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Development of a Reality-Based Multimedia Case Study Teaching Method and its Effect on Students' Planned Food Safety Behaviors

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Abstract: There is opportunity to decrease the frequency of foodborne illnesses by improving food safety competencies and planned behaviors of college students before they begin careers in the food industry. The objectives of this study were to (1) develop a multimedia case study teaching method that provides real world context for food science education; and (2) evaluate the extent to which it improves the intentions of students to implement food safety management systems upon entering the workforce, as well its impact on knowledge gains and students' abilities to understand complex concepts. The target audience consisted of all participants in an upper-level undergraduate food safety management systems course ($n = 17$). A pretest and posttest survey research instrument was developed to measure knowledge gains and also students' food safety intentions using the framework of the Theory of Planned Behavior. Students experienced significant gains in knowledge, attitude, and intention after completion of the course ($P < 0.05$). One hundred percent of students agreed that the interactive videos aided in their understanding of food safety concepts. A paired t test suggested that both behavioral control beliefs and attitudes of students toward food safety management significantly increased ($P < 0.5$) after completion of the case study. These results suggest that integrating multimedia case studies into food science education may enhance food safety behaviors.

Keywords: case study, food science, food safety, theory of planned behavior, video

Introduction

Foodborne pathogens are responsible for 48 million illnesses, 120000 hospitalizations, and 3000 deaths annually in the United States, and the associated economic burden is estimated to be $77.7 billion annually (Scallan and others 2011; Scharff 2012). Many outbreak and recall events are a result of post process contamination or poor personal hygiene, which are preventable through ensuring the workforce possess appropriate behaviors and competencies (Chapman and others 2010). Although many food safety training interventions reported in the literature have focused on food service and retail applications (Viator and others 2015), interventions for food manufacturing environments have been less commonly reported (Sperber 2005).

Better preparing college students to enter the industry should supply the workforce with more qualified employees and improve food safety in manufacturing facilities. There is a need to continuously improve food safety curricula in higher education because college graduates are often hired into supervisory positions in food manufacturing facilities (National Research Council 2009) and there is a shortage of qualified professionals in this occupation (Freudenheim 2009; Scott-Thomas 2012; Stevenson 2015).

Successful implementation of food safety management systems is a critical job task for managers in food manufacturing. Hazard Analysis and Critical Control Points (HACCP) is a systematic approach to prevent foodborne illnesses by identifying food safety hazards and controlling them through prerequisite programs and critical control points (Wallace, 2014). This system is globally recognized by international organizations such as Codex Alimentarius. Within the U.S., HACCP is required to be implemented in facilities that manufacture red meat and poultry (Hazard Analysis and Critical Control Point Systems 2015a), juice (Hazard Analysis and Critical Control Point Systems 2015b), and fish and fishery products (Fish and Fishery Products 2015). Manufacturers of Grade A dairy products have been encouraged to implement HACCP by adopting principles outlined in the voluntary Pasteurized Milk Ordinance (Food and Drug Administration 2014). The Food Safety Modernization Act of 2011 resulted in a different system, hazard analysis and risk-based preventive controls, being required for essentially all other food manufacturers (Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Human Food 2016). Therefore, training college students on how to develop and implement a food safety

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management plan and improving their aspirations to do so is essential to providing the food industry with workforce ready graduates.

Despite the resources and efforts invested in implementing food safety training programs throughout the food industry, there has not been a significant decrease in foodborne illnesses (Viator and others 2015). One explanation is that the majority of education programs focus on achieving knowledge gains as opposed to behavioral changes (Viator and others 2015). Although knowledge gains are important, targeting a specific behavior, attitude, and aspiration is the key to ensuring the desired behavioral change will actually be achieved (Egan and others 2007; Seaman and Eves 2010; Low and others 2013).

An effective evaluation program is necessary to demonstrate the impacts of food safety education and training programs (Wallace 2014). In a review of food safety training programs conducted by Viator and others (2015), only 3 out of 23 cases adopted a framework or theory for their program evaluation. To ensure participants' food safety behavioral intentions are impacted by a training program, an approach for evaluating food safety education and training programs' impacts on planned behaviors is needed. The theory of planned behavior is founded on the premise that social pressure, attitude toward a behavior, and perceived control over performing the behavior predicts a person's intent on preforming the behavior (Figure 1; Armitage and Conner 2001). Behavior is influenced by intentions and the perceived control one has over performing the behavior (Ajzen 2002). Intentions are described as how willing and how much work someone would put into performing a behavior (Ajzen 2002). By providing a training program that targets the factors affecting intentions and thus behavior, the training program is more likely to influence participants' future behaviors. The theory of planned behavior has been used, for example, to predict behavioral intention of students learning to drive (Ferguson 2005), athletes (Palmer and others 2005; Egan and others 2007; Roberts and others 2008; Shapiro and others 2011), and other audiences.

The case study method of teaching can improve food safety competencies and behaviors (Yiannas 2008). A case study is defined as "a particular instance of something used or analyzed to illustrate a thesis or principle" (Merriam-Webster Inc. 2004). These learning interventions can be presented in a variety of ways, including discussions, group work, lectures or combinations of these (Abrahamson 1998; Herreid 2007; Pai 2014). Case studies can provide students hands on experiences in applying theoretical knowledge to a specific scenario that has real world context. Hands on learning opportunities are not always facilitated in college science courses for various reasons (Gallego and others 2013). But, at least providing students the opportunity to apply theoretical knowledge toward a case study gives them a valuable experience that will improve their preparedness for their future careers (Wolter and others 2013).

The addition of videos to case studies enhances learning and student engagement, which can improve desired behavioral changes. Both traditional college students and nontraditional students tend to learn best in environments where they have hands on learning experiences (Cantor 1997; Nakayama and Jin 2015), but when the facilitation of hands on learning is not feasible, one option is to integrate videos into a case study such that students can virtually experience and conceptualize the case. This has been shown to improve student engagement and understanding (Pai 2014). Adding interactive components to case studies has been effective in a variety of other safety-related fields (Guo and others 2012).

The objectives of this study were to (1) adapt the theory of planned behavior to measure changes in planned food safety behaviors of students as affected by their participation in an undergraduate course on food safety management systems; and (2) determine to what extent a multimedia case study can develop students' abilities to apply theoretical knowledge of food safety management to real-world scenarios.

Methodology

The analyze-design-develop-implement-evaluate (ADDIE) model (Peterson 2003) was used to frame a course redesign project for a senior-level undergraduate course on food safety management systems. The course was taught via distance education through the Moodle Learning Management System (LMS). The ADDIE model is based on the premise that learning should be student-centered, innovative, authentic, and inspirational and is a common model used for performance based learning (Branch 2010) and consists of a 5-part continuous improvement cycle. The analyze phase was used to determine the learning needs of the students, the competencies their employers were looking for, and the constraints and resources available for the course redesign project. This needs assessment informed the design phase as the learning interventions were drafted. After the learning interventions were created in the development phase, the implementation phase involved teaching the course throughout a 16-wk semester, which was assessed during the evaluation phase.

Analyze Phase

The objectives for the case study were determined by compiling information gathered from past class evaluations, subject matter experts, instructional designers, and a review of the literature. A team of subject matter experts reviewed students' feedback from previous semesters and chose commonly reoccurring problems and suggestions provided by the students. For example, previous class evaluations indicated students thought the instructor needed to better explain difficult concepts. The majority of students in the course had never been inside a food manufacturing facility, which presented a challenge of providing real world context while teaching the subject matter. A recent study determined that applying theoretical knowledge to real world settings was the number one skill college graduates lack (Johnston and others 2014). Even though a student may comprehend the subject matter, the student may not know how to apply this in the workplace or other situations (Egan and others 2007).

Design Phase

To achieve the objectives determined in the analyze phase, the course needed to be redesigned with the objectives of preparing students to (1) explain difficult material well, and (2) apply theoretical knowledge after completion of the course. Teaching with a story is expected to increase student understanding and their planned behaviors (Abrahamson 1998). Case studies enhance engagement, memory and help students apply what they have learned to simulations of the real world. Therefore, the case study approach was chosen because of its capacity for students to apply what they have learned to real world situations and break down a complicated situation in a way that makes the student feel part of the situation.

The case study was based on the Howling Cow™ dairy plant, which is located on campus at North Carolina State Univ. Howling Cow™ processes Grade A milk and ice cream products that are

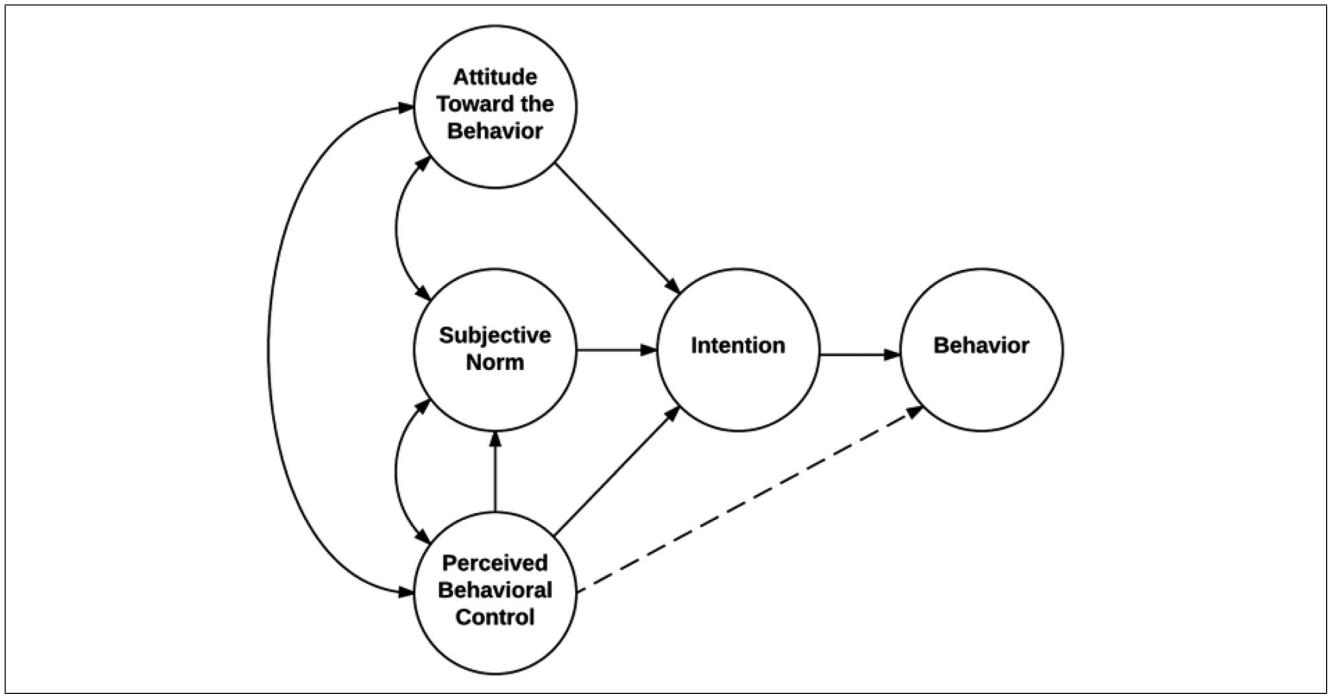

Figure 1–Schematic illustration of the theory of planned behavior model. Adapted from Ajzen (2002).

sold on campus, at the North Carolina State Fair, and to select local foodservice establishments. The Howling Cow™ operation is a vertically integrated business.

Videos were chosen as the format to teach students about the Howling Cow™ operation because videos have been shown to create a higher level of engagement for the participants and create an emotional connection to the content (Yadav and others 2011; Borup and others 2012). The case study consisted of a series of 15 videos detailing the Howling Cow™ process, pertinent federal regulations, and certain food safety practices in different locations throughout the facility. The titles, objectives, and descriptions of these videos are provided in Table 1. These videos were categorized as either a longer (5 to 15 min) documentary style video (including Ice Cream Makers, The Processing Tour, and Pasteurized Milk Ordinance vs. HACCP) or one of the 12 brief (less than 2 min) videos about Good Manufacturing Practices.

To give students spatial context of Good Manufacturing Practices examples in the processing facility, the framework for a "plant tour GMP game" in which students could interact with a blueprint of the facility that displayed the GMPs videos where these videos were to be recorded was drafted. One multiple choice question that asked students to identify the relevant federal regulations was written for each video. The design of this learning object also included a leaderboard so students could see how their total score ranked along with their classmates.

Development Phase

A collaborative team consisting of an instructional designer, video production manager, 2 video production specialists, subject matter expert, and a teaching assistant produced the videos. It took approximately 2 wk to record footage for all the videos and another 2 wk to edit rough cuts, each of which received multiple revisions.

The 12 GMP videos ranged from 39 s to 2 min and 12 s in length. The "Ice Cream Makers" video was 11 min and 12 s long (Stevenson 2014a). The processing tour video was 6 min and 34 s (Stevenson 2014b) The PMO vs. HACCP video was 5 min and 32 s (Stevenson 2014c).

The plant tour GMP game was designed with Articulate Storyline e-learning software (New York, N.Y., U.S.A.). A blueprint of the Howling Cow™ facility was designed using 3D animation software, Maya, and flat design icon hotspots were placed at the locations where the 12 GMP videos were placed. JavaScript code was written so that the videos would play after clicking the hotspots and then one multiple choice question about the federal regulations appeared at the end of the video. A button was placed on the blueprint that led to a leaderboard so students could enter their student ID number and sees how their scores ranked with their classmates.

Implementation Phase

Throughout the 16-wk course, the case study was inserted into the course in a variety of ways, including knowledge assessments, discussion forum posts and responses, a Moodle workshop activity. Knowledge was assessed through weekly quizzes, which were timed for 20 min and ranged from 5 to 10 multiple choice, true/false, or fill in the blank questions. The weekly discussion forums required students to debate about their satisfaction with the Howling Cow food safety management system with regard to the lesson of the week. Students were required to post their response to the instructor's discussion prompt and then reply to one classmates' response. Students were also required to complete time-linked questions facilitated through eduCanon that placed questions concerning the weekly lesson at specific time points within the videos. Students had to answer the question correctly before they were able to continue watching the video.

Throughout the course, students developed a food safety management plan based on a Howling Cow™ product. Each student was assigned a different product and added to their food

Table 1–List and descriptions of videos produced for a multimedia case study of dairy processing and food safety.

Video	Objective	Design description	Duration (h:m)	URL
Ice Cream Makers	Give students an idea of what a day in the life of a worker in the Howling CowTM processing facility is like	Inspired by the Discovery Channel television show "Dirty Jobs" to help students develop an emotional connection between the viewers and the employees at the plant	11:12	https://youtu.be/99FcrWNqNWY
The Processing Tour	Teach students about unit operations in the dairy plant	A walkthrough tour of the dairy plant and taught the students how the ice cream is made, what equipment is used, and how the product flows through the plant	6:34	https://youtu.be/V_xLcZpUy7c
Pasteurized Milk Ordinance vs. HACCP	Explain how food safety regulations impact the managers of the Howling CowTM dairy processing facility	An interview of the managers inside the ingredients warehouse and cutaway shots to b-roll video of the processing operation	5:32	https://youtu.be/2Fibv753fb0
Good Manufacturing Practices at Howling CowTM (list provided below)	Show examples of Good Manufacturing Practices in specific locations of the Howling CowTM facility	Each of the 12 videos is at a different location in the processing facility, and in each video 2 employees from Howling CowTM demonstrated some examples of their Good Manufacturing Practices		
○ Loading Docks			1:40	https://youtu.be/OREOecASVeY
○ Hand Washing, Floors & Ceilings			1:33	https://youtu.be/Vf04bjfnKGs
○ Personnel Hygiene Facilities			1:15	https://youtu.be/rAgTFbUbb4E
○ Walk-in Coolers			1:07	https://youtu.be/MzP_i1QOPm4
○ Sanitation Chemicals Storage			1:33	https://youtu.be/j9WKqE8IouM
○ Pumps, Parts and Labels			1:37	https://youtu.be/7lM9nGm4z7c
○ Exterior Grounds			0:53	https://youtu.be/RuC7Jho-NQY
○ Main Entrance			1:01	https://youtu.be/WYMV9WzsyKQ
○ Workwear and the Locker Room			0:55	https://youtu.be/_8Uk6SGXpVc
○ Drainage and Backflow Prevention			1:09	https://youtu.be/a1wsse3TIp0
○ Ingredients and Packaging Warehousing			2:27	https://youtu.be/TWITs02UA_0
○ Cleaning Out of Place			1:48	https://youtu.be/vpk5-mUwVcs

safety management plan each week in relation to the week's lesson content. This assignment enabled students to have a hands on approach to developing a food safety management plan for a company with which they were involved and it was facilitated using Moodle Workshops. Once the student submitted their updated food safety management plan, they were assigned to review 2 of their classmates' work and grade their work following a rubric developed by Wallace and others (2005).

Evaluation Phase

Pretest and posttest surveys were developed using Qualtrics to evaluate the multimedia case study. The North Carolina State University Institution Review Board approved the surveys (IRB Protocol No. 4190). Written consent was achieved from all participants. The pretest and posttest surveys contributed to a total of 2% of the course grade.

Survey questions were written to determine to what extent difficult information was taught. These questions included how the instructor explained information, and what aided in the student's understanding of the course information. Also, the framework for the theory of planned behavior was used to determine if objective 2 was achieved. Questions about attitude, subjective norm, and perceived behavioral controls about food safety management were developed and distributed. Surveys using the theory of planned behavior in similar fields (Gallego and others 2013; Pragle and others 2007) were adapted to measure plans to implement food safety management systems in participants' future careers.

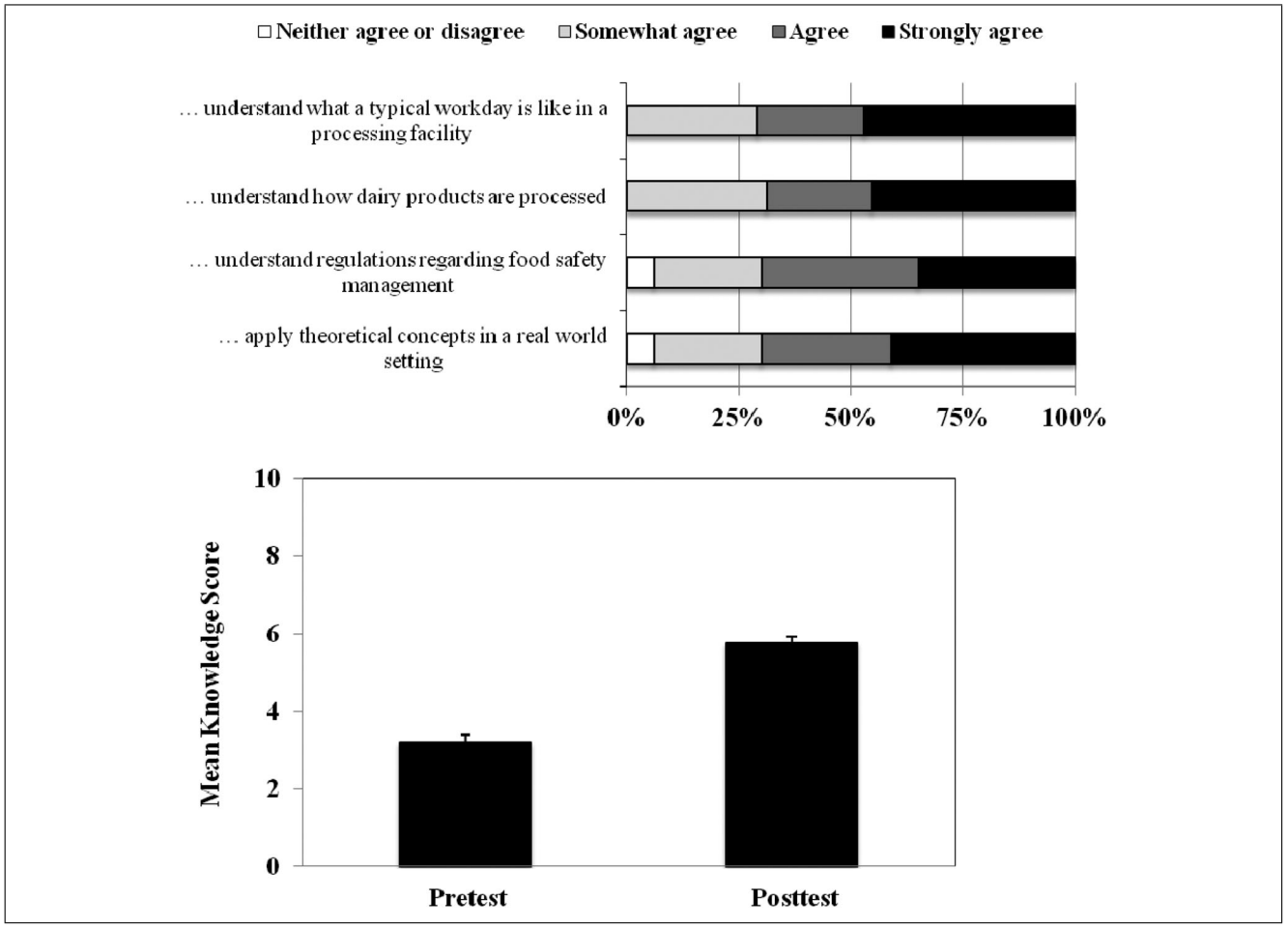

Figure 2–Student ratings of how much the Howling Cow case study helped them with course learn objectives.

A Delphi style method was used to improve the content validity of the survey. Three food safety experts provided suggestions for modifying the survey. Two focus groups of 3 students each were also used before survey distribution to improve face validity of the survey. The survey was distributed to the students through the Moodle Learning Management System. The students were required to take the survey as part of a grade. Students were provided with the option to withhold their information from being used in the research and still earn 100% of the allotted course grade. This survey took students approximately 30 to 40 min to complete.

The pretest survey contained 66 different questions. This study consisted of demographic questions, 4 aspiration questions, 10 knowledge questions, 2 questions on perceived behavioral control, 6 subjective norm questions, 11 attitude questions, and 2 intention questions The posttest survey included all of these questions along with formative questions to be used for course improvement. The reliability of the survey questions were measured by calculating Cronbach's α (Knabe 2012), which was 0.70 or higher for each question. These values were acceptable for this exploratory study (Bonett and Wright 2015).

A limitation of the study is that a control group was not compared to the treatment group, which would have provided a more exclusive analysis of the effect of the multimedia case study. This study was a case study involving only 17 students, so future studies with larger sample sizes may lead to a code of practice. Although measuring the food safety management skills in undergraduate courses is difficult since students do not typically hold jobs in the food industry, future studies that assess specific competencies will further determine how to optimize the multimedia case study teaching method.

When asked to what extent students' thought the instructor explained difficult material well, students rated the instructor 4.2 on a 5-point scale and a standard deviation of 1.0, whereas in the previous semester, the students rated the instructor with an average score of 2.7 and a standard deviation of 1.4. This suggests that the students believe that the instructor explained the information well. Although the classes were not the same, the extent to which difficult material was explained was significantly higher than in previous semesters ($P < 0.05$). The learning interventions used in the improved course focused on providing students with information in a manner that engaged the student as well as informed the student on the subject matter at hand. Being able to see the processing facility gave students a better idea of the environment that was being discussed. The interactivity of the learning modules allowed students to apply what they had learned to a real life situation. This finding is consistent with other studies that have concluded that videos make difficult concepts easier to understand (Mehrpour and others 2013; Shiatis and Tsiligiannis 2013).

One hundred percent of students believed that the "Ice Cream Makers" video aided in their understanding of difficult concepts (Figure 2). One hundred percent of students believed that the "Processing Tour" video aided in their understanding, as well. The

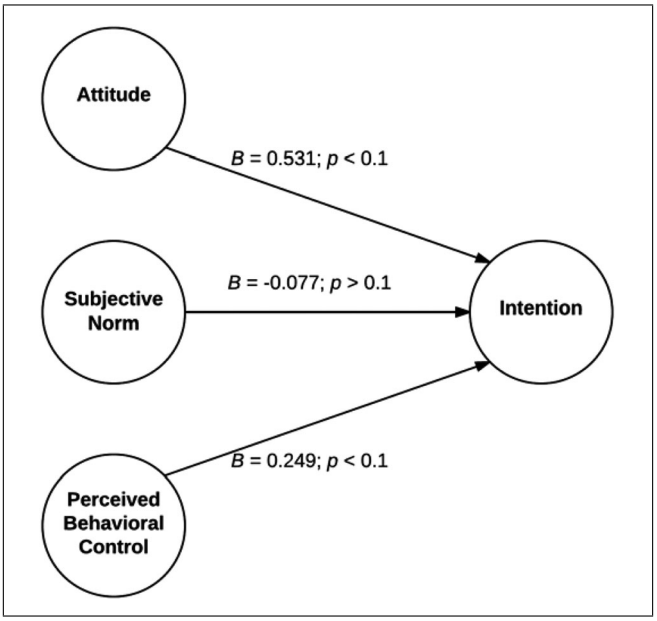

Figure 3–Posttest pathways analysis of undergraduate students' intentions to implement food safety management systems in their future careers. Pathways coefficients (β) and significance values (P) provided.

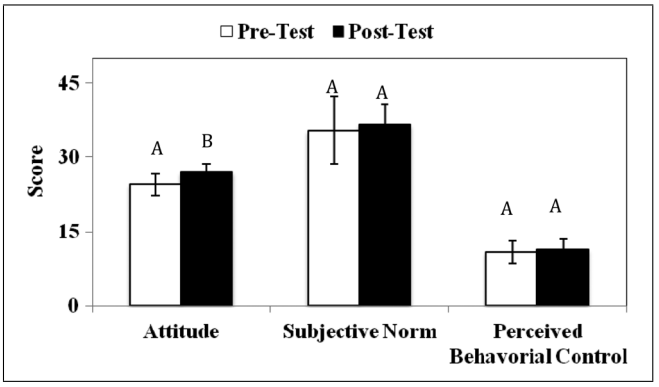

Figure 4–Average pretest and posttest score of participants' attitudes, perceived subjective norms, and perceived behavioral control concerning food safety management systems. Different letters denote significant differences between pretest and posttest pairs ($P < 0.1$). Standard deviations represented by error bars.

"PMO vs. HACCP" video was analyzed to determine whether the students' knowledge of PMO and HACCP was improved due to the video. Ninety-four percent of students self-reported that the PMO video aided in their understanding, and 6% of students neither agreed nor disagreed that the video helped. None of the students disagreed with the statement that the videos helped understanding overall. This suggests that the students believe that the videos helped their understanding of topics.

Significant knowledge gains were observed among the participants from the pretest to posttest ($P < 0.05$; data not shown). This is consistent with numerous studies conducted in the health industry where videos were used to improve the viewer's knowledge on a health-related subject (Brace and others 2010; Del Carmen Cabesa and others 2014; Trinh and others 2014). The entirety of knowledge gains cannot be attributed to the videos, but the videos likely contributed to knowledge gains to some extent.

A pathways analysis was conducted using SPSS AMOS (Wuensch 2014) to analyze students' intentions to implement food safety management systems in their future careers. The variables selected to study were attitude, subjective norm, and perceived behavioral control within the framework of the theory of planned behavior. The pretest and posttest data were compared using paired *t*-tests to determine to what extent the learning intervention significantly changed the variables being studied (90% confidence interval). The posttest data were also analyzed to determine the demographics gathered from the study.

There were no significant effects of attitude, subjective norm, or perceived behavioral control and intentions in the pretest, which could be explained by the fact that most students had very little understanding of what exactly food safety management systems were at the beginning of the course. For the posttest there were significant effects of attitude ($P < 0.1$) and perceived behavioral control ($P < 0.1$) on students' intentions to implement food safety management systems in their careers, whereas the subjective norm did not have a significant effect ($P > 0.1$; Figure 3). These findings were consistent with a study of athletic trainers' opinions regarding concussion management practices, in which the subjective norm did not significantly predict the athletic trainer's behavioral intent (Rigby and others 2013). Ingram and others (2000) found similar results when analyzing students' intentions to apply to graduate school. However, in the present study there was a significant effect ($P < 0.05$) of students' social pressures felt specifically by their instructor (as opposed to their peers and family) on intention (data not shown), which suggests that the instructor should maintain and foster a dialogue that allows him/her to communicate his/her commitment to food safety while teaching class.

There was a significant improvement ($P < 0.05$) in students' attitudes toward food safety management throughout the duration of the course (Figure 4), whereas changes in perceived behavioral controls and the subjective norm were not significant ($P > 0.05$). Students learned how to develop a food safety management plan, but not necessarily implement one. Many of the students (96%) were not employed in the food industry at the time they took the course, so perhaps their lack of work experience inhibited them from imagining themselves managing and controlling the food safety management plan once in the industry.

Conclusions

A multimedia case study teaching method for providing real world in an introductory food safety management course was developed. The theory of planned behavior was used to predict students' intentions to implement food safety management systems in their careers and both attitudes and control beliefs were significant predictors ($p < 0.05$) of such intentions. Students experienced significant improvements in knowledge, and there was a significant change in behavioral intentions ($P < 0.05$). The multimedia case study aided in the student's ability to understanding difficult information. Future studies that assess specific food safety management skills are warranted.

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Appendix

Survey research instrument to measure undergraduate students' intentions to implement food safety management systems

Question	Question type	Construct
Food safety is important Personnel training is important to limiting foodborne illness GMPs are more important than HACCP GMPs and SSOPs are equally important Prerequiste programs are important to the HACCP plan Prerequisite programs are necessary to reduce foodborne illness Personnel training is not important to limiting food borne illness HACCP is more important than GMPs Prerequisite programs are not important to the HACCP plan Prerequisite programs are not important in reducing food borne illness	7-Point scale ranging from strongly disagree to strongly agree	Attitude toward food safety management
Risk factors for food poisoning can be controlled My actions at work can prevent customers from contracting food poisoning I am able to diligently conduct food safety tasks in my workplace Costumers could contract food poisoning from my work regardless of how diligent I am about food safety I have control over whether someone contracts food poisoning from a place you currently work or will work in the future	7-Point scale ranging from strongly disagree to strongly agree	Control beliefs concerning food safety management
Please indicate how likely it is that the following people think that it is important to implement food safety behaviors at ever possible occasion ● My friends ● My family ● My boss ● My coworkers ● My teacher ● My fellow students	7-Point scale ranging from highly unlikely to very likely	Normative beliefs concerning food safety management
After completion of this class I plan to implement prerequisite programs in my future facility After completion of this class I plan to keep up to date with requirements of prerequiste programs After completion of this class I plan to evaluate prerequisite programs of the food service or food processing facilities you enter After completion of this class I plan to practice food safety behaviors in my current or future food service or food processing facility	7-Point scale ranging from very unlikely to very likely	Intentions concerning food safety management
FDA seafood HACCP regulation applies to the following except: ○ Imitation crab dip ○ Caesar salad dressing with anchovies ○ Frogs ○ Salmon What are critical control points? ○ Essential steps for the production of a safe finished product ○ Steps to take at all points of production to ensure a safe food product ○ Control measures to ensure a safe food measure ○ Steps where food safety can be controlled	Multiple choice	Knowledge about food safety management

(Continued)

Table 1–Continued

Question	Question type	Construct
A CCP is designated at CCP B1. What does the B1 stand for? ○ A hazard potential at the baking step ○ Burn Hazard ○ "B" grade hazard, which means moderate risk ○ Biological hazard		
According to current regulations in the United States, who has the responsibility for development and implementation of HACCP plans? ○ Industry ○ Codex ○ FDA, FSIS, and USDA ○ NACFCM		
The FDA and USDA/FSIS require that HACCP records for frozen and shelf stable be held for at least: ○ 6 months ○ 1 year ○ 2 years ○ 5 years		
What is typically the cause of HACCP system failures? ○ Too many products and processes requiring HACCP plan development ○ Inadequate documentation of the HACCP plan ○ Inadequate training for all employees ○ Employee competency		
Prerequisite programs have no effect on the HACCP hazard analysis ○ True ○ False		
For HACCP purposes, which of the following is considered a problem because it is aesthetically displeasing, as compared to a food safety hazard? ○ Glass particles ○ Metal fragments ○ Wood splinters ○ 1 inch long hair		
What is the primary role of the HACCP team members? ○ Perform monitoring and corrective actions procedures ○ Provide specific expertise ○ Offer an opinion when asked ○ Follow the directions of the FDA/USDA inspector		
The 1st preliminary task in developing a HACCP team is to: ○ Appoint a HACCP coordinator and form a HACCP team ○ Describe the food product and how it is made ○ Construct a process flow diagram ○ Identify and evaluate the food safety hazards		