asked: what was the most important thing that they have learned during the training and what else they would have liked to have learned during the training?

The teacher training instrument also measured the teachers’ self-perceived ability to conduct specific food science skills before and after the teacher training (Table 3.3). Teachers retrospectively rated if they could or could not perform a specified food science skill to implement food science lessons and activities before and after the training on a three-point scale with the following response options: 0 = No, 1 = Maybe, or 2 = Yes. The scale measuring the self-perceived ability to conduct specific food science skills of participating teachers had a high internal consistency, as reflected by the Cronbach's reliability coefficient of 0.85. In addition, the
participants were asked what one specific thing they would do as a result of participating in the food science professional development training (Table 3.4).

Participants’ self-efficacy was assessed using a validated Teaching Engineering Self-Efficacy Scale (TESS) (Yoon Yoon et al., 2014). Adapted from the TESS survey, teachers were presented nine items to assess their self-efficacy to teach food science. A five-point Likert-type scale of agreement was used in which teachers indicated the degree to which they agreed or disagreed with each statement. Response options for the self-efficacy section of the survey were 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree (Table 3.5). The scale measuring teachers' self-efficacy had high internal consistency (Cronbach's $\alpha = 0.93$). Additionally, the participants were asked to provide any additional comments or suggestion and if they were willing to use the food science curriculum during the following school semester and provide feedback to the research team about curriculum implementation.

Teachers’ satisfaction with the overall training and instruction was measured on a five-point Likert-type scale of agreement, with response options of 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree. Teachers were asked to rate their level of satisfaction with each of the nine items listed (e.g., the instructor was knowledgeable of the subject matter and the training was effective at teaching me how to implement the food science lessons and activities) (Table 3.6). The Cronbach's reliability alpha of the five-point Likert-type scale for measuring teachers’ level of satisfaction with the training was 0.89. This indicates that the questions were extremely reliable.

The research team administered and collected the survey at the end of the 2 hour food science professional development training. Teachers that completed the food science professional development training were asked to complete the training survey, for which 31
surveys were collected. Survey data from teachers were not included in the data analysis if the analyzed section of the survey was not entirely completed. The research study was approved by and followed all IRB procedures as implemented by the Mississippi State University's Institutional Review Board (protocol # 18–396).

**Experimental design and data analysis**

A one-shot case study design was used to assess the effectiveness of food science professional development training, the teachers’ satisfaction, and self-efficacy. All data analysis was performed using Statistical Analysis Software version 9.4 (SAS version 9.4, SAS Institute, Cary, NC). Changes in teachers’ self-perceived knowledge of food science, their self-perceived ability to conduct specific food science skills pre- and post-training scores were evaluated using one-tailed, paired t-tests with statistical significance set at $p < 0.05$. Teachers’ self-efficacy to teach food science and their satisfaction with the training were summarized using descriptive statistics.

**Results and Discussion**

**Teachers’ self-perceived knowledge and ability to conduct food science skills**

Teachers’ self-perceived knowledge of food science was determined by analyzing whether they had much and/or little perceived knowledge of specified food science concepts before and after the food science professional development training. Teachers’ self-perceived knowledge scores significantly increased ($p < 0.05$) for each assessed food science concept (Table 3.2). The mean values for teachers’ self-perceived knowledge to all assessed concepts before the training ranged from $2.00 \pm 0.94$ to $3.21 \pm 1.07$. On average, teachers stated that they had “little” to “some” knowledge of all assessed concepts before the food science
professional development training. After the training, teachers stated that they had “much”
knowledge of all the assessed concepts with mean values ranging from 3.93 (±0.60) to 4.29
(±0.60). Specifically, the largest and smallest changes in teacher's self-perceived knowledge
mean values were observed when teachers were asked their self-perceived knowledge of the five
D's of food product development (MDifference = 2.29) and career opportunities in food science
(MDifference = 0.89), respectively (Table 3.2). These results indicate that the food science
professional development training was effective at increasing teachers’ self-perceived knowledge
of the specific food science topics that were evaluated.

Teachers’ self-perceived knowledge of the five D's of food product development links
back to the experiential learning framework that was used to design the food science professional
development training (Kolb, 1984). The teachers engaged in a product development activity
showcasing the five D's of food product development just as high school students would learn in
a classroom setting. The participating teachers were separated in small groups of five to six
teachers per group and were guided through the application of the five D's of food product
development activity during the training session. Hosting a group work session during the food
professional development training provided an environment supportive of collaborative learning,
in which the teachers were able to provide each other with varying perspectives about the learned
food science concepts and their experience teaching food science. Sturko and Gregson (2008)
confirms the impact of professional development among CTE educators in their qualitative study
that described how CTE teachers “become more skilled practitioners” via professional
development trainings that incorporated group and collaborative learning.

The teachers rated their self-perceived ability to conduct food science skills to effectively
implement food science lessons and activities before and after the training. Prior to the training,
teachers said that “maybe” they had the ability to discuss food safety concepts ($M = 1.38$); however, the teachers rated “no” to “maybe” of their skills in all other areas assessed (Table 3.3). Results suggest that teachers did not perceive that they had a clear understanding of skills such as how to “employ the five D’s of food product development” ($M = 0.31$) and how to “exemplify techniques to perform an aroma evaluation” ($M = 0.55$) before the training. However, teachers’ self-perceived ability to employ the five D’s of food product development ($M = 1.72$) and their ability to “exemplify techniques to perform an aroma evaluation” ($M = 1.72$) significantly increased ($p < 0.05$) post training (Table 3.3). Overall, the means of the teachers’ scores for performing certain food science skills after the training ranged from 1.72 ($\pm 0.45$) to 1.93 ($\pm 0.26$). The significant increases ($p < 0.05$) in evaluated practices that were surveyed post training indicated that the food science professional development training was effective at increasing the teachers’ perceived ability to conduct food science activities and practices. The results also suggest that the food science professional development training provided teachers the practices and skills that were needed to implement the food science lessons and activities.

After stating their self-perceived knowledge of food science and their self-perceived ability to conduct food science skills, several teachers stated that the most important concept learned during the training was how to implement food product development concepts in their courses and that, in general, there are applied and hands-on lessons available for teachers to teach food science concepts such as food safety, product development, and ingredient functionality of foods. Teachers also stated that they were interested in learning more about additional food product development concepts and the principles of HACCP (Table 3.4).

Prompted opportunities of reflection within the training allows teachers to reflect on knowledge constructed, skills developed, and their overall experience during the training which
is pivotal in the experiential learning cycle. Kolb (1984) states that the inclusion of hands-on activities alone does not constitute experiential learning, but constructive reflection is what characterizes experiential learning; therefore, the design of the food science professional development training supports and promotes effective self-perceived knowledge gain among teachers (Knobloch, 2003). Teachers’ reflections provided the research team insight on areas of food science that teachers considered to be most important to learn and how to improve future training sessions.

When teachers were asked, “what is one specific thing they would do as a result of participating in the food science professional development training”, they stated that they would implement activities within their courses and use the material to prepare students for the FFA Organization's Food Science and Technology Career Development Event (Table 3.4). The food science professional development training can help teachers meet the expectation to integrate innovative instruction strategies and practices to enhance student learning abilities as CTE curricula continuously develops and advances (Reese, 2010). Positive responses among CTE teachers towards the food science professional development training suggests that the training was effective at increasing teachers’ skills to perform food science lessons and activities in their CTE courses.

**Participants’ self-efficacy and satisfaction**

When evaluating teachers’ personal belief of how confident they are in their ability to teach food science curriculum, namely self-efficacy, more than 77% of the teachers “agreed” or “strongly agreed” to survey statements 1–6 which affirmed their belief of their food science knowledge and ability to teach food science concepts (Table 3.5). Posterior to the food science professional development training, 42% of the teachers “agreed” or “strongly agreed” that they
“know how to teach food science concepts effectively”; however, 52% of the teachers’ responses were “neutral” to this statement and 6% of the teachers “disagreed” with the statement. Less than 13% of the teachers “disagreed” or “strongly disagreed” that “[they] can teach food science as well as [they] do most subjects” (Table 3.5). Overall, these results suggest that the food science professional development training was effective at improving teachers’ self-efficacy to teach food science in their CTE courses.

At the end of the survey, teachers were asked if they were willing to teach the food science lessons and activities in the upcoming school year and to provide additional comments. Results expressed that 74% of the teachers were willing to implement the food science lessons and activities in the upcoming school year, and 19% of the participants were not willing to implement the food science lessons and activities in the upcoming school year. Specifically, a teacher stated that, “[she] did not want to use the entire food science curriculum; however, [she] would use certain competencies to tie in with [her] regular instruction.” Only two (6%) teachers were unsure and responded that they were “maybe” willing to implement the food science lessons and activities in the upcoming school year. These results indicated that most of the teachers were positive and willing to teach the food science lessons as well as confident in their ability to effectively deliver the food science lessons and activities in their CTE classrooms.

Constructed by Bandura in the Social Cognitive Theory, self-efficacy is defined as a person's belief about their ability to perform or conduct a task (Bandura, 1977). Self-efficacy is highly regarded as an essential point of measure in the education field, and past and recent studies have depicted how teacher's self-efficacy influences their instructional practices which were directly linked to student performance (Coladarci, 1992; Gibson & Dembo, 1984; Muijs & Reynolds, 2002). A teacher's positive and strong personal belief in their ability to perform tasks
renders them more receptive to learning and performing new concepts and tasks. Teachers with a strong self-efficacy are also more willing to implement new instructional strategies to further enhance student learning experiences (Liceaga et al., 2014; Stein & Wang, 1988; Tschannen-Moran et al., 2001). Teachers’ personal belief of their ability to teach food science may be impacted by several factors such as limited exposure or training in food science concepts and/or lack of knowledge and skills to teach food science on a high school level. Previous studies revealed how self-efficacy is essential for effective teaching; however, it is not independently adequate to describe effective implementation of teaching instruction (Raudenbush et al., 1992). The engagement in learning experiences also shapes confidence levels related to teachers’ abilities to conduct teaching methods (Lent et al., 1994). Therefore, it is vital to provide teachers professional development opportunities to increase their self-perceived knowledge and self-perceived ability to conduct food science skills to further impact teachers’ efficacy towards teaching food science in high school CTE courses.

Participating teachers were asked to rate how satisfied they were with the food science professional development training. The teachers’ level of satisfaction was measured utilizing nine items that assessed the teacher's satisfaction with the food science professional development training instructor, the materials delivered in the training, and the impact of the training (Table 3.6). On a 5-point Likert-type scale of agreement, the results of this study showcased that the participating teachers were satisfied with the training instructor, the materials delivered in the training, and the impact of the food science professional development training (Table 3.6). More than 80% of the teachers “agreed” or “strongly agreed” to all nine items that were used to measure teacher satisfaction with the food science professional development training. When asked “was the content relevant to my needs” and “attending the training was worth my time,”
60% and 67% of the participating teachers strongly agreed with these statements, respectively. Overall, no teacher strongly disagreed nor disagreed with the items that were used to assess teachers’ satisfaction with the food science professional development training. The data suggests that the food science professional development training met the needs of the CTE teachers, and they were satisfied with the design and delivery of the training and food science content.

The research design in this study provides researchers with data to strengthen the current body of literature on professional development training focused on food science curriculum implementation. As researchers continue to investigate how professional development trainings impact teachers’ knowledge of food science, their ability to perform food science skills and practices, and their self-efficacy to teach food science, researchers can use the design of the food science professional development training as an outline to develop trainings for other CTE programs. Applying the research design to develop teacher professional development opportunities in other CTE programs gives the opportunity for researchers to further enhance CTE programs by equipping teachers with knowledge, skills, and relevant resources to integrate in course curricula.

Considering the results of this study in connection with existing literature, several recommendations for future work can be made. Future studies should include an assessment of the implementation process by teachers that participated in the food science professional development training. This would allow researchers to further observe and understand the impact of the training on teachers’ perceived knowledge, skills, and self-efficacy to teach food science. To support the continued development of the food science professional development training, it is recommended to incorporate additional experiential learning activities centralized around food safety and food product development to further increase CTE teacher's self-perceived knowledge.
gain in these specified areas. Lastly, future studies should evaluate the effectiveness of the food science professional development training when disseminated to other formal and informal education audiences such as public and private high school science teachers, 4-H Extension agents, and/or other youth development program coordinators. Conducting the training for varying audiences will help researchers further extend their reach in promoting food science career pathways among educators and students.

Conclusions

The purpose of this study was to assess the effectiveness of a food science professional development training for Mississippi CTE teachers. These results suggest that the food science professional development training was effective at improving teachers’ self-perceived knowledge of food science concepts, their self-perceived ability to conduct food science skills, and their self-efficacy to teach food science in their CTE courses.
Table 3.1  Topics of each food science lesson and associated training activity.

<table>
<thead>
<tr>
<th>Lesson and Description</th>
<th>Training Activity (Allotted Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discover Food Science</strong></td>
<td>Ice breaker – “Have you wondered…?” explores how food science and technologies are used to formulate and produce foods. (5 minutes)</td>
</tr>
<tr>
<td>This module defines food science, investigates various disciplines and career opportunities within the food science industry.</td>
<td>Focus Activity – Teachers are introduced to various disciplines (e.g., food chemistry and quality control) within food science via training presentation. (4 minutes)</td>
</tr>
<tr>
<td><strong>Food Product Development</strong></td>
<td>Ice breaker – A discussion on what people think when they purchase products. (2 minutes)</td>
</tr>
<tr>
<td>This module describes the main principles of food product development such as identifying the target audience, creating a product description, and developing a prototype of the product.</td>
<td>Focus Activity – Teachers participate in a hands-on group session which they act as a food scientist product development team tasked to create and develop a prototype of an ice cream product. (35 minutes)</td>
</tr>
<tr>
<td><strong>Food Chemistry</strong></td>
<td>Ice breaker – Teachers are to determine the name of a product from a list of ingredients presented. (3 minutes)</td>
</tr>
<tr>
<td>This module examines the main components found in food products such as water, carbohydrates, and lipids and their functionality.</td>
<td>Focus Activity – Teachers participated in a lecture on ingredient functionality of each groups ice cream product. (4 minutes)</td>
</tr>
<tr>
<td><strong>Food Safety</strong></td>
<td>Ice breaker – A demonstration of the Glo Germ Handwashing toolkit. (3 minutes)</td>
</tr>
<tr>
<td>This module describes the importance of food safety and explores the seven principles of HACCP and its importance for maintaining a safe food supply.</td>
<td>Focus Activity – A guided discussion on identifying biological, chemical, and physical hazards in a processing facility and teachers determined what corrective actions is needed to reduce/eliminate the risk of the identified hazard. (3 minutes)</td>
</tr>
</tbody>
</table>
### Table 3.1 (continued)

<table>
<thead>
<tr>
<th>Lesson and Description</th>
<th>Training Activity (Allotted Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food Processing</strong></td>
<td>Ice breaker – A discussion on various food products and the food processing techniques used to develop the products (i.e., freezing, freeze drying, fermenting). (2 minutes)</td>
</tr>
<tr>
<td>This module explores different types of food processes such as refrigeration, freezing, canning, and fermentation and how these processes are important in developing diverse food products that can improve health outcomes.</td>
<td>Focus Activity – Teachers examine a demonstration of the process of fermentation via the inflation of balloons by the gasses produced when yeast, sugar, and water are mixed. (3 minutes)</td>
</tr>
<tr>
<td><strong>Sensory Evaluation</strong></td>
<td>Ice breaker – A discussion on the definition of sensory evaluation and how our senses are used when eating various food products. (2 minutes)</td>
</tr>
<tr>
<td>This module aims to explain the importance of sensory evaluation and describe various sensory evaluation tests.</td>
<td>Focus Activity – Teachers learn how to properly conduct an aroma analysis and to identify various aroma samples. (5 minutes)</td>
</tr>
<tr>
<td><strong>Food Packaging</strong></td>
<td>Ice breaker – Food packaging/marketing trivia game. (2 minutes)</td>
</tr>
<tr>
<td>This module explores the main functions of food packages and describes the components required on the principal display panel of food products.</td>
<td>Focus Activity – Teachers explore the main functions of food products (i.e., containment, protection, etc.) and identify the various components needed on the principal display panel of food products. (2 minutes)</td>
</tr>
</tbody>
</table>
Table 3.2  Average teachers’ self-perceived knowledge before and after completing the food science professional development training (n=28).

<table>
<thead>
<tr>
<th>Statements</th>
<th>Before M (SD)</th>
<th>After M (SD)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>The definition of food science</td>
<td>3.14 (0.80)</td>
<td>4.14 (0.59)</td>
<td>6.48</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>The branches of food science</td>
<td>2.50 (0.96)</td>
<td>3.93 (0.60)</td>
<td>8.22</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>The 5 D’s of Food Product Development</td>
<td>2.00 (0.94)</td>
<td>4.29 (0.60)</td>
<td>11.16</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Career opportunities in food science</td>
<td>3.04 (0.88)</td>
<td>3.93 (0.72)</td>
<td>5.68</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ingredient functionality</td>
<td>2.75 (1.00)</td>
<td>3.96 (0.79)</td>
<td>8.17</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Food safety concepts</td>
<td>3.21 (1.07)</td>
<td>4.14 (0.65)</td>
<td>4.84</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Food processing methods</td>
<td>2.82 (1.06)</td>
<td>3.96 (0.64)</td>
<td>6.00</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sensory evaluation: Aromas test</td>
<td>2.68 (1.06)</td>
<td>3.96 (0.74)</td>
<td>7.59</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Food marketing and packaging</td>
<td>2.96 (1.04)</td>
<td>4.18 (0.61)</td>
<td>6.46</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Note: M – Mean, SD – Standard Deviation; 5-point scale: 1- Very little, 2- Little, 3- Some, 4-Much, 5- Very Much
Table 3.3  Average teachers’ self-perceived ability to conduct food science skills before and after completing the food science professional development training.

<table>
<thead>
<tr>
<th>Statements</th>
<th>Before M (SD)</th>
<th>After M (SD)</th>
<th>n</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss branches of food science</td>
<td>0.724 (0.75)</td>
<td>1.79 (0.49)</td>
<td>29</td>
<td>7.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Employ the 5 D’s of Food Product Development</td>
<td>0.310 (0.54)</td>
<td>1.72 (0.53)</td>
<td>29</td>
<td>11.16</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Describe the function of ingredients in food products</td>
<td>0.655 (0.81)</td>
<td>1.72 (0.45)</td>
<td>29</td>
<td>7.21</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Discuss the importance of food safety</td>
<td>1.38 (0.86)</td>
<td>1.93 (0.26)</td>
<td>29</td>
<td>3.79</td>
<td>0.004</td>
</tr>
<tr>
<td>Exemplify techniques to perform an aroma evaluation</td>
<td>0.552 (0.74)</td>
<td>1.72 (0.53)</td>
<td>29</td>
<td>8.89</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Describe the function of food packaging</td>
<td>0.931 (.80)</td>
<td>1.89 (0.31)</td>
<td>28</td>
<td>7.35</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Note: M – Mean, SD – Standard Deviation; 3-point scale: 0- No, 1- Maybe, 2- Yes
<table>
<thead>
<tr>
<th>Questions</th>
<th>Teacher Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the most important thing you learned during this training?</td>
<td>“I found the product development worksheet and activity informative.”</td>
</tr>
<tr>
<td></td>
<td>“New Food Science Curriculum... would like to add to our CTE program.”</td>
</tr>
<tr>
<td></td>
<td>“The 5 D's... how to use the homemade ice cream activity to teach the 5 D's and help the students to apply this knowledge.”</td>
</tr>
<tr>
<td></td>
<td>“Ingredients of food products.”</td>
</tr>
<tr>
<td></td>
<td>“How to do aroma test. Way to implement the lessons.”</td>
</tr>
<tr>
<td></td>
<td>“Ways to involve students in Food Science.”</td>
</tr>
<tr>
<td></td>
<td>“Applied/hands on things to use to improve teaching/learning.”</td>
</tr>
<tr>
<td>What else would you have liked to have learned during this training?</td>
<td>“What additional professional development available.”</td>
</tr>
<tr>
<td></td>
<td>“More product development”</td>
</tr>
<tr>
<td></td>
<td>“Seven principles of HACCP”</td>
</tr>
<tr>
<td>What is one specific thing you will do as a result of participating in this training?</td>
<td>“Pursue training/ teaching to implement in my program.”</td>
</tr>
<tr>
<td></td>
<td>“Implement what I learned today into my classroom as well as my training of my Food Science FFA team.”</td>
</tr>
<tr>
<td></td>
<td>“Try more food science activities.”</td>
</tr>
<tr>
<td></td>
<td>“Do more research into the subject and talk to admins about adding the class.”</td>
</tr>
<tr>
<td></td>
<td>“Better prepare students for CDE.”</td>
</tr>
<tr>
<td>Statement Numbers</td>
<td>Statements</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>I can explain the different aspects of food science.</td>
</tr>
<tr>
<td>2</td>
<td>I can employ food science activities in my classroom effectively.</td>
</tr>
<tr>
<td>3</td>
<td>I can increase students’ interest in learning food science.</td>
</tr>
<tr>
<td>4</td>
<td>I can promote a positive attitude toward food science learning in my students.</td>
</tr>
<tr>
<td>5</td>
<td>I can help my students apply their food science knowledge to real world situations.</td>
</tr>
<tr>
<td>6</td>
<td>My effectiveness in food science teaching can influence the achievement of students with low motivation.</td>
</tr>
<tr>
<td>7</td>
<td>I can explain food science concepts well enough to be effective in teaching food science.</td>
</tr>
<tr>
<td>8</td>
<td>I know how to teach food science concepts effectively.</td>
</tr>
<tr>
<td>9</td>
<td>I can teach food science as well as I do most subjects.</td>
</tr>
</tbody>
</table>

Note: 5-point scale: 1- Strongly disagree, 2- Disagree, 3- Neutral, 4- Agree, 5- Strongly agree
Table 3.6  Teachers’ level of agreement (%) to instruction and satisfaction post food science professional development training (n=30).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The instructor was knowledgeable of the subject matter.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>The instructor related training content to real-life situations.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>87</td>
</tr>
<tr>
<td>The content was well-organized.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>The content was based on credible, up-to-date information.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>The content was at an understandable level.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>27</td>
<td>70</td>
</tr>
<tr>
<td>Attending this training was worth my time.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>30</td>
<td>67</td>
</tr>
<tr>
<td>I would recommend this training to others.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>27</td>
<td>70</td>
</tr>
<tr>
<td>The training was effective at teaching me how to implement the food science lessons and activities.</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>23</td>
<td>70</td>
</tr>
<tr>
<td>The content was relevant to my needs.</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
</tbody>
</table>

Note: 5-point scale: 1- Strongly disagree, 2- Disagree, 3- Neutral, 4- Agree, 5- Strongly agree
CHAPTER IV

MISSISSIPPI CAREER AND TECHNICAL EDUCATION TEACHERS’ PERCEPTION TOWARD IMPLEMENTING A FOOD SCIENCE TOOLKIT DESIGNED TO INCREASE FOOD SCIENCE CURRICULUM USE IN MS

Abstracts

Teachers’ perceptions of curriculum implementation support the evaluation of curriculum design and development and curriculum adoption and usefulness. Examining teachers’ perspectives towards the design and usefulness of curricular content can render evidence on how curriculum design impacts the implementation of educational resources and potential ideas on improving curricular design and content. A pilot test implementing a food science toolkit, designed to increase student awareness, interest, and knowledge of food science academic and career pathways, in Mississippi (MS) Career and Technical Education (CTE) courses was conducted to determine teacher’s perception of the food science education resources. After implementing the food science toolkit in their CTE course, four teachers individually participated in a semi-structured interview to capture each teacher’s detailed experience implementing the food science toolkit. The results of this study revealed that teachers are interested in teaching food science on the secondary education level to increase student knowledge of food science and to enhance student performance on the FFA food science career development event. Teachers also revealed their positive experience implementing the food science toolkit and their intentions to continue to use the food science toolkit in their CTE
courses to further increase their exposure to food science competencies. Teachers’ perceived that the food science toolkit increased student exposure to, engagement in, and interest in food science academic and career pathways, which encourages students to select and pursue a career in food science.

Key words: teaching toolkit, secondary education, curriculum, implementation, career pathways

Introduction

Mississippi is primarily an agricultural state that sends most agriculture commodities to food companies in other states for added-value processing. This has led to Mississippi’s lack of focus on developing “new economic activity” through state-based raw commodities (Meter & Goldenberg, 2014). With the decline of agriculture-related businesses and an increased interest in exporting agriculture commodities, many youth lack the basic skills and knowledge about farming and agriculture-based concepts. Specifically, youth lack an understanding of food science concepts and basic acknowledgment of commonly consumed foods. Education in food science at the secondary education level will help train students for jobs in the food industry as well as produce a trained workforce so that food companies have greater opportunities and incentives to open added value food plants in Mississippi.

Students are generally exposed to food concepts in agriculture-based career technical education (CTE) courses that are taught in MS public school districts; however, there is limited time allotted for teaching food science concepts in CTE courses as well as minimum professional development opportunities to enhance teachers’ ability to teach food science based instruction effectively. Several studies describe the development, dissemination, and implementation of
food-related interventions to promote food science-related concepts at the secondary education level (Kahnke et al., 2006; McEntire & Rollins, 2007; Jideani & Jideani, 2010; Bell, 2014; Shearer et al., 2014). These findings indicate that providing teacher training and educational resources enhanced the implementation process of the food science related resources as well as increased interest in the food science career pathway among high school students and teachers. However, few qualitative studies exist related to teachers’ perceptions of implementing food science educational resources in CTE courses. More specifically, there were no formal professional development opportunities available for MS CTE teachers to enhance their knowledge and teaching strategies to support high-quality implementation of food science-related concepts in their classes.

Our research group trained teachers to implement food science lessons and observed an increase in MS CTE teachers’ self-perceived knowledge, skills, and self-efficacy to teach food science (Hendrix et al., 2021). Han & Weiss (2005) investigated similar factors that impacted teachers’ perceptions towards implementing various school programs, and they determined that evaluating and understanding teachers’ perceptions is highly important and impactful towards the implementation and continued use of school program resources. Therefore, the purpose of this qualitative research study is to understand and describe MS CTE teachers’ experiences when implementing food science educational resources. The following research questions were answered in this study:

1. Why are Mississippi CTE teachers interested in teaching food science in secondary career and technical education courses?
2. How do Mississippi CTE teachers characterize their experiences implementing food science educational resources in their secondary career and technical education courses?

3. What were the perceptions of the CTE teachers towards the quality of the food science educational resources and implementation process?

4. Why would CTE teachers continue to use the food science educational resources?

**Materials and Methods**

**The development of the food science teaching toolkit**

Members of Mississippi State University’s Research Curriculum Unit (RCU) identified a growing interest and participation of middle and high school CTE students and teachers in the Mississippi FFA Food Science Career Development Event. A collaborative team consisting of RCU members, Mississippi State University Food Science faculty, and MS CTE teachers developed a secondary education food science curriculum framework that consists of competencies in food microbiology, food sanitation and safety, food processing, food chemistry, and professionalism in the field. To further promote food science career pathways in MS secondary education CTE courses, a food science teaching toolkit was created to support the development of the food science curriculum framework and offer MS CTE teachers educational resources to implement food science lessons in their CTE courses.

The food science teaching toolkit was developed using lessons created by the research team and adapted versions of existing food science secondary education resources provided by multiple education organizations such as the Institute of Food Technologists, Agriculture in the Classroom, and Mississippi State University Extension Services. The food science teaching
The food science toolkit

Within the food science teaching toolkit, teachers were provided a loose-leaf notebook containing: 1) lesson plans consisting of a lesson summary, objectives, overview of lesson activities, and lists of supplies needed for the lessons; 2) lesson notes and teaching scripts; 3) student activity worksheets and instructional handouts; 4) PowerPoint presentations; and 5) consent forms and evaluation tools. Teachers were also provided access to an electronic file containing all documents included in the loose-leaf notebook. The food science teaching toolkit also included various non-perishable supplies (i.e., biuret solutions and food fragrances) needed for conducting the learning activities. The specific food science lessons included: 1) an introduction to food science, 2) food product development, 3) food chemistry, 4) food safety, 5) food processing, and 6) sensory evaluation, and these lessons are further described in Table 4.1. The related experiential learning activities that allowed students to explore various food science disciplines and careers, food product development steps for producing ice cream, fermentation, protein identification in food samples, candy chemistry and production, identification and
correction of hazards in food processing facilities, and food sample and aroma identification. All toolkit supplies were disseminated to CTE teachers after acquiring their consent to participate in the research study and acquired approval from the district and school officials.

**Implementation procedures and participants**

A food science professional development training featuring an introduction to and teaching strategies on implementing the food science toolkit resources was conducted for MS CTE teachers (Hendrix et al., 2021). At the end of food science professional development training, teachers were invited to participate in a pilot study to assess the implementation of the food science teaching toolkit resources. Teachers who committed to participate in the study:

- Implemented the food science educational resources during the 2019-2020 school year,
- Assisted the research team in acquiring parent permission and student consent before implementing the food science teaching toolkit in their CTE courses,
- Administered a student assessment before and after implementing the six food science lessons and activities in their classes, and
- Participated in a post-implementation interview to capture their experience implementing the food science teaching toolkit.

High school CTE teachers (N=4) participated in this pilot study, and those teachers reached approximately 70 students. Participating teachers were from public school districts located in rural communities of Mississippi. Teaching experience among the teachers ranged from 6 to 21 years of teaching 8th-12th-grade agriculture and natural resources, agricultural sciences, and/or agriculture-related courses.
Measurements

After the implementation period, post-implementation interviews were conducted to capture each teacher’s detailed experience implementing food science lessons and activities in their CTE classroom. A semi-structured interview protocol was developed and used to maintain consistency and to limit opportunities for bias during the interview process. The interview protocol highlighted the following topics:

1. Teacher interest in teaching food science in MS career and technical education courses
2. Teacher perceptions towards implementing the food science lessons and activities in CTE courses
3. The perceived quality of the food science lessons and activities
4. Continued use of food science lessons and activities in CTE courses

The interview protocol was piloted and reviewed to clarify interview questions and terminology and approximate the time to conduct interviews. Interviews were hosted via an online meeting platform and were all audio-recorded and transcribed for analysis. Pseudonyms were assigned to the names of participating teachers when data was transcribed. Each interview lasted 45 min to 1 hour. The guiding interview questions were aligned with the objectives of this research study. Approval to conduct this study was provided by the Mississippi State University’s Institutional Review Board (protocol # 18-396), and all IRB procedures were followed accordingly.
**Statistical analysis**

Data were analyzed using a qualitative research approach (Creswell, 2009) that followed a conventional content analysis. Within the scope of a conventional content analysis, the knowledge gained, and codes identified are generated directly from the data allowing new perceptions and understanding to result from the data without the influence of preconceived theories (Kondracki et al., 2002; Hsieh & Shannon, 2005). All raw data were collected, organized, and read multiple times by two researchers. Initially, data were coded by two researchers independently via an open-coding approach. When interpreting the data, codes were examined and charted via recurring patterns and characteristics identified among data. Recurrent themes among the data were identified, and direct quotes from participating teachers were also charted per category to support data analysis. Data analysis was repeated and validated by a member not involved in the interview process. This member was trained in content analysis by the research team. This member 1) independently categorized the qualitative data for each research question, 2) compared and validated the researcher’s analysis to arrive at a consensus, and 3) selected appropriate quotes for each theme and category of the data set.

**Results and Discussion**

Research findings were organized and presented by research question. Four main categories were highlighted: 1) Teacher interest in teaching food science, 2) Teacher experience implementing food science education resources, 3) Teacher perception of food science education resources, and 4) Teacher’s reasons for continued use of the food science education resources. Per category, prominent themes among participating teachers’ responses were noted corresponding to each research question.
Research question one: Why are Mississippi career and technical education teachers interested in teaching food science in secondary CTE career and technical education courses?

Teachers stated a range of reasons for their interest in teaching food science in their CTE course. Two themes emerged from the data analysis: 1) to increase understanding of food science among students, and 2) to enhance student training and performance for/at the FFA food science career development event (CDE). Table 4.2 showcases the themes that emerged from the data analysis of teachers’ interest in teaching food science.

**Theme 1: Increase knowledge of food science among students.**

Teachers’ interest to teach food science is motivated by their desire to increase their students’ knowledge of food science principles. For example, Emma, a teacher with eight years of experience teaching high school agriculture courses, stated that students showcased a true interest in food science, but they did not understand concepts such as “how food is processed,” “how food is brought to the table,” and “how [food] is packaged.” Additionally, one teacher, Sarah, thoroughly described how students she had previously exposed to food science concepts were confused about various food science principles. Sarah also expressed how she believed the students would benefit from correctly understanding food science principles. Sarah stated:

Firstly, anything related to food is going to get kids' attention automatically... I think from a personal standpoint, packaging really confuses kids and not just kids, even [teachers] for as what is healthy and what is not, or what does the terminology on the packaging mean? And I think they will be more educated consumers if they understand the words and the packaging and the labeling. And I think that's something that every one of them ... [will] benefit from it.
It was expected that all participating teachers discussed that their interest to teach food science is driven by increasing knowledge of food science among their students. Due to the growing demand for innovative food products, the current strong interest in food and overall wellness, and the steady growth in the U.S. population, there is a growing need for science literate people who are more aware, knowledgeable, and technically trained in the field of food science and technology. In 2007, Peacock examined the effects of food science-based instruction on high school students, and it was determined that teaching food science at the secondary level increases the number of students that are more aware and knowledgeable of food science, and that would select food science as a college major (Peacock, 2007). These findings indicate that teachers’ interest to teach food science should be cultivated to further extend food science based instruction on the secondary education level and to increase knowledge of food science among students.

**Theme 2: Enhancement of student training and performance for/on the FFA food science CDE.**

A commonality among participating teachers for their interest in teaching food science was their desire to enhance student performance on the FFA food science career development event. All participating teachers train student FFA teams to annually compete in the state level FFA food science CDE. Some teachers expressed how their team competed and placed at the state level food science CDE and participated at the national level. However, teachers desired to enhance training methods and student performance on the FFA food science CDE. This response coincides with the previous emerging theme of increasing student knowledge of food science concepts. Teachers observed increased interest in food science among students who participated in the FFA food science CDE; therefore, they began to pursue opportunities to further increase
their knowledge of food science and acquire resources to teach food science concepts in their CTE courses. Christine specifically expressed:

I got started doing food science when I had a group of students that were interested in the food science competition when we first started with FFA… and so the [students and I] both, we kind of dove in together and we started learning about all of it and it was really interesting [and] fascinating.

Sarah extended this idea beyond food science as the subject of focus when she expressed how food is a vehicle to teach various subject areas, hence, she was interested in teaching food science among her students, and the increased desire of her students to compete instilled and motivated her to teach food science in her classroom curriculum. These findings are supported by Schmidt and other (2012) who also discussed how students are familiar with food and it is essential to identify the current knowledge of students to effectively scaffold upon and enhance their current knowledge in STEM related fields. As more MS CTE teachers pursue opportunities to enhance students training and performance for/on the FFA food science CDE, there is potential to increase CTE students’ practical experiences in which they can showcase their knowledge and skills in the field of food science, hence, supporting FFA’s overall mission to “develop youth through premier leadership, personal growth and career success” (“FFA Vision, Mission, and Motto,” 2021).

Research question two: How do Mississippi CTE teachers characterize their experiences implementing food science educational resources in their secondary career and technical education courses?

Four prominent themes emerged among teachers’ responses towards their experiences implementing food science educational resources: 1) Teacher passion yields increased
promotion, 2) Teacher interest in specific lessons, 3) Implementation process eased by food
science toolkit, and 4) Student engagement. Table 4.3 depicts the four emerging themes that
categorized teachers’ experiences implementing food science educational resources.

**Theme 1: Teacher passion yield increased promotion.**

Teachers’ personal motivation to teach food science increased promotion of the food
science educational resources among the CTE students. Several teachers heavily promoted the
food science lessons as fun and exciting before implementing resources of the food science
toolkit. Mary stated, “[Food science is] something that I love, and kids can always pick up on
that. Literally because I love it so much, I promoted it… we're just about to have some fun, and
they loved it… they were super excited about it… I had gotten them pumped up, excited about
it.” In addition to generated excitement and interest among the CTE students, Emma, who also
promoted the food science lessons prior to implementing the food science toolkit, expressed that
her students desired to participate in activities that are similar to the implemented food science
activities on a daily basis.

**Theme 2: Teacher interest in specific lessons.**

All participants explained their interest and perspective towards specific food science
lessons within the food science toolkit. Specifically, three teachers expressed that the food
product development lesson was appealing to students, which resulted in heightened
participation and engagement among students. It was also explained that the design of the food
product development lesson created opportunities for teachers to extend the lesson for further
exploration of various food science disciplines via intriguing questions presented by students.
Sarah stated:
The [food product development lesson] was good. Um, most of them had done that at some point in their school year, but I will tell you… after we did your lesson, they were very engaged… so that lesson, we ended up just really growing and stretching and doing a lot of stuff with… they kept asking questions… [the lesson] just had a good flow from their conversation, from the ice cream into… labeling, which then kind of went into marketing and packaging… [and] we gained a lot from that.

Teachers’ interest in specific lessons such as the food product development lesson was also noted by increased creativity among students as they completed specific food science activities. The teacher feedback confirms the intended design of the food science toolkit. The food science lessons were designed to be introductory lessons to expose students to the food science curriculum competencies and the activities included in the food science toolkit stimulated and increased student awareness, interest, and exposure to the field of food science. The feedback provided by the teachers towards specific food science lessons and activities stimulated the students’ interest and curiosity. In addition, the food science lessons derived additional discussion and lesson expansion beyond the presented educational resources. This further supports that exposing students to food science on the secondary education level has the potential to increase the number of students interested in food science and who will pursue an academic and/or career pathway in food science.

**Theme 3: Implementation process eased by food science toolkit.**

The participating CTE teachers characterized their experiences implementing food science educational resources by their ability to easily implement the lessons via the food science toolkit. All teachers expressed that it was convenient to teach the food science lessons based on
the provided lesson plans, activity guides, and other supplemental teaching supplies. Several teachers expressed the demand to find new and innovative resources to teach agriculture topics; however, teachers have limited time to search for educational resources and effectively implement these educational resources in their classroom. For example, during the school year, Mary explained the various tasks and roles she has as a CTE teacher within her school district. Mary stated that she enjoys teaching food science in her courses; however, “it’s just a lot on [her] plate, and to be able to just open the [food science toolkit] book… it helped organize my thoughts” and Mary was able to implement the food science toolkit. In addition, other teachers explained their appreciation for the lesson plans, scripts, and other teaching resources that supported a positive and simple implementation experience. Kahnke and others examined the effectiveness of a dairy foods curriculum package that they developed for high school agriculture education teachers in South Dakota, and it was determined that providing teachers with “ready-made” educational resources enhanced high school dairy education (Kahnke et al., 2006). Developing and providing CTE teachers education resources to teach subjects like food science can be used in curriculum design and development, ensure successful implementation of food science lessons and activities, as well as increase the amount of instructional time allotted to teach food science on the secondary education level.

**Theme 4: Student engagement.**

Teachers discussed that student engagement was the most meaningful experience acquired during the food science lessons and activities. For example, Emma described her experience teaching her students food chemistry concepts, and she expressed, “the most meaningful was seeing [the] kids' reaction [to the candy chemistry activity].” During the candy
chemistry activities, teachers explained the science involved in making hard candy. They observed that students were engaged and had positive reactions towards the simplicity of applying learned food science concepts to successfully making hard rock candy to enjoy at the end of class. In addition to observing how engaged her students were during the food science lessons, Sarah discussed how her students continuously presented intriguing questions during class discussion and the students’ desire to engage in additional food science lessons. Specifically, Sarah shared, “[food science] is a topic that [the students] are not scared to ask about [be]cause they feel good about food.” Schmidt and others (2012) found that while conducting food science demonstrations on the secondary and post-secondary level, students were highly engaged in the food science lessons and actively participated in the demonstrations by asking questions that generated further class discussion. The findings from this study indicate that implementing the food science toolkit in high school CTE classes can increase students’ engagement in and satisfaction with their learning experiences which ultimately can lead to them pursuing future food science academic and career opportunities.

Research question three: What were the perceptions of the CTE teachers towards the quality of the food science educational resources and implementation process?

Data analysis resulted in three prominent themes for teachers’ perceptions towards the quality of the food science toolkit and the implementation process: 1) Organizational structure of resources, 2) Useful and relatable resources, and 3) Desire for additional resources/opportunities (Table 4.4).
Theme 1: Organizational structure of resources.

All teachers expressed that the food science education resources were well organized, and it was easy to follow the design of the lessons and the overall implementation process. One teacher expressed, “… [the food science toolkit] made putting the lessons together a whole lot…easier, which you're more apt to do [the lesson] … as a busy teacher, if you have it on hand. So that was very beneficial.” A teacher also noted that “...even if [a teacher is] not proficient [in] food science, …everything's laid out, it's scripted, you've got examples and the videos and everything… it's a good set of information.” In addition, all teachers provided positive feedback regarding the organizational design of the food science teaching materials such as the lesson plans, PowerPoint slides, and student activity guides and worksheets. Previous studies identified the absence of “appropriate” agriculture related instructional resources for teachers as a potential barrier for proper implementation of new learning material (Ham & Sewing, 1988; Trexler et. al, 2000). Therefore, it is important to supply teachers with educational resources that are organized and designed for effective implementation. In addition, the organizational design of the food science toolkit can be used as a model for future curriculum design and development.

Theme 2: Useful and relatable resources.

The usefulness and relatability of the food science toolkit to CTE students and teachers contributed to the quality of the toolkit. Emma described the objectives of the food science lessons as “adequate” for the targeted age group, she also expressed, “…the kids understood it, and it was actually useful to them in their real life.” The food science toolkit was also described as a useful tool for teachers. One teacher expressed that “…[the food science toolkit] would be
very helpful for [teachers] that are still learning the whole food science process… this would definitely give them information on what they need to know [and what] to say.”

With the extensive display and promotion of food, nutrition, and overall health on all varying media platforms, having food science based instruction taught on the secondary education level is “extremely relevant” to supporting and/or combating food and health-related information presented to the public (Schmidt et al., 2012). Schmidt and others (2012) also determined that students observe food science’s relevance and significance in their day-to-day lives when food science based instruction was implemented on the secondary education level (Schmidt et. al, 2012). Based on teacher perception towards the lessons, these findings indicate that the food science toolkit has the potential to be a useful and relatable tool among students and teachers when implemented in MS CTE courses.

In previous studies that examined the impact of implementing food science based instruction have on secondary and post-secondary students, authors determined that students are food science-based demonstrations take advantage of this current abounding inquisitiveness about food and health, making food science based demonstrations not only useful and engaging.

**Theme 3: Desire for additional resources/opportunities.**

All teachers expressed their desire for additional food science teaching resources to implement in their CTE courses. The teachers described how they incorporated lesson extensions to several of the food science lessons and they also provided possible recommendations for enhancing the food science toolkit. Several teachers stated how they extended the food science lessons by showcasing additional food processing videos or invited guest lecturers to further elaborate on food science related topics. One teacher conveyed that “after [her class] had done
everything in [the food product development] lesson, [she] made them design a new product, and [she instructed] them [to] make a package…” to continue students’ application of learned food science concepts. Additionally, the teacher further extended the lesson by “actually show[ing] [the students] how to come up with their carb[ohydrate]s, fats, protein[s] and get their calories.” One teacher expressed her desire for resources which provide students opportunities to connect with food science professionals. Mary stated, “Maybe just be[ing] able to go somewhere to… pull lessons and have contacts for the kids to maybe come visit industry [representatives]. [The students] would know who they could talk to and feel comfortable about reaching out…” Advance CTE confirms the perceptions of the teachers which emphasizes the positive connections students can make via the link between secondary and post-secondary education CTE resources (Advance CTE, 2021c). Additionally, the implementation of the food science toolkit was supported by Mississippi State University faculty and students to further nurture and support the need for increased secondary and post-secondary education connections among MS CTE students and teachers. Teachers’ perceptions towards the quality of the food science educational resources and implementation process not only showcased that the food science toolkit was successful at generating interests and desire for more resources among students and teachers, but it also depicted specific activities such as the food product development lesson, that had a positive outcome and led to increased interest by the teachers and students to further explore these topics.

Research question four: Why would CTE teachers continue to use these food science educational resources?

All teachers stated that they would continue to use the food science toolkit in their classes and provided reasons to support their selected choice. Data analysis resulted in two emerging
themes from the teachers’ responses: 1) Preparation for FFA Food Science CDE, and 2) New education experiences (Table 4.5).

**Theme 1: Preparation for FFA Food Science CDE.**

Considering teachers’ interest to teach food science for the enhancement of student training and performance for/on the FFA food science CDE, it is not surprising that teachers desired to continually use the food science toolkit for preparation for the FFA Food Science CDE. For example, one teacher stated she would have teams participate in future FFA Food Science CDEs, and she expressed that “this is good training material” for the competition. Another teacher discussed how she would continue to use the food science toolkit to prepare her FFA teams for the Food Science CDE; however, would also “…tie [the food science toolkit] in with [her] FFA, giving [the students] … knowledge to see whether or not they are interested in the competition.”

The national FFA organization states that the food science CDE is designed to help increase student knowledge and technical skills in the field of food science (“Food Science & Technology,” 2021). Using the food science toolkit to prepare students for the FFA Food Science CDE has the potential to enhance student CTE learning experiences, which ultimately can increase the number of students who pursue academic and career pathways in food science.

**Theme 2: New education experiences.**

Several teachers stated that they would continue to use the resources because of the new education experience that the food science toolkit provides. Christine stated that continuing to use the food science toolkit “would give [the students] an opportunity to learn something new and different and experience something new, like the sensory [evaluation content].”
Additionally, one teacher expressed that food science is “very pertinent in our day-to-day life” and the food science toolkit offers opportunities to “expose [the students] to some new things” and different experiences while forwarding the opportunity of “understanding the why's” of food science.

Brand (2008) described how students are encouraged to pursue higher education when participating in CTE courses on the secondary education level because students can bridge their current interest to their future career goals. In addition, Schmidt and others (2012) depicted that the students who engage in food science demonstrations and lessons are more aware and interested in food science competencies and opportunities in the field. Gaining new education experiences provided by the implementation of the food science toolkit can further increase exposure to food science competencies among MS CTE students and potentially help students make an inclusive decision about selecting food science as a post-secondary education or career pathway.

**Conclusions**

There are several studies that examine the implementation of specific food science concepts on the secondary education level; however, there are a limited number of studies that examine teachers’ perceptions towards the implementation of secondary education food science resources. The research results indicated that MS CTE teachers had positive experiences implementing the food science toolkit and perceived that implementing the toolkit was useful at implementing food science education in MS CTE courses. Teachers also expressed that implementing the food science toolkit also increased student exposure to, engagement in, and
interest in food science academic and career pathways, which empowers students to select and pursue a career in food science.

Implications for Future Practice

These research results cannot be generalized to all cases where food science educational resources are implemented; however, the results of this study offer several implications for curriculum developers, state and district-level school administrators, and university food science faculty and staff. Curriculum developers can use teachers’ perceptions of specific food science lessons to assist with modifying and enhancing curricula design. All participating teachers cited several reasons for their interest in specific food science lessons (i.e., stimulated interest in food science among students and the ability to expand lesson content to teach other related topics) that would allow curriculum developers to further enrich teaching resources before reimplementation. Curriculum developers can also use the results about the food science toolkit as a model to develop additional resources to enhance student performance on various FFA student competitions.

Research findings also offer implications for state and district-level school administrators. With an increased focus on ensuring students are college and career ready, state and district-level school administrators can use teachers’ insights to assess the adoption of innovative resources that are designed to prepare students for various career pathways. Additionally, teacher feedback that the food science toolkit provides students with new educational experiences provides data to help state and district-level administrators approve food science curriculum for classroom instruction.
The results are useful to university food science faculty and staff who desire to promote food science academic and career pathways. Teacher feedback can inform university food science faculty and staff how to promote food science-based instruction more effectively among secondary education teachers. These findings also demonstrate how university food science faculty and staff understand how to strengthen university and secondary education partnerships to enhance student recruitment in the field of food science.

**Recommendations for Future Work**

Future research should consider implementing the food science toolkit among a larger population of MS CTE teachers to identify additional teacher perceptions when implementing the food science toolkit and to examine differences in implementation among participating teachers. In addition, future research should explore process indicators that depicts implementation reach, dose, and fidelity to obtain an in-depth understanding of the implementation process which can assist in improving the food science toolkit design. Lastly, future research can also examine non-CTE teachers’ perceptions of the food science toolkit. By studying non-CTE teachers’ perspectives, future researchers can explore the cross-curricular aspects of the food science toolkit as well as converge CTE and non-CTE teachers’ varying perspectives to determine consistency among study conclusions. In doing so, the food science toolkit can be implemented in additional subject areas, ultimately increasing the number of teachers implementing food science curriculum and the number of students that are exposed to food science educational resources.
Table 4.1  Food science toolkit lesson objectives and sample food science lesson activities and toolkit supplies.

<table>
<thead>
<tr>
<th>Lesson Title</th>
<th>Lesson Objectives</th>
<th>Sample Lesson Activities and Description</th>
<th>Food Science Toolkit Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discover Food Science</strong></td>
<td>1. Define food science&lt;br&gt;2. Explain the farm to fork concept&lt;br&gt;3. Describe the branches of food science</td>
<td>I’m Eating What? ¹ - Students identify how raw materials are converted to final food products&lt;br&gt;</td>
<td><em>I’m Eating What?</em> Student Flashcards and Teacher Discussion Guide ¹</td>
</tr>
<tr>
<td></td>
<td>1. Describe the steps involved in product development</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Food Product Development</strong></td>
<td>2. Apply the steps of food product development in the process of making ice cream</td>
<td>Food Scientist for a Day² – Students create an ice cream product following the steps of product development&lt;br&gt;</td>
<td><em>Food Scientist for a Day</em> Student Handout</td>
</tr>
<tr>
<td></td>
<td>3. Demonstrate leadership, teamwork, and creative thinking skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Food Chemistry</strong></td>
<td>1. Define the term food chemistry</td>
<td>Candy Chemistry³ – Students learn to make hard rock candy</td>
<td>Candy molds&lt;br&gt;Candy flavoring&lt;br&gt;Candy thermometer</td>
</tr>
<tr>
<td></td>
<td>2. Identify and describe the six main components found in food</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Define supersaturation and explain what that means in terms of candy production</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Food Safety</strong></td>
<td>1. Discuss the personal hygiene requirements of food handlers</td>
<td>Glo Germ Handwashing Demonstration⁴ – Students learn proper handwashing procedures&lt;br&gt;</td>
<td><em>Glo Germ™ Handwashing toolkit - Glo Germ solution and UV light</em></td>
</tr>
<tr>
<td></td>
<td>2. List the seven steps of HACCP (Hazards Analysis Critical Control Point) as a method to prevent foodborne illness</td>
<td>Sanitation Scenarios – Students identify all hazards and corresponding corrective action&lt;br&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Identify the types of food hazards and describe corresponding corrective action</td>
<td></td>
<td>Sanitation scenario cards</td>
</tr>
</tbody>
</table>
Table 4.1 (continued)

<table>
<thead>
<tr>
<th>Lesson Title</th>
<th>Lesson Objectives</th>
<th>Sample Lesson Activities and Description</th>
<th>Food Science Toolkit Supplies</th>
</tr>
</thead>
</table>
| **Food Processing** | 1. Define the term food processing and associated terms  
2. Describe why foods are processed  
3. Identify the various food processing methods and explain procedures used to process food safely: Drying, dehydration, freezing, canning, etc.  
4. Describe how food safety is monitored and regulated during processing | Fermentation Balloons⁵ - Students learn how gasses are produced when yeast, sugar, and water are mixed  
Food Tasting - Students taste and analyze food products that are processed differently | Fermentation balloon demonstration kit (3 - 12 oz plastic bottles and balloons)                                                                                                                                           |
| **Sensory Evaluation** | 1. Define sensory evaluation  
2. Define the term triangle test and explain its use  
3. Practice how to conduct a triangle test  
4. Describe the steps of evaluating and identifying aromas | Aroma Identification⁶ - Students learn how to identify various aroma samples  
One of These Things is Not Like the Other - Triangle Test⁷ - Students learn how to conduct a triangle test and identify an odd sample using sensory evaluation techniques | Aroma sample kit (30 aroma samples)  
Triangle test and aroma identification student handouts                                                                                               |

Note: These lessons and activities were adapted by using the following resources: Rowley & Peacock (n.d.)¹; Gardner (n.d.)²; Crist et al. (2021)³; Glo Germ (n.d.)⁴; Exploratorium (n.d.)⁵; Bohlscheid (n.d.)⁶; Rowley & Peacock (n.d.)⁷
Table 4.2 Career and technical education teacher’s interest in teaching food science in Mississippi career and technical education courses

<table>
<thead>
<tr>
<th>Themes</th>
<th>Example Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance student training and performance for FFA Food Science CDE</td>
<td>“The food science competition for FFA is what brought me to be interested in learning you know more about it.”</td>
</tr>
<tr>
<td></td>
<td>“I got started doing food science when I had a group of students that were interested in the food science competition when we first started with FFA... and so the [students and I] both, we kind of dove in together and we started learning about all of it and it was really interesting, fascinating.”</td>
</tr>
<tr>
<td>Increase understanding of food science among students</td>
<td>“Firstly, anything related to food is going to get kids' attention automatically... I think from a personal standpoint, packaging really confuses kids and not just kids, even us for as what is healthy and what is not, or what does the terminology on the packaging mean? And I think they will be more educated consumers if they understand the words and the packaging and the labeling. And I think that's something that every one of them, no matter what career field they go to, they're going to eat. So they're going to benefit from it.”</td>
</tr>
<tr>
<td></td>
<td>“I feel like that students don't really have an understanding of course, obviously, in the agriculture world where their food comes from, but then after that, you know how [sic] food [is] processed?”</td>
</tr>
</tbody>
</table>

Note: FFA – Future Farmers of America, CDE – Career Development Event
<table>
<thead>
<tr>
<th>Themes</th>
<th>Example Quotes</th>
</tr>
</thead>
</table>
| Teacher passion yield increase promotion | “It's something that I love, and kids can always pick up on that. Literally because I love it so much, I promoted it... we're just about to have some fun, and they loved it... they were super excited about it... I had gotten them pumped up, excited about it.”  
“Oh, they loved it. They were like, "I wish we could do stuff like this every day."  
“The ice cream in the bag was good. Um, most of them had done that at some point in their school year, but I will tell you... after we did your lesson, they were very engaged... so that lesson, we ended up just really growing and stretching and doing a lot of stuff with... they kept asking questions... [the lesson] just had a good flow from their conversation, from the ice cream into... labeling, which then kind of went into marketing and packaging... [and] we gained a lot from that.”  
“The kids and [I] [sic], we really enjoyed making the ice cream. We had a lot of laughs with that, and we just had a really good time making it and... talking about [the food product development lesson].”  
“It's just a lot on my plate, and so to be able to just open the book and be like, "Ah,"... it made me a better teacher because it helped organize my thoughts.”  
“I really appreciate the...script of everything...I liked the videos that were provided. There was one series...about how they were producing carrots. And so we kind of took that series and watched a few more in the process...that was kind of fascinating.”  
“...the most meaningful was seeing these kids' reaction... like when we made the lollipops... within such a short timeframe, and that's something you could do... so simply”  
“...just seeing them get kind of creative with their ice cream was really fun.”  
“...it's just such a great recruitment tool for your program because if [teachers] teach it properly, we make it fun and engaging, that's what open these kids' eyes to what else is out there, and we want to teach the right things.” |
### Table 4.4  Mississippi career and technical education teachers’ perception of food science educational resources.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Example Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational structure of resources</td>
<td>“… [the toolkit] made putting the lessons together a whole lot…easier, which you're more apt to do [the lesson] … as a busy teacher, if you have it on hand. So that was very beneficial.”</td>
</tr>
<tr>
<td></td>
<td>“…the PowerPoint slides with the notes below them was great. The materials list was good. So overall, I liked the worksheets for the product development…I think it was very well put together.”</td>
</tr>
<tr>
<td></td>
<td>“…even if they're not proficient food science, I mean, everything's laid out, it's scripted, you've got examples and the videos and everything. I mean, it's a good set of information.”</td>
</tr>
<tr>
<td></td>
<td>“... they were...six really good [lessons] that...was good information, and the kids understood it, and it was actually useful to them in their real life.”</td>
</tr>
<tr>
<td>Useful and relatable resources</td>
<td>“I think this would be very helpful for [teachers] that are still learning the whole food science process... this would definitely give them information on what they need to know [and what] to say.”</td>
</tr>
<tr>
<td></td>
<td>“Maybe just be[ing] able to go somewhere to extension service or Mississippi State and pull lessons and have contacts for the kids to maybe come visit industry folks… they would know who they could talk to and feel comfortable about reaching out... if that's the field that they want to go into.”</td>
</tr>
<tr>
<td>Desire for additional resources/opportunities</td>
<td>“After we had done everything in your [food product development] lesson, I made them design a new product, and I made them make a package…I actually showed them how to come up with their carbs, fats, protein and get their calories.”</td>
</tr>
</tbody>
</table>
Table 4.5  Career and technical education teachers’ intended continued use of the food science educational resources

<table>
<thead>
<tr>
<th>Themes</th>
<th>Example Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for FFA Food Science CDE</td>
<td>“...tie it in with my FFA, giving them that little bit of knowledge to see whether or not they are interested in the competition.”</td>
</tr>
<tr>
<td></td>
<td>“Yes, because I'm sure I will have another food science team. This is good training material...”</td>
</tr>
<tr>
<td></td>
<td>“...it’s just very pertinent in our day-to-day life. Um, and you can fit so much into [food related lessons] from picking your own meals to... dairy alternatives. So at least expose [the students] to some new things... just having different experiences for them and [the students] understanding the why's.”</td>
</tr>
<tr>
<td>New education experiences</td>
<td>“I think it gives the students knowledge that they are not going to gain elsewhere.”</td>
</tr>
<tr>
<td></td>
<td>“...this would give them an opportunity to learn something new and different and experience something new, like the sensory stuff.”</td>
</tr>
</tbody>
</table>

Note: FFA – Future Farmers of America, CDE – Career Development Event
CHAPTER V
CONCLUSIONS, IMPLICATIONS FOR FUTURE PRACTICES, AND RECOMMENDATIONS

This chapter provides an overview of the main conclusions formed from this research study and includes implications for future practice, limitations of the study, and recommendations for future research.

Conclusions

Delivery and evaluation of a food science professional development training for Mississippi career technical education teachers

There are limited food science professional development opportunities offered to MS CTE teachers to expand student exposure to food science academic and career experiences. The purpose of this study was to assess the effectiveness of a food science professional development training for Mississippi CTE teachers. The objectives of this study were to: 1) identify and compare the self-perceived knowledge and self-perceived ability to conduct specific food science skills among MS high school teachers before and after food science professional development training, and 2) determine teachers’ self-efficacy and satisfaction after completing the food science professional development training. Results indicated that the food science professional development training was effective at improving teachers’ self-perceived knowledge of food science concepts, their self-perceived ability to conduct food science skills, and their self-efficacy to teach food science in their CTE courses. It was also determined that the food science
professional development training met the needs of the MS CTE teachers, who were satisfied with the training instructor, the materials delivered in the training, and the impact of the food science professional development training.

**Mississippi career and technical education teachers’ perception toward implementing a food science toolkit designed to increase food science curriculum use in MS**

There are a limited number of studies that examine teachers’ perceptions towards the implementation of secondary education food science resources. MS CTE teachers’ perception of food science educational resources offer insight towards curriculum development and adoption of the MS Agricultural Food Science and Technology curriculum framework. Post implementation of the food science toolkit in their classes, MS CTE teachers perceived that the student exposure to, engagement in, and interest in food science academic and career pathways increased. Overall, MS CTE teachers had positive experiences implementing the food science toolkit.

**Implications for Future Practice**

Statistics have depicted the decline in the number of graduates in the field of food science and technology, and universities cannot meet the demand of the number of graduates in the field of food science. To bring awareness to the field among students and to increase the number of graduates that enter the field of food science and technology, educational and technical training should be implemented at the secondary education level. At the 8th-12th grade level, students are encouraged to think about and explore various career opportunities that they would like to pursue, make their decision on which higher education academic program to select, and/or what career pathways they would like to enter. It is important for students to be exposed to various
programs, curricula, and/or trainings to make a sound decision on which academic and career pathway to pursue.

There are several implications for future practice that were revealed in this study. Researchers can use the design of the food science professional development training as an outline to develop trainings for other CTE programs. Applying the food science PD design to develop teacher PD opportunities in other CTE programs affords the opportunity for researchers to further enhance CTE programs by equipping teachers with knowledge, skills, and relevant resources to integrate in CTE courses. When teachers are properly trained and are confident in their ability to teach specified course content, knowledge transfer is enhanced, and effective and accurate application of knowledge by students is commonly increased. In addition, these research results provide professional organizations such as the MS Association for Career and Technical Education information on the importance of offering interactive PD experiences and ways to structure PD opportunities offered at professional meetings.

Research findings of this study also offer advances in curriculum development and design of the MS Agricultural Food Science and Technology curriculum and support the adoption of the curriculum by the Mississippi Department of Education. Teacher’s feedback can inform university food science faculties and staff how to promote food science-based instruction more effectively among secondary education teachers. Curriculum developers can use teachers’ perceptions of specific food science lessons to assist with modifying and enhancing curricula design. These research results are useful to university food science faculties and staffs by demonstrating how to strengthen university and secondary education partnerships to enhance student recruitment in the field of food science. Creating a talent pipeline can support a steady
stream of innovative and creative food science professionals that can develop technology necessary to feed 9 billion people population projected by 2050.

Limitations

There were several limitations associated with this study including geographic scope, small sample size, and use of data collection methods. The geographic scope of this study was limited due to the sole inclusion of MS agriculture CTE teachers, therefore there is lack of generalizability of the research results among CTE teachers outside of MS. The small sample size also prevents generalizing the study results among varying populations. The use of semi-structured interviews may have led to response bias resulting in more skewed answers. However, the interviewer, a member of the research team, followed the developed interview protocol to remain unbiased throughout the interview process such that the teachers’ responses would not be biased. It is acknowledged that an independent interviewer who is not associated with the research team is recommended to conduct future interviews with study participants. The abrupt closing of MS schools due to the onset of the COVID-19 pandemic caused changes to data collection procedures and decreased the number of teachers that were available to implement the food science educational resources. Collecting data from a larger population of MS CTE teachers on their experience implementing the food science-based instruction would provide a more enriched understanding of the food science PD and teachers’ implementation process.

Recommendations

The following recommendations are provided to continue the exploration of food science curriculum implementation in MS. Due to the small number of teachers that implemented the food science toolkit, it is recommended that the toolkit be implemented among a larger
population of MS CTE teachers to identify additional teachers’ perception towards the food science-based instruction. It is recommended that researchers utilize methods of process evaluation to identify reach, dose, barriers, fidelity, etc. to obtain an in-depth understanding of the implementation process which can also assist in improving the food science toolkit curriculum design. It is essential to evaluate how the students are impacted by the food science resources implemented in their classes; therefore, it is recommended for researchers to explore student awareness and knowledge of food science pre and post implementation of the food science toolkit in MS CTE courses. Continuing this research to increase awareness of food science academic and career pathways at the secondary education level can help further develop a talent pipeline of educated and skill food science graduates that enter the field of food science
REFERENCES


APPENDIX A

FOOD SCIENCE LESSON PLAN OVERVIEW
Lesson 1
Discover Food Science

Lesson Summary
Food science is an applied science that uses concepts of various fields such as chemistry, math, engineering, and law to solve real-world problems. Lesson 1 focuses on various branches of food science and the importance of food production.

Lesson Objectives
Investigate the various dimensions of the food science industry
1.1 Define food science
1.2 Explain the farm to fork concept
1.3 Describe the branches of food science

Standards
Common Career Technical Core Career Ready Practices Content Standards
CRP.10.01. Identify career opportunities within a career cluster that match personal interests, talents, goals and preferences.

Food Products and Processing Systems Career Pathway Content Standards
FPP.04. Explain the scope of the food industry and the historical and current developments of food product and processing.

Lesson Overview

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening</td>
<td>Introduction and objective slides</td>
<td>7 minutes</td>
<td>PowerPoint presentation</td>
<td>Open presentation located in Lesson 1 within PowerPoint folder on Google Drive</td>
</tr>
<tr>
<td>Objective 1.1</td>
<td>Define food science (lecture &amp; discussion; see provided notes)</td>
<td>5 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective 1.2</td>
<td>Crunchy Carrots video activity</td>
<td>10 minutes</td>
<td><a href="https://www.youtube.com/watch?v=PT74m1uLkE">https://www.youtube.com/watch?v=PT74m1uLkE</a></td>
<td>Open video in internet browser tab</td>
</tr>
<tr>
<td>Objective 1.3</td>
<td>Describe the branches of food science (lecture &amp; discussion; see provided notes) - Food scientist Quality Assurance video activity</td>
<td>25 minutes</td>
<td><a href="https://www.youtube.com/watch?v=RF59yZ_clUwA">https://www.youtube.com/watch?v=RF59yZ_clUwA</a></td>
<td>Open video in internet browser tab</td>
</tr>
<tr>
<td>Practice</td>
<td>“I’m Eating What?” class activity</td>
<td>10 minutes</td>
<td>I’m Eating What? Flashcard handout</td>
<td>Cut out flashcards from handout located in Lesson 1 within Handout folder on Google Drive</td>
</tr>
<tr>
<td>Conclusion</td>
<td>Overview and closure; see provided notes</td>
<td>3 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson Summary
Food products are developed through a process that combines biology, chemistry, microbiology, nutrition, mathematics, marketing, etc. Lesson 2 will examine the steps of food product development and apply the steps to ice cream production.

Lesson Objectives
1. Describe the steps involved in product development
   a. Identify the target audience
   b. Product description
   c. Develop the product
   d. Packaging
   e. Marketing
2. Apply the steps of food product development in a given scenario
   a. Decide
   b. Discover
   c. Define
   d. Develop
   e. Deploy
3. Demonstrate leadership, teamwork, and creative thinking skills

Standards
Common Career Technical Core Career Ready Practices Content Standards
CRP.12.01. Contribute to team-oriented projects and builds consensus to accomplish results using cultural global competence in the workplace and community.

Food Products and Processing Systems Career Pathway Content Standards
FPP.03.02. Design and apply techniques of food processing, preservation, packaging and presentation for distribution and consumption of food products.

Lesson Overview

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening</td>
<td>Introduction, Objective slides, and “What do you think?” question</td>
<td>5 minutes</td>
<td>PowerPoint presentation</td>
<td>Open presentation located in Lesson 2 within PowerPoint folder on Google Drive</td>
</tr>
<tr>
<td>Objective 1</td>
<td>Describe the steps involved in product development (lecture, see provided notes)</td>
<td>5 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 2 - 3</td>
<td>Apply the steps of food product development in a given scenario - “Food Scientist for a Day” activity</td>
<td>45 minutes</td>
<td>PowerPoint presentation, See Prep Work below for materials required for the “Food Scientist for a Day” activity, Coloring utensils</td>
<td>Handouts located in Lesson 1 within Handout folder on Google Drive, See lecture notes on page 5</td>
</tr>
<tr>
<td>Lesson Item</td>
<td>Included Activities</td>
<td>Activity Time</td>
<td>Materials</td>
<td>Preparatory Work</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>Conclusion</td>
<td>Overview and closure; see provided notes</td>
<td>2 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
</tbody>
</table>

**Prep Work**

Before lesson begins, set up activities and prepare computer with PowerPoint slides and videos:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Materials</th>
</tr>
</thead>
</table>
| Ice Cream in a Bag Activity | * It is recommended to prepare listed ingredients for 1 group consisting of 4-5 students  
* It is recommended to premeasure all ingredients per group prior to the lesson.  
Ingredients prepare ~ 2 cups of ice cream  
1 Food Scientist for a Day Student Handout  
Ice cream production processing instruction sheet (included in PowerPoint slides)  
1/4 cup of sugar  
1 cup of heavy whipping cream or half and half  
1 cup of whole milk  
2 cups of ice  
1 cup of rock salt (*Note: can be premeasured and stored in gallon size bag)  
Flavors: 1/2 tablespoon of each: Vanilla Extract, Chocolate Syrup, Strawberry Syrup  
1 quart size freezer bag  
1 gallon size freezer bag  
1 medium size towel  
Small plastic/Styrofoam cups (one per student)  
Plastic spoons (one per student)  

*General associated allergens for ice cream products: Milk, Wheat, Eggs, and Soy  

*Please check all ingredient labels for associated allergens.*
Lesson 3
Food Chemistry

Lesson Summary
Food Chemistry is defined as the study of the composition and properties of food components and the chemical and physical changes that occur during handling, processing, and storage of food. Lesson 3 will explore and describe the various categories of nutrients found in food.

Lesson Objectives
1. Define the term food chemistry
2. Identify the six categories of nutrients found in food
3. Describe the concept of water activity and the relationship between water, food and product shelf life
4. Describe the function of proteins in foods
5. Describe the function of lipids in foods and identify various sources of fats and oils
6. Define supersaturation and explain what that means in terms of candy production

Standards
Food Products and Processing Systems Career Pathway Content Standards
FPP.02.02. Apply principles of microbiology and chemistry to develop food products to provide a safe, wholesome and nutritious food supply for local and global food systems.

Lesson Overview

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening</td>
<td>Introduction and objective slides - The Chemistry of Cookies video activity</td>
<td>15 minutes</td>
<td>PowerPoint presentation</td>
<td>Open presentation located in Lesson 3 within PowerPoint folder on Google Drive. Open video in internet browser tab</td>
</tr>
<tr>
<td>Objective 1</td>
<td>Define the term food chemistry (lecture &amp; discussion; see provided notes)</td>
<td>3 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 2</td>
<td>Identify the six categories of nutrients found in food</td>
<td>2 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 3</td>
<td>Describe the concept of water activity and the relationship between water, food and product shelf life</td>
<td>5 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 4</td>
<td>Describe the function of proteins in foods - Biret Test Demonstration</td>
<td>8 minutes</td>
<td>PowerPoint Presentation</td>
<td>*See page 2 for Prep Work section for required preparatory work</td>
</tr>
<tr>
<td>Objective 5</td>
<td>Describe the function of lipids in foods and identify various sources of fats and oils</td>
<td>2 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Lesson Item</td>
<td>Included Activities</td>
<td>Activity Time</td>
<td>Materials</td>
<td>Preparatory Work</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>Objective 6</td>
<td>Define supersaturation and explain what that means in terms of candy production</td>
<td>30 minutes</td>
<td>PowerPoint presentation *See page 2 for Prep Work section for recommended preparatory work</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>Overview and closure; see provided notes</td>
<td>2 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Prep Work**

Before the lesson begins, set up activities and prepare computer with PowerPoint slides and videos:

<table>
<thead>
<tr>
<th>Activity Description</th>
<th>Materials</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biuret Test Demonstration</td>
<td>Biuret Test: 1 mL of egg white from one egg 1 clean test tube Biuret reagent (2-3 drops) Test tube rack (optional) 1 - 1 mL Dropper</td>
<td>Crack one egg, add 1 mL of egg white to test tube using a dropper Perform consecutive steps during the class demonstration as listed in part 7 of the lesson plan.</td>
</tr>
<tr>
<td>Candy Chemistry</td>
<td>Spray oil 435 grams (about 2 1/8 cups) sugar 1/2 cup light corn syrup 1/2 cup water 2-quart saucepan or 1000 mL beaker 1 candy thermometer Stove/Electric burner (for saucepan) or hot plate (for beaker) food color 1/2 teaspoon oil flavoring Candy mold and lollipop sticks (one per student) Oven mitt Wet and dry measuring utensils Metal mixing utensil</td>
<td>1. Premeasure 435 g of sugar and 1/2 cup of water 2. Set up a saucepan/beaker and a burner/hot plate <strong>Caution:</strong> Do not pre-heat the burner 3. Make all supplies and ingredients easily accessible 4. Follow the instructions listed in part 8 of the lesson plan.</td>
</tr>
</tbody>
</table>
Lesson 4
Food Safety

Lesson Summary
Food safety involves protecting consumers from pathogens and chemicals in our food supply and preventing contaminated food from making people sick. Lesson 4 examines food safety through Hazards Analysis Critical Control Point (HACCP) principles to help students investigate ways to keep foods safe from contamination.

Lesson Objectives
1. Discuss the personal hygiene requirements of food handlers
2. List the 7 steps of HACCP as a method to prevent foodborne illness
3. Identify the types of food hazards and describe the corrective action needed for the hazard:
   a. Physical
   b. Chemical
   c. Biological

Standards
Common Career Technical Core Career Ready Practices Content Standards
CRP CP.08.01. Apply reason and logic to evaluate workplace and community situations from multiple perspectives.

Food Products and Processing Systems Career Pathway Content Standards
FPP.01.02.01.a. Examine contamination hazards associated with food products and processing (e.g., physical, chemical and biological).
FPP.01.02.01.c. Identify sources of contamination in food products and/or processing facilities and develop ways to eliminate contamination.

Lesson Overview

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening</td>
<td>Introduction and objective slides (see provided notes starting on page 2)</td>
<td>3 minutes</td>
<td>PowerPoint presentation</td>
<td>Open presentation located in Lesson 4 within PowerPoint folder on Google Drive</td>
</tr>
<tr>
<td>Objective 1</td>
<td>Glo Germ Sanitation Test (see provided notes)</td>
<td>15 minutes</td>
<td>Glo Germ gel UV black light Handwashing video: <a href="https://www.youtube.com/watch?v=JjOzbMK5v&amp;feature=youtu.be">https://www.youtube.com/watch?v=JjOzbMK5v&amp;feature=youtu.be</a> Access to sink and soap for hand washing</td>
<td>Open video in Internet browser tab</td>
</tr>
<tr>
<td>Lecture</td>
<td>Microbial Storage Food Pathogens Undesirable Changes</td>
<td>3 minutes 5 minutes 2 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 2</td>
<td>HACCP (see provided notes)</td>
<td>10 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 3 (Practice)</td>
<td>Sanitation Scenarios (see provided notes)</td>
<td>10 minutes</td>
<td>PowerPoint presentation</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>Overview and closure</td>
<td>3 minutes</td>
<td>PowerPoint presentation</td>
<td>See provided notes</td>
</tr>
</tbody>
</table>
Lesson 5  
Food Processing

Lesson Summary
The largest segment of employment in the food business is food processing. This unit will examine the various processing techniques and highlight two government agencies that help keep food safe.

Lesson Objectives
1. Define the term food processing and the terms associated with food processing
2. Describe why foods are processed
3. Identify the various food processing methods and explain procedures used to process food safely
4. Describe how food safety is assured

Standards
Common Career Technical Core Career Ready Practices Content Standards
CRP.10.01 Identify career opportunities within a career cluster that match personal interests, talents, goals and preferences.

Food Products and Processing Systems Career Pathway Content Standards
FPP.03.02 03.a Identify methods of food preservation and give examples of foods preserved by each method.

Lesson Overview

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening</td>
<td>Introduction and objective slides (see provided notes starting on page 3)</td>
<td>2 minutes</td>
<td>PowerPoint Presentation Fermentation Balloons</td>
<td>Open presentation located in Lesson 5 within PowerPoint folder on Google Drive</td>
</tr>
<tr>
<td></td>
<td>- Fermentation Balloons</td>
<td>10 minutes</td>
<td>(see Prep Work Table on page 2)</td>
<td></td>
</tr>
<tr>
<td>Objective 1</td>
<td>Define food processing (see provided notes)</td>
<td>2 minutes</td>
<td>PowerPoint Presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 2</td>
<td>Why are foods processed (see provided notes)</td>
<td>3 minutes</td>
<td>PowerPoint Presentation</td>
<td></td>
</tr>
<tr>
<td>Objective 3</td>
<td>Identify the various food processing methods and explain procedures used to process food safely (see provided notes) - Product Tasting Activity</td>
<td>18 minutes</td>
<td>PowerPoint Presentation Product Tastings (see Prep Work Table)</td>
<td></td>
</tr>
<tr>
<td>Objective 4</td>
<td>Describe how food safety is assured - A Day in the Life of FDA Food Scientist Cory Bryant video</td>
<td>12 minutes</td>
<td>PowerPoint Presentation</td>
<td>Open video in internet browser tab</td>
</tr>
<tr>
<td>Experiment</td>
<td>Fermentation Balloons observations</td>
<td>6 minutes</td>
<td>See Prep Work Table</td>
<td></td>
</tr>
</tbody>
</table>
**Prep Work**

Before the lesson begins, set up activities and prepare computer with PowerPoint slides and videos:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Materials</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermentation Balloons</td>
<td>Fermentation Balloons&lt;br&gt;3 – 2 oz bottles&lt;br&gt;3 – large balloons&lt;br&gt;1 pack of yeast (2.25 teaspoons)&lt;br&gt;1.5 oz of warm water (microwave water for ~30 seconds)&lt;br&gt;3/4 teaspoons of sugar&lt;br&gt;1/4 teaspoon measuring utensils (yeast and sugar) table spoon or oz measuring</td>
<td>Collect all material (bottles and balloons provided in toolkit)&lt;br&gt;Label bottles&lt;br&gt;Bottle 1: Warm water + Yeast&lt;br&gt;Bottle 2: Warm water + Sugar + Yeast&lt;br&gt;Bottle 3: Warm water + Sugar (2x) + Yeast&lt;br&gt;Microwave 5 oz of water prior to class&lt;br&gt;Premeasure:&lt;br&gt;3 – 1/2 teaspoon of yeast&lt;br&gt;1 – 1/4 teaspoon of sugar&lt;br&gt;1 – 1/3 teaspoon of sugar&lt;br&gt;3 – 1.5 oz (3 tablespoons) of warm water</td>
</tr>
<tr>
<td>Product Tasting</td>
<td>Purchase enough for all students to sample the following:&lt;br&gt;- fresh grapes&lt;br&gt;- raisins&lt;br&gt;- fresh blueberries&lt;br&gt;- frozen blueberries (thaw before serving)&lt;br&gt;- fresh pineapples&lt;br&gt;- canned pineapples</td>
<td>Prepare samples of each product for each student&lt;br&gt;<strong>Note:</strong> You may use other types of fruit. It is important to make sure to use the same fruit in two forms (e.g., one frozen and the other fresh)&lt;br&gt;See lesson notes</td>
</tr>
</tbody>
</table>

*Please inform students and parents of allergens associated with products listed above*
Lesson 6  
Sensory Evaluation  

Lesson Summary  
Sensory evaluation is used to analyze and interpret human sensory responses to food products based on the five senses: sight, sound, smell, taste, and touch. It is also used to improve existing food products or to determine consumer acceptability of new food products. Lesson 6 will expose students to a sensory evaluation test and teach students how to identify food aromas.

Lesson Objectives  
1. Define sensory evaluation  
2. Define the term triangle test and explain its use  
3. Identify food aromas  

Standards  
Food Products and Processing Systems Career Pathway Content Standards  
FPP.02.01.01.k. Compare and contrast the relative value of food constituents relative to food product qualities (e.g., taste, appearance, etc.)

Lesson Overview  

<table>
<thead>
<tr>
<th>Lesson Item</th>
<th>Included Activities</th>
<th>Activity Time</th>
<th>Materials</th>
<th>Preparatory Work</th>
</tr>
</thead>
</table>
| Opening     | Introduction and objective slides (see provided notes starting on page 3)  
- Sensory Evaluation: Potato Chips | 6 minutes | PowerPoint Presentation | Open presentation located in Lesson 6 within PowerPoint folder on Google Drive |
| Objective 1 | Define Sensory Evaluation (see provided notes) | 5 minutes | PowerPoint Presentation | |
| Objective 2 | Define the term triangle test (see provided notes)  
- Triangle Test Activity | 25 minutes | PowerPoint Presentation  
Triangle Test Student Handout | See Prep Work Table on page 2  
Please inform students and parents of allergens associated with products |
| Objective 3 | Identify food aromas  
(see provided notes)  
- Aroma Test Activity | 20 minutes | PowerPoint Presentation  
Aroma Test Student Handout  
Aroma Kit Reference Sheet | See Prep Work Table  
Acquire handouts from Lesson 6 within Handouts folder on Google Drive |
| Conclusion  | Lesson overview and review questions | 2 minutes | PowerPoint Presentation | |
APPENDIX B

SUPPLEMENTAL TEACHING RESOURCES
Supplemental Teaching Resources

Teachers were provided supplemental teaching resources such as PowerPoint slides, activity guides, and student handouts per lesson. Examples of the supplemental teaching resources are included below.

PowerPoint slides
Activity guide/student handouts

Food Scientist for a Day: ICE CREAM

<table>
<thead>
<tr>
<th>Decide</th>
<th>Choose the flavor of ice cream</th>
</tr>
</thead>
<tbody>
<tr>
<td>what product will be produced</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discover</th>
<th>Audience:</th>
<th>How will you make it unique?</th>
</tr>
</thead>
<tbody>
<tr>
<td>who will buy the product and how to make it unique</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Define</th>
<th>Product Name, Ingredients, Nutritional information, Serving size, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>what is in the product</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Develop</th>
<th>Processing steps and food safety concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>all aspects of the product</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deploy</th>
<th>Packaging, costs, marketing/sales, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>the product into the marketplace</td>
<td></td>
</tr>
</tbody>
</table>

*Please draw a sample packaging label on the back of this sheet*
Triangle Test
Student Handout

1. You have been provided with two sets of samples containing 3 coded samples (cookies and juice).
2. Beginning with Test 1, taste the coded samples from in order from A to C. Two coded samples are identical (in taste) and one is different (odd).
3. Select the odd/different sample and place an X only by the sample letter you think is the odd/different sample.
4. Cleanse your pallet by taking a bite of a cracker and rinsing your mouth with water.
5. Once finished with Test 1, begin Test 2. Follow the same direction listed above.

Test 1: Cookies

<table>
<thead>
<tr>
<th>Sample</th>
<th>Indicate Odd Sample</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test 2: Beverages

<table>
<thead>
<tr>
<th>Sample</th>
<th>Indicate Odd Sample</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

FOOD SCIENCE PROFESSIONAL DEVELOPMENT
Preserving Success of Food Science Education

“Providing teachers training and tools to effectively implement food science based instruction.”

2019 MACTE Summer Conference
July 24, 2019
9 - 10:50 AM
Jackson Convention Complex
105 E. Pascagoula Street
Room 218

Calling All Teachers!

Please join us for an in-service training workshop that will expose you to the world of food science!

Let us train you to implement food science lessons and activities designed to promote food science and Career Development Event preparation.

Participants Will Receive

1. Teacher’s Guide
   Lesson plans, presentations, and scripts to teach food science principles and techniques

2. Toolkit
   Activity instructions, handouts, and supply lists for each lesson to easily conduct hands-on activities

3. Expert Support
   Training and support provided by agriculture education and food science professionals

For more information contact:

Jasmine D. Hendrix
Graduate Research Assistant
e-mail: [redacted]
mobile: [redacted]

Competitive Edge
Learn the principles and techniques of food science to help your students perform well in the FFA and FCCLA food science competitions.

Hands-on Demonstrations
Learn techniques to get students excited about the science behind food and steps to develop innovative food products.
SUCCESS IN FOOD SCIENCE

FOOD SCIENCE TEACHER TRAINING

MS ACTE SUMMER CONFERENCE

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND HEALTH PROMOTION
SCHOOL OF HUMAN SCIENCES
MISSISSIPPI STATE UNIVERSITY

Promote food science academic and career pathways among high school students and educators

Provide teachers training and instructional tools to effectively implement food science-based instruction

Expose students to a broad view of food science concepts in efforts to increase awareness, interest, and knowledge of food science
OBJECTIVES

- Expose teachers to the food science lessons and activities
  - Provide teachers an introduction to food science and product development
- Practice a food product development project
- Discuss the requirements of teachers participating in the research study
- Review instructional material toolkit

2018 Agricultural Food Science Technology

Overall Framework
Unit - Product Development
Success in Food Science
Lessons and Objectives

Introduction to Food Science
Lesson 1
HAVE YOU EVER WONDERED...?

FOOD SCIENCE
IS AN APPLIED SCIENCE

Solve problems using...

Chemistry
Culinary Arts
Biology
Law
Math
Material Science
Engineering
Statistics
INTRODUCTION TO FOOD SCIENCE

“The application of food science concepts to the selection, preservation, processing, packaging, distribution, and use of safe and wholesome food, and the mass production of food products”

- The Institute of Food Technologists
Introduction to Food Product Development

Lesson 2

What do you think about when you purchase a product?
INTRODUCTION TO FOOD PRODUCT DEVELOPMENT

- **DECIDE** what product will be produced,
- **DISCOVER** who will buy the product and how to make it unique,
- **DEFINE** what is in the product,
- **DEVELOP** all aspects of the product, and
- **DEPLOY** the product into the marketplace

Food Scientist for a Day
Food Product Developer
Ice Cream Production
WE ALL SCREAM FOR ICE CREAM

- Specialty: Product Development
- Product: Ice cream
- Project Task:
  - Develop an ice cream that represents career technical education
  - Be creative!
  - Follow the 5 D's of product development to create an ice cream

WHAT'S YOUR FLAVOR?

DECIDE DISCOVER DEFINE DEVELOP DEPLOY
WHAT'S IN YOUR PRODUCT?

Ingredient
Milk
Cream
Sugar
Additives

PRODUCTION

Instructions:
- Put the milk, whipping cream, sugar and vanilla in a 1 quart freezer bag and seal. For security, fold a piece of duct tape over the seal.
- Place the bag with the ingredients inside a gallon freezer bag.
- Pack the larger bag with crushed ice around the smaller bag. Pour 3/4 to 1 cup of salt evenly over the ice.
- Wrap in a bath towel and shake for 10 minutes.
- Open the outer bag and remove the inner bag with the ingredients. Wipe off the bag to be sure salt water doesn’t get into the ice cream.
- Cut the top off and spoon into cups.
- Serve plain or top with nuts, chocolate or fruit.

Enjoy!

Materials
- One gallon sized bag
- One quart sized bag
- Dust tape
- Ice
- 1 cup rock salt
- 1 cup of milk
- 1 cup heavy whipping cream
- 1/4 cup of sugar

Flavors
- Vanilla
  (1/2 teaspoon of vanilla extract)
- Chocolate
  (1/2 tablespoon of chocolate syrup)
- Strawberry
  (1/2 tablespoon of strawberry syrup)
Food Chemistry

Lesson 3
Ingredients: Fresh Milk & Cream, Sucrose, Corn Syrup, Nonfat Dry Milk, Whey, Cellulose Gel, Cellulose Gum, Mon & Diglycerides, Polysorbate 80, Carrageenan, Vanilla, Vanillin Extract, Annatto (Color)

FOOD CHEMISTRY

The study of the composition and properties of food components and the chemical and physical changes that occur during handling, processing, and storage of food
FOOD CHEMISTRY

- Ingredient Functionality
  - Milk
  - Cream
  - Sugar
  - Additives

Food Safety
Lesson 4
Improper personal hygiene

Explanation: All employees should wear hair nets, caps, and beard covers (if applicable) to avoid contamination of food, food contact surfaces, and food packaging materials.
Food Processing

Lesson 5

Fermenting Balloons Activity
Sensory Evaluation

Lesson 6

A tool used to analyze and interpret human sensory responses to food products based on the five senses: sight, sound, smell, taste, and touch.

SENSORY EVALUATION
AROMA TEST

1. Uncap and hold about \( \frac{1}{2} \) in. below your nose
2. Close your eyes
3. Take two short strong sniffs then one longer one where you can feel the air at the back of your throat
4. Move the bottle away and visualize the smell
5. Cap the bottle

Food Packaging

Lesson 7
FOOD PACKAGING/MARKETING TRIVIA

FUNCTIONS OF FOOD PACKAGES

- Containment
- Protection
- Communication
- Convenience
RESEARCH STUDY

Requirements to participate in the study

- Conduct a total of 7 1-hour food science lessons in your classrooms
- Open to complete reflection tools per lesson to gain teacher feedback from lesson implementation
- Administer a 45-minute student survey before and after implementation that will assess student awareness, interest, and knowledge of food science
- Participate in a 1-hour interview to acquire your feedback of the lessons, activities and the curricular implementation process

<table>
<thead>
<tr>
<th>July</th>
<th>September</th>
<th>October - November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Training</td>
<td>Receive Teaching Toolkit</td>
<td>Implement Lessons Administer Surveys</td>
<td>Teacher Interviews Collection of Evaluations</td>
</tr>
</tbody>
</table>
Toolkit
- Lesson Plans
- PowerPoint presentations
- Presentation script
- Student Handouts
- Instructions for activities
- Supply lists for activities
- Sanitation Glo Germ Kit
- Aroma sample Kit

Questions
THANK YOU

Jasmine D. Hendrix
Graduate Research Assistant
email: [email protected]

39

TRAINING EVALUATION
APPENDIX D

TEACHER TRAINING SURVEY INSTRUMENT
## General Information

<table>
<thead>
<tr>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email:</td>
</tr>
<tr>
<td>Phone Number:</td>
</tr>
<tr>
<td>School:</td>
</tr>
<tr>
<td>School Location/Address:</td>
</tr>
<tr>
<td>Grade Level(s):</td>
</tr>
<tr>
<td>Number of years teaching:</td>
</tr>
<tr>
<td>Type of class schedule (periods, blocks, etc.):</td>
</tr>
<tr>
<td>Anticipated number of students in class:</td>
</tr>
</tbody>
</table>

### Directions:
For each statement, circle the response that most closely reflects your level of agreement.

<table>
<thead>
<tr>
<th>A. Instruction and Satisfaction</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The instructor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. was knowledgeable of the subject matter.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>b. related training content to real-life situations.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>2. The content was</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. relevant to my needs.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>b. at an understandable level.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>c. well-organized.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>d. based on credible, up-to-date information.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>3. The training was effective at teaching me how to implement the food science lessons and activities.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>4. Attending this training was worth my time.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>5. I would recommend this training to others.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>
Directions: For each statement listed below, place an X in the box that indicates what you knew BEFORE and AFTER participating in this training.

<table>
<thead>
<tr>
<th>B. Specific Learning</th>
<th>BEFORE this training I knew...</th>
<th>NOW I know...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very little</td>
<td>Little</td>
</tr>
<tr>
<td>1. The definition of food science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The branches of food science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The 5 D’s of Food Product Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Career opportunities in food science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Ingredient functionality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Food safety concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Food processing methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Sensory evaluation: Aromas test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Food marketing and packaging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. What is the most important thing you learned during this training?

11. What else would you have liked to have learned during this training?
Directions: For each statement listed below, place an X in the box that indicates what you could perform BEFORE and AFTER participating in this training.

<table>
<thead>
<tr>
<th>C. Specific Practices</th>
<th>BEFORE this training...</th>
<th>AFTER this training...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Discuss branches of food science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Employ the 5 D’s of Food Product Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Describe the function of ingredients in food products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Discuss the importance of food safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Exemplify techniques to perform an aroma evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Describe the function of food packaging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. What is one specific thing you will do as a result of participating in this training?

Directions: This survey contains statements about teachers' teaching food science self-efficacy. Here, teaching food science self-efficacy is defined as teachers' personal belief in their teaching food science ability to positively affect student learning of food science. Please indicate the degree to which you agree or disagree with each statement below by marking the appropriate response that most closely reflects your level of agreement.

<table>
<thead>
<tr>
<th>D. Self-Efficacy</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can explain the different aspects of food science.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>2. I can explain food science concepts well enough to be effective in teaching food science.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>3. I know how to teach food science concepts effectively.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>4. I can teach food science as well as I do most subjects.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>5. I can employ food science activities in my classroom effectively.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>6. I can increase students' interest in learning food science.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>7. I can promote a positive attitude toward food science learning in my students.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>8. I can help my students apply their food science knowledge to real world situations.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>9. My effectiveness in food science teaching can influence the achievement of students with low motivation.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>
Please provide any additional comments or suggestions below.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Would you be willing to use this food science curriculum during the Fall 2019 school semester and provide feedback to our team?

☐ Yes       ☐ No

THANK YOU FOR ATTENDING

FOOD SCIENCE WORKSHOP SUMMER 2019
APPENDIX E

INTERVIEW PROTOCOL AND QUESTIONS
Post Implementation Teacher Interview Protocol

Introduction:
Thank you for participating in this research study titled, *The implementation of food science based instruction in career technical courses*. I am conducting post implementation teacher interviews to capture and understand your first-time experience implementing food science lessons and activities in career technical education (CTE) courses. My overall goal is to understand your perception towards teaching the food science lessons in your classrooms, understand any barriers faced while implementing the lessons, and to gain feedback on improving the food science lessons.

Throughout this interview, I will ask a lot of “why” and “could you elaborate” questions to ensure that I acquire an in-depth understanding of your experience teaching the food science lessons in your CTE course. Please be assured that your personal information will be de-identified, and your responses will be kept anonymous as results are reported. If you desire, you may choose a pseudonym for your name. This name will be used to identify you in both verbal and written presentations of our research findings.
Would you like to choose a pseudonym at this time? [Participant identifies pseudonym]
The interviews will be recorded in order to transcribe your responses later. Is this ok?
Please understand that your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue your participation at any time without penalty or loss of benefits.
Do you have any questions?
[Participant provides verbal consent]

Interview Questions:

**Research Objective:** Determine teacher perceptions towards implementing the food science lessons and activities in their CTE classroom.

1. What interests you most about teaching food science in your CTE course(s)?

2. Was the teacher training effective at preparing you to implement the food science lessons and activities? Why or Why not?

3. What influences did the food science teacher training have on the following when implementing the food science lessons and activities in your CTE course(s)?
   a. Knowledge of specific food science topics
   b. Specific skills to conduct food science lessons
   c. Self-efficacy (Your personal belief in their ability to teach food science)

4. Tell me about your experience implementing the lessons? Can you share examples of your experience:
   a. Preparing for each lesson implemented
b. Engagement with the students in lesson activities and discussion

c. Students response to the lessons and activities

5. What were the most meaningful experiences you encountered during implementation?

6. What do you think about the food science lessons and activities in regards to the following:
   a. Lesson objectives
   b. Lesson plans and activities adequate for targeted grade level(s)
   c. Teaching resources (i.e., lesson plan, lesson overview, lesson script, discussion guides, activity sheets, toolkit supplies, etc.)

7. How would you describe the usefulness of the provided teaching toolkit for implementing the lessons and activities?

8. Can you describe other teaching resources needed and/or desired for implementing the lessons and activities?

9. What opportunities have you had to learn about food science (i.e., teacher training, seminars, workshops, personal communication, etc.)?

   [If teacher has had other opportunities to learn about content area, ask the following questions]
   a. How have these opportunities been presented to you? (i.e., face-to-face lecture, interactive video, etc.)
   b. Can you describe how the opportunities affected your teaching and engagement with your students?

Research Objective: Evaluate the reach, dosage, fidelity, and continuation of food science-based instruction implemented by high school career technical education teachers

[Review submitted research instruments with teachers. If the teacher did not submit research instruments, use the research instruments and record data for each lesson the teacher implemented.]

1. Reach: Who did the program reach in the first phase of implementing the food science lessons?
   Probing Questions
   a. What CTE course(s) were the food science lessons implemented?
   b. How many students participated in each food science lessons implemented? [Attendance log]
   c. What was the average class size which the lessons were implemented? [Ask there is not an Attendance log received]
   d. What is the length of the class period/block in which the food science lessons were implemented?
   e. Why did you select to implement the food science lesson in the selected class period/block?
2. Dosage: To what extent was the food science lessons implemented by the teachers?

_Probing Questions_

[Review and complete the Lesson Completed Form for each lesson taught by the teacher if they did not submit forms for each lesson]

a. In general, in “Lesson [Lesson number]: [Lesson title],” were there
   - Too many activities
   - About the right amount of activities
   - Not enough activities

b. In general, how well did “Lesson [Lesson number]: [Lesson title]” go?
   - Very well
   - Pretty well
   - Not well
   - Not well at all

c. Where you able to complete the following?
   [Review Part B of each Teacher Evaluation of Lesson form. Example of activities tables and response below]

<table>
<thead>
<tr>
<th>Lesson Activity</th>
<th>[Activity 1]</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Activity 2]</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Activity 3]</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If no, please describe the sections you were not able to complete and why?
____________________________________________________________________________________
____________________________________________________________________________________

3. Barriers: What barriers were faced during implementation of the food science lessons and activities?

_Probing Questions_

a. In general, were there any challenges faced when you implemented the food science lessons?

b. Did any issues arise in “Lesson [Lesson number]: [Lesson title]” that were particularly difficult to handle/address?
   - Yes
   - No

If yes, please describe:
____________________________________________________________________________________
____________________________________________________________________________________

[Ask above question for each lesson implemented by the teacher]

4. Fidelity: To what extent were the lessons and activities implemented as planned?

_Probing Questions_

[Ask the following questions for each lesson implemented if teacher did not complete the Reflection Tool for each lesson implemented]
a. What worked well in the lesson implemented?

b. What needs improvement in the lesson implemented?

[Review the following question for each Teacher Evaluation of Lesson form provided. Example of question below]

c. Did you change any of the activities in this lesson from what was written in the lesson plan? (For example, eliminate questions, explained a topic differently, do a different activity to get at the same point, etc.) Do not count paraphrasing, minor changes in questions, or additional discussion/facilitation type questions.

   o Yes
   o No

If yes, please describe the changes specific to each lesson implemented. Please let us know why you chose to change the activity and let us know if you think the changes went well.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

d. What influenced what worked well and what needs improvement?

e. What would you do next time to improve implementation of the lessons?

5. Continuation: Would teachers continue to implement the food science lessons and activities in their classrooms?  
   Probing Questions

   a. Do you intend to implement the food science lessons/activities in the future? Why or Why not?

   b. Would you recommend the lessons and activities to other colleagues to implement? Why or Why not?

Teacher Demographics:

1. How many years of experience do you have teaching?

2. What is the name of your school district?

3. What is the name of your school?

4. What grade level(s) do you teach?

5. What subject(s) do you teach?

Is there anything else that you would like to share?

Thank you again for your participation in this research study and this post implementation interview. If you have any questions or think of anything else you would like to share, feel free to contact me.