FOOD, NUTRITION, CULINARY, AND PACKAGING SCIENCE UNDERGRADUATE RESEARCH, EXPERIENTIAL LEARNING, AND PRODUCT DEVELOPMENT FOCUSING ON CHILDHOOD NUTRITION

A Thesis
Presented to
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In Partial Fulfillment
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Master of Science
Food, Nutrition, and Culinary Science

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ABSTRACT

The objective of this research project was to develop a two-semester Applied Interdisciplinary Product Development (AIPD) course for sophomore students in the Food, Nutrition, and Packaging Science (FNPS) department that would increase students' confidence in skills pertaining to product development of food products and childhood nutrition, increase their sense of connection with the department, and would better prepare them to enter industry than students that did not participate in the course. A Subject Knowledge Assessment (SKA) was used to evaluate the mean difference value (MDV) of food science, nutrition, packaging science, and general product development knowledge gained through the AIPD course. An Exit Questionnaire (EQ) was used to evaluate attitudes pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The Student Satisfaction Inventory (SSI) evaluates a student's level of importance and resultant satisfaction with various aspects of their college or university experience. For this research study, the SSI was used to evaluate responses of the treatment group before and after the AIPD course. SKA results indicated that the MDV were significantly different between the treatment and control groups in the overall score and in every subject score area except packaging science. EQ quantitative results indicated that mean scores between the treatment and control groups were significantly different in seven of the nine statements pertaining to product development knowledge and skills, both statements pertaining to pedagogy, and the statement pertaining to department engagement. EQ qualitative results indicated that the

response to working in interdisciplinary teams was exceptionally positive. Students embraced the two-semester course format and experiential learning elements. Some students commented on the desire for more structure, greater clarity in objectives, and well-defined deadlines. For the SSI, the level of satisfaction of the item "The instruction in my major field is excellent." was significantly lower in the post-response of the treatment group than the pre-response. Overall, the research project was considered a successful intervention for engaging sophomores, increasing students' confidence in skills pertaining to product development of food products and childhood nutrition, increasing engagement with the FNPS department, increasing industry readiness of students for internships and co-ops.

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CHAPTER ONE

REVIEW OF CURRENT LITERATURE

Introduction

The goal of this research project was to design, implement, and evaluate a sophomore-level two-semester course encompassing the knowledge and skills necessary to develop new food products, packages, and menus that addressing childhood nutrition. The course was titled Applied Interdisciplinary Product Development (AIPD). This USDA Higher Education Challenge (HEC) grant-funded course was offered as a Creative Inquiry (CI) course in the Food, Nutrition, and Packaging Science (FNPS) Department at Clemson University. It was the first interdisciplinary course to bring together undergraduate students from all majors within the newly merged department. The following review of current literature highlights the educational theory implemented in designing the AIPD course as well as the major topics related to the research project.

Experiential Learning

Experiential learning is the process of acquiring knowledge through firsthand experience (Dewey 1938). Every individual from birth employs this method of learning. It does not require a teacher or facilitator to guide the experience. However, when incorporated into formal learning, an instructor can be employed in order to bring efficiency to the experiential learning process. Experiential learning differs from academic learning, a process in which knowledge is gained through study and learned

theory. Academic learning includes lecture-style teaching and does not necessarily require direct experience of the subject matter (except occasionally through labs).

While experiential learning refers to an individual's learning process, experiential education is the application of broader educational theory that includes methods, structure, and objectives by which experiential learning may take place. Pioneers of experiential education and learning include John Dewey, Kurt Hahn, and David A. Kolb. John Dewey is often considered the founder of experiential education. In his 1938 lecture, *Experience and Education*, he outlined the theory, benefits, and consequences of learning through experience. He believed that the primary goal of school is to transmit knowledge gained in the past to new generations, which was typically achieved through study of textbooks and lectures given to pupils who were told to practice "docility, receptivity, and obedience." As a result, the student may associate formal education and learning with passivism. While Dewey advocated for instruction through experience, he warned that the value of the education gained depended greatly on the quality of the experience. "The belief that all genuine education comes about through experience does not mean that all experiences are genuinely or equally educative. Experience and education cannot be directly equated to each other. For some experiences are mis-educative. Any experience is mis-educative has the effect of arresting or distorting the growth of further experience" (Dewey 1938).

David A. Kolb developed the Experiential Learning Model (ELM) shown in Figure 1.1 to depict the four stages in the process of synthesizing experiences into knowledge. In order to have a valuable learning experience, the learner must first have a

concrete experience upon which they immediately reflect. Information gleaned from the concrete experience is considered abstract for the learner, who may have little to no prior knowledge with which to compare this new information. Finally, the learner must synthesize the new information and apply it to another concrete experience in order to solidify knowledge (Kolb 1984).

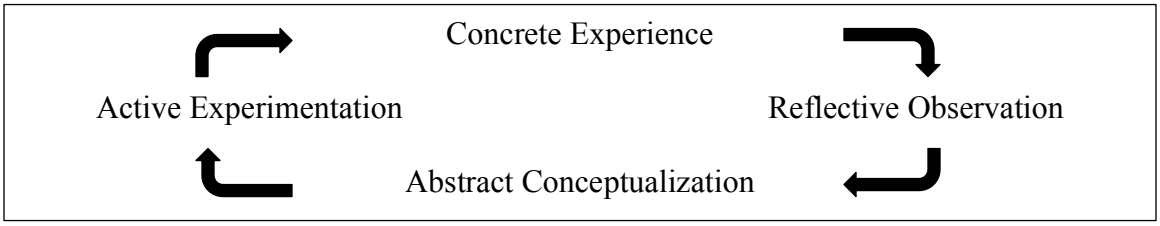

Figure 1.1 Experiential Learning Model (Kolb 1984)

Experiential learning can occur in many structured forms including active learning, problem- and inquiry-based learning, place-based learning, service-based learning, and project-based learning (Wurdinger and Carlson 2010). A single experience can often employ more than one style of experiential learning. Active learning is the simplest form of experiential learning and can be achieved by engaging students in a thoughtful discussion of a topic. Any type of student interaction with a subject outside of lecture-style learning can be considered active learning. Problem- and inquiry-based learning have many similarities but differ in the amount of guidance by the instructor. In problem-based learning a student is presented with a specific problem and is asked to solve it. In inquiry-based learning the student is allowed to determine their own problems and solve them. Place-based learning occurs when a student steps outside of the

classroom and experiences a situation firsthand. Kurt Hahn was a strong advocate of this type of experiential learning. In 1941, he co-founded Outward Bound, an international, non-profit organization that gave students across the globe opportunities to learn through outdoor adventures and expeditions. Service-based learning (or service-learning) is a form of experiential learning through volunteerism or community service. Place-based learning and service-based learning can occur simultaneously if the experience is part of a service related project. Finally, project-based learning is a self-directed style of education in which students are able to control the majority of the experience. The topic of the project may be assigned or students may be allowed to select a subject that interests them. This type of experiential learning relies strongly on student motivation to determine the quality of the experience.

Students that engage in experiential learning are able to develop strong critical thinking skills and retain substantial information about the subject matter. The students are held accountable for the success of the experience, which can result in a greater sense of achievement and empowerment. Although experiential education has numerous benefits, educators face many barriers to employing these techniques. Depending on the type of experience, it can require a substantial amount of time, effort, and possibly funding. Additionally, educators may not feel confident in their ability to orchestrate and conduct a quality experience. Criticisms to experiential learning include limitations in effect measurement and theoretical limitations (Kayes 2002). Cross-subject comparison of experiential learning can prove difficult because of the variation in value of experiences from one field to another. Where laboratory experience is standard procedure

for STEM fields, it may be viewed as a more substantial experience in a psychology field where laboratory experience is more common. Theoretical limitations of experiential learning include psychodynamic (greater emphasis placed on retrospective reflection rather than the "here and now"), social (the role of social status, gender, and cultural background), and institutional limitations (department and university agendas that may have counter goal orientation) (Kayes 2002).

Undergraduate Research

The Council on Undergraduate Research (CUR) defines undergraduate research (UR) as "an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline" (CUR 2011). It allows undergraduate students to gain exposure to the research process at the university level. UR was originally pioneered by the sciences but soon expanded into the arts and humanities (CUR 2011). Once thought to be a supplement to undergraduate education, UR is quickly becoming a standard pedagogy at many research universities (CUR 2011). If properly organized, UR can be beneficial to the students, advisors, department, and university.

There is some disagreement about when UR became an established practice. In 1810, Wilhelm von Humboldt founded the University of Berlin where he implemented a unified teaching and research strategy (Kinkead 2012). This is believed to be the first documented establishment of research at the undergraduate level. UR programs at small colleges in the United States have been documented as early as the 1940's (Laursen and

others 2010). However, it is the Undergraduate Research Opportunities Program (UROP) at the Massachusetts Institute of Technology (MIT) founded in 1969 that is often credited as the first established UR program in the United States. Soon to follow was the founding of the Council for Undergraduate Research (CUR) in 1978, the first CUR national conference in 1985, the beginning of Research Experiences for Undergraduates (REU) by the National Foundation of Science (NSF) in 1986, and the first National Conference of Undergraduate Research (NCUR) in 1987 (Kinkead 2012).

One of the most monumental impacts to UR occurred in 1998 when the Boyer Commission on Education Undergraduates in the Research University (led by Dr. Ernest L. Boyer, president of the Carnegie Foundation for the Advancement of Teaching) published *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. The report outlined 10 ways to change and improve the undergraduate experience, which Dr. Boyer believed was in need of reformation in order to meet the evolving expectations of undergraduate students. The first recommendation was to make research-based learning the standard, echoing John Dewey's advocacy of experience as a means to better engage and educate students. The Boyer Commission Report became largely influential in the works to follow and its impact is still evident almost two decades later.

Clemson University responded to the necessity for faculty-led undergraduate research with the development of the Creative Inquiry (CI) program in 2005, which provides students in all disciplines with team-based, collaborative research opportunities that address real-world problems (Speziale 2013). The CI program advocates for UR as a

method of engaged learning that can improve critical-thinking, problem-solving, presentation, and communication skills (www.clemson.edu/academics/programs/creative-inquiry). Students work in small teams with a faculty mentor on projects that can be embedded within one or more academic courses that span multiple disciplines (Speziale 2013). In addition to earning course credits, students are able to present their research at conferences or publish their findings in scholarly journals. The course developed for this research project was administered through the CI program. While most students within the department are required to participate in CI, many do so in only one of the emphasis areas, such as food safety, packaging science, culinary nutrition, etc. This course is unique in that it focuses on multiple emphasis areas and fields of study. Students are able to simultaneously conduct undergraduate research and gain multi-disciplinary education and experience.

Interdisciplinary Teaching

In order to discuss interdisciplinary teaching, one must first define the parameters of a "discipline." It can be as contrasting as the differences between subject areas such as the arts, sciences, and humanities, or it can be more closely related such as different areas of medicine. Both definitions are applicable depending on the scenario in which interdisciplinary teaching is being discussed.

The exact definition of the term "interdisciplinary" and others similar to it have been somewhat debated. In *Interdisciplinarity: History Theory and Practice*, Julie Thompson Klein (1990) outlines key differences between "interdisciplinary", "cross-

disciplinary", "multidisciplinary", and "transdisciplinary" terms. "Cross-disciplinary" is the act of viewing a problem or scenario through the lens of another discipline. "Multidisciplinary" is applicable in situations where specialists from multiple disciplines work side-by-side to solve different parts of the same problem. "Transdisciplinary" refers to a theme or issue that transcends two or more disciplines. The final term, "interdisciplinary", infers the greatest amount of collaboration and teamwork between persons of different disciplines. It can be applied to many different situations, which can be a source of confusion. For the purpose of this research project, "interdisciplinary" is the collaboration of faculty members and students from two or more disciplines, subdisciplines, or degree programs within a single course.

According to the Boyer Commission Report (1998), interdisciplinary programs should be a standard feature of any research university. The growing interdisciplinarity of research stands as the rationale for the need of interdisciplinary undergraduate education. Removal of barriers to interdisciplinary education is the fourth recommendation outlined in the Boyer Commission Report. However, there is a need for traditionally defined departments for organizational and administrative reasons, as well as allowing for some degree of specialization.

Instruction of an interdisciplinary course can be taught in many different approaches. A single instructor can present a scenario and outline the ways in which different disciplines may view the scenario. "Cluster courses" are separate courses that are routinely taught in the same sequence. In this approach, the faculty members coordinate their curriculum so that knowledge and skills can be enhanced with each

succeeding course. The most common is the team-teaching approach in which two or more faculty members from different disciplines collaborate to teach a single course. The degree of collaboration may vary. The faculty members may choose to separate the course into coordinating modules with each instructor taking responsibility for their subject area alone. Or the faculty members may choose to work together to develop a syllabus in which the modules overlap, conveying the extent to which their different disciplines interrelate. This interdisciplinary team-teaching approach is the most unified method of topic integration (Davis 1995).

The goal of interdisciplinary teaching and education is to glean new or greater understanding of one's own and other disciplines (Hayes 2002). It presents students with a multiperspective view of subject areas and greatly reduces the fragmentation of knowledge that is common in many universities. Interdisciplinary teaching actively shows a student the ways in which their chosen discipline can interact with others, often in a manner that can be mutually beneficial. Post-graduation, the world does not exist in neatly segmented disciplines. Collaboration is constant and the ability to effectively communicate with professionals in other fields will translate to more rapid completion of tasks and, potentially, to greater profitability.

There are many skeptics of interdisciplinary teaching methods. Some educators strongly believe that specialization and development of subject-specific knowledge should be the goal of undergraduate and graduate degree programs. While some amount of specialization is necessary in order to build a strong foundation in a subject area, mental flexibility is a valuable skill in any profession and it is important for graduates to

be able to view their own and other disciplines from multiple vantage points (Boyer 1998). Another criticism of interdisciplinary teaching is the belief that students will not perform as well on state and university mandated tests. Although these tests are important to gauge overall student population performance, they may not accurately gauge social skills and ability to effectively interact with persons of other disciplines, which are critical in almost every career path.

The Challenges of Sophomore Year

It has long been acknowledged that the freshman and senior years are difficult transition periods for college and university students. However, the sophomore year has been the subject of more recent retention efforts due to growing concern over the phenomenon known as the "sophomore slump." Characteristics of this period during the second year include student disengagement, dissatisfaction with the collegiate experience, developmental confusion, major and career indecision, and failure to meet academic progress expectations (Hunter and others 2010).

In the past, the "sophomore slump" has been difficult to define and measure but the growing attrition rates during this year of college indicate a distinct need for support. Part of the reason that this phenomenon has been difficult to define is because the sophomore year itself can differ depending on the institution. For example, at a two-year college, the sophomore and senior year are one and the same. The number of credits that a student transfers from high school can also affect class standing.

Understandably, most universities focus on freshman year support programs. This support tapers off during the sophomore year when it is expected that the student will find support within their chosen degree program. The primary objectives for sophomores are to select a major and develop a purpose for their educational career (Hunter and others 2010). Declaration of a major is a source of immense stress for sophomores. Not only will this decision affect the duration of their college experience, it will direct the course of their career and the rest of their life. It is not a decision that should be taken lightly and students that are indecisive can find themselves falling behind their peers in terms of time required to graduate. Student apathy or lack of motivation can further exacerbate this problem.

The first college year is often focused on the completion of general education courses that can be reiterative of material covered in high school. The intention is to compensate for any educational deficiencies in order to meet the expectations of higher-level instructors. Unfortunately, it does not allow for exposure to alternative experiences or introductions to various majors that can help students find a field of study that they are passionate about (Hunter and others 2010). Providing this type of sampling of disciplines is more common in liberal arts universities.

In *How College Affects Students, Vol. 2, A Third Decade of Research*, Pascarella and Terenzini (2005) suggest that actively engaging students in academic work can have a positive impact on the sophomore experience. Active engagement can be achieved through techniques such as collaborative learning, small group learning, problem-based learning, and participation in undergraduate research. Sophomores are sometimes

referred to as the "invisible" or "middle" child of post-secondary education (Schreiner and Pattengale 2000). Engaging them in experiential learning and providing opportunities for them to gain visibility can greatly enhance their college experience and motivate them to continue on through graduation.

The University of South Carolina's National Resource Center for The First-Year Experience and Students in Transition has been a pioneer in addressing the specific issues affecting student transition years, which includes the sophomore year. This center published the first book-length literary work that explored the specific sophomore challenges, *Visible Solutions for Invisible Students: Helping Sophomores Succeed* (Schreiner and Pattengale 2000). It was shortly followed by *Shedding Light on Sophomores: Explorations into the Second College Year* (Tobolowsky and Cox 2007). Both works provide successful examples of sophomore engagement programs in addition to national survey data on sophomore year initiatives. The survey found that the most successful initiatives are customized to the culture of the institution. For example, a research university would be most successful in engaging sophomores through undergraduate research projects.

Another technique to solve the "sophomore slump" and student disengagement during all transition years is to provide tailored support at each level of the university experience. For sophomores, this could be as simple as providing survey courses on different fields of study and possible career paths in each field. Each year presents its own set of challenges and providing resources that are unique to each step can improve student efficacy and increase their sense of belonging. This technique also reinforces the

Boyer Commission Report (1998) recommendation of cultivating a sense of community whereby the student can find an identity and a voice in both large and small communities within a university.

New Food Product Development

New product development (NPD) plays an integral role in any successful food company. There are two primary reasons why it is necessary for food companies to continually develop new products; (1) no product will last on the market indefinitely and (2) profits derived from new products significantly contribute to a company's continuity (Fuller 1994). In today's industry, as much as 28% of company sales are the result of new products (Cooper 2011). Many other factors can lead to the development of new products including changes in ingredient supply or cost, evolution of consumer preferences, the need to establish new markets (e.g. organic, gluten-free, "natural"), the desire to expand into global markets, technological advances in food processing, or changes in legislation and policy (Fuller 1994).

There are many types of new products. In *New Food Product Development*, Gordon W. Fuller (1994) outlines seven different categories; (1) line extensions, (2) repositioned existing products, (3) new form or size of an existing product, (4) reformulation of an existing product, (5) repacking of an existing product, (6) innovative products, and (7) creative products. Each category will require varying degrees of developmental and financial support. The same is true of the amount of time required to develop a product from idea to launch.

It is a general rule that all products will travel through the five phases of the product life cycle (Fuller 1994). First, the product is introduced to the market along with substantial advertisements in order to educate the general public about the new product and its features. Second, as consumers repeatedly purchase the product the sales will show a strong period of growth. Third, sales growth will decline and marketing for the product will decrease. Fourth, sales of the product reach a constant and stagnant level. Finally, overall product volume will begin to decline as new and competing products enter the market and capture market share. The cyclical nature of food products indicates a need for continued introduction of new products into the market in order to capture the attention of consumers. In a market that is constantly flooded with new products a common mantra has evolved; "innovate or die."

In conjunction with an established product development process, many companies employ some variation of the idea-to-launch Stage-Gate® model (Cooper 2011) depicted in Figure 1.2. Each step along the development process is considered a "stage" and the "gates" between each "stage" act as "go/kill" decision points. At each decision point, the product is evaluated based on whether or not it has met the requirements (e.g., consumer approval, cost effectiveness, operational feasibility) in order to advance to the following "stage." If the product has not proven its potential for success it is placed on hold or terminated. The establishment of key decision points provides a means of identifying unsuccessful products before they reach market, thus reducing financial risk.

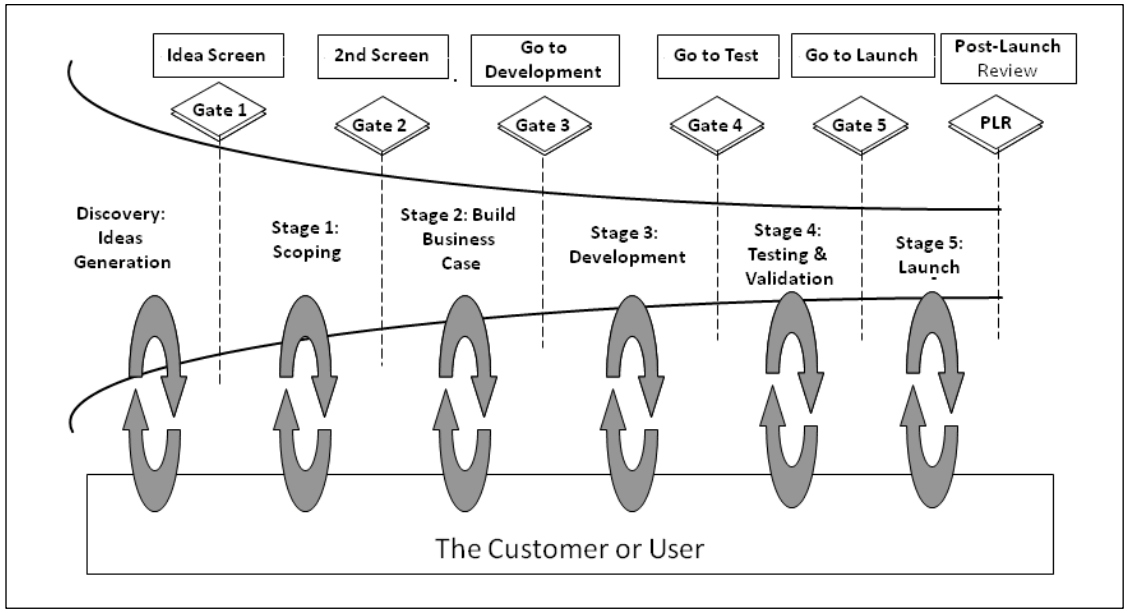

Figure 1.2 Stage-Gate® Model (Cooper 2011)

Industry Readiness

According to the 2013 report on *Occupational Employment and Wages of Food Scientists and Technologists* by the Bureau of Labor Statistics (BLS) and the United States Department of Labor (USDL), scientific research and development services reported the highest level of employment of the career fields within food science. Food scientists and technologists specializing in product development fall within this category. In order to meet the growing demand for food product developers, many universities offer courses in product development where students are equipped with the basic knowledge and skills necessary to carry out the NPD process. A recent study on the opinions of academia and industry professionals on the knowledge and skills that undergraduate students should glean from NPD courses found a general agreement

existed on most competencies (Saad 2010). However, industry professionals believed that students should also have the ability to formulate for large-scale production, perform statistical calculations, understand project management, and understand flavor and ingredients applications and interactions (Saad 2010). Additionally, they believed students should possess knowledge of processing, packaging, culinary skills, and have the ability to relate to others inside and outside the company (Saad 2010). It is difficult to develop an NPD course that encompasses all of the knowledge and skills requested by industry professionals that will also fit within a timely course schedule. Internships and product development competitions can provide a means for students to supplement their formal education and gain experience, which can improve their opportunities for NPD career placement. Trade organizations such as the Research Chefs Association (RCA) can also provide invaluable networking opportunities for students as well as an opportunity to remain current on industry trends and advances. The more knowledge and skills that a student possesses upon graduation (especially pertaining to culinary arts, nutrition, and packaging science), the greater their advantage will be upon entering the industry.

Childhood Nutrition

The health status of American children has been a major concern for decades. In the past 30 years, the incidence of childhood obesity in the United States has doubled in children and quadrupled in adolescents (Ogden and others 2014). In 2012, one of every three children and adolescents were overweight or obese and approximately 12.5 million children and adolescents (ages 2 to 19) were obese (CDC 2013). These statistics are

deeply concerning because children who are obese are more likely to have high blood pressure and high cholesterol, which are risk factors for cardiovascular disease (Freedman and others 2007). They also have a greater risk of prediabetes, bone and joint problems, sleep apnea, and social problems (Ogden and others 2014). Childhood obesity commonly leads to adult obesity, which can also result in cardiovascular disease, type 2 diabetes, osteoarthritis, and cancer (OSG 2010).

Many factors have contributed to the current obesity epidemic, including increasingly sedentary lifestyles, declining socio-economic status, and poor eating habits. The *Let's Move!* initiative pioneered by First Lady Michelle Obama has focused on strategies to get children excited about being active (http://www.letsmove.gov). The school environment is also a strong point of interest when looking for solutions for childhood obesity because of the significant role it plays in the development of social and nutritional habits.

Children are not consuming the recommended amounts of fruits, vegetables, plant and fish proteins, dairy, and whole grains needed for a healthy diet (NCCOR 2010). According to the 2010 *Dietary Guidelines for Americans*, sodas and pizzas are among the top sources of calories in the diets of younger children and adolescents (USDA 2010). The *Dietary Guidelines* list current recommendations for improving health such as reducing portion size, making better choices when dining out, and balancing food and beverage intake with physical activity. The *Dietary Guidelines* also recommend decreasing intake of sodium, saturated fats, and added sugars as well as increasing intake of fruits, vegetables, and whole grains.

The worsening of childhood nutrition in the United States has created a demand for food companies to develop healthy, convenient options for children. In today's busy world, it can be difficult for parents to find time to prepare healthy dishes and many parents depend on prepared, ready-to-eat meals. This demand has created a financial opportunity for food companies that develop healthy products for the growing children's healthy food and beverage market.

USDA Higher Education Challenge Grant

The United States Department of Agriculture (USDA) and the National Institute of Food and Agriculture (NIFA) founded the Higher Education Challenge (HEC) grant program (CFDA No. 10.217) as a means to support innovative educational opportunities at colleges and universities that offer food and agricultural science curriculum. In 2014, the total funding for the HEC grant program will be an estimated $4,770,000 with individual awards ranging from $30,000 to $750,000.

According to the USDA and NIFA website (http://www.nifa.usda.gov/), the HEC grant supported projects must fulfill the following requirements.

1) Address a state, regional, national, or international educational need
2) Involve a creative or non-traditional approach toward addressing that need that can serve as a model to others
3) Encourage and facilitate better working relationships in the university science and education community, as well as between universities and the private sector, to enhance program quality and supplement available resources

4) Result in benefits that will likely transcend the project duration and USDA support

In order to be eligible for the grant, the college or university must be an 1864, 1890, or 1994 land-grant institution, a Hispanic-serving institution, or a state controlled institution of higher education that offers a degree program in at least one area or discipline of food and agricultural sciences.

This research project was made possible by the USDA HEC grant program. The central tenets of the grant program were woven into the structure, goals, and outcomes of the course that was developed as part of this research project. The value of both agriculture and healthy cooking were cornerstones of the course curriculum. Modernizing the curriculum to a level applicable with industry will better prepare graduates and provide a competitive edge for the university and its offering of food and agricultural science.

Discussion

This research project was multifaceted in both the design of the AIPD course and course curriculum. Educational strategies pertaining to experiential and interdisciplinary teaching were utilized to promote engagement with students in undergraduate research. The overarching theme of new product development provided opportunities for students in each field of study (food science, nutrition, Culinology®, and packaging science) to relate to the project through their role as a member of a cross-functional product development team. Increased student accountability to ensure the success of the final

product provided an incentive for success at the sophomore level. In addition to gleaning information about childhood nutrition and product development, students were given the opportunity to glimpse into what may be their future career.

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CHAPTER TWO

ENGAGING SOPHOMORES IN PRODUCT DEVELOPMENT: COURSE DESIGN AND IMPLEMENTATION

Abstract

The objective of this research project was to develop a two-semester Applied Interdisciplinary Product Development (AIPD) course for sophomore students in the Food, Nutrition, and Packaging Science (FNPS) department at Clemson University. It was postulated that this course would increase students' confidence in skills pertaining to product development of food products and childhood nutrition, increase their sense of connection with the department, and would better prepare them to enter industry than students that did not participate in the course. Research participants in both the treatment and control groups were required to be enrolled in the department with a declared major in either food science (with an emphasis in human nutrition or Culinology) or packaging science. Both the treatment and control groups were composed of at least 70% sophomore-level (second year) undergraduate students. There were 37 students in the treatment group and 31 students in the control group. Significant differences did not exist (α=0.05) between the treatment and control groups based on major (P=0.4210), class standing (P=0.9510), gender (P=1.0000), age (P=0.8580), ethnicity (P=1.0000), or grade point average (P=0.4880) based on Fisher's Exact Test. A Subject Knowledge Assessment (SKA) was used to evaluate the mean difference value (MDV) of food science, nutrition, packaging science, and general product development knowledge

gained through the AIPD course. The differences between the treatment and control groups' MDV for each subject area were analyzed using a Paired Sample Satterthwaite *t*-test (α=0.05). An Exit Questionnaire (EQ) was used to evaluate attitudes pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The difference between the treatment and control groups' level of agreement with each statement was analyzed using a two-sided Wilcoxon rank-sum *t*-test (α=0.05). SKA results indicated that the MDV were significantly different between the treatment and control groups in the overall score and in every subject score area except packaging science. EQ results indicated that mean scores between the treatment and control groups were significantly different in seven of the nine statements pertaining to product development knowledge and skills, both statements pertaining to pedagogy, and the statement pertaining to department engagement. Overall, the research project was considered a successful intervention for engaging sophomores in the FNPS department at Clemson University. The evaluation tools generally supported the conclusion that the AIPD course provided the students an opportunity to learn more about department capabilities, interact with faculty members, and learn skills pertaining to the development of healthy products for children.

Introduction

The objective of this research project was to develop a two-semester course on product development for sophomore students in the Food, Nutrition, and Packaging Science (FNPS) department at Clemson University. It was postulated that this course would increase students' confidence in skills pertaining to product development of food

products and childhood nutrition, increase their sense of connection with the department, and would better prepare them to enter industry than students that did not participate in the course. Although sophomore-level students may not have all of the skills and knowledge necessary to fully commercialize a food product, an introductory course on culinary skills, nutrition, and packaging as it pertains to product development can provide a means to engage students during a time when they may feel least connected to the university.

The two-part course offering was incorporated using Clemson's already active and successful undergraduate research program entitled Creative Inquiry (CI). Since its inception in 2005, the CI program has concentrated on encouraging student and faculty participation in engaging activities for students in all disciplines. Students consider problems that spring from their own curiosity, from a professor's challenge, or from the pressing needs of the world around them. CI participants develop critical thinking skills, learn to solve problems as a team, and hone their communication and presentation skills (Speziale 2013).

The inquiry-based structure of the course was designed as a means to promote student self-efficacy in both product development and undergraduate research. Students were given the opportunity to design products that catered to specific health niches within the childhood nutrition market. Features of these products included enhanced protein quality, appropriate portion sizes, gluten-free, vegetarian, and minimally-processed components. With minimum limitations or restrictions on concepts, students were encouraged to develop healthy, creative, and innovative products so long as the market

demand was justified. The student led teams were held to a greater degree of accountability for their success in terms of education gleaned and value of experience gained.

The recently merged FNPS department at Clemson University is uniquely positioned to become a leader in preparing graduates for dynamic careers in the food, agricultural, and packaging sciences. The merger has created an opportunity for interdisciplinarity in curriculum and course structure. Clemson is one of seven schools in the United States to offer an undergraduate degree in packaging science (www.clemson.edu/majors/packaging-science). At Clemson University, a packaging science major will gain knowledge in the design, engineering, science, innovation, research and business that make up the packaging industry (www.clemson.edu/majors/packaging-science). Emphasis areas within this major include distribution, transportation, and engineering technology; packaging materials; food and health care packaging; and package design and graphics (http://www.clemson.edu/majors/packaging-science).

Students involved in this research project represented the two majors in the FNPS department: food science and packaging science. Participating emphasis areas within these majors included Culinology®, nutrition and dietetics, food and healthcare packaging, and package design, thus creating a somewhat representative sample of the entire department population. The multidisciplinary student participants reflected how the entire department or, more importantly, how industry could operate cohesively and efficiently. The course curriculum was designed to integrate all fields of study within the

department as well as emulate the cross-functionality of the food product development industry environment. It was believed that modernizing the curriculum to a level applicable with industry would better prepare graduates, enhance efficiency in the workplace, and provide a competitive edge for the university, its students, and its offering of food and agricultural sciences.

The potential impact of this research project is not only on a localized educational front but also flows into industry and eventually to consumers, creating a domino effect to help in the fight against childhood obesity. By having direct effects on college students poised for future leadership roles in industry, this research should lead to changes in the food supply and food advice fueling the needed modifications in eating behaviors for the next generation.

The increasing incidence of childhood obesity in the United States had created a demand for food companies to develop healthy, convenient options for children. This demand has created a financial opportunity for food companies that develop health conscience products for the growing children's healthy food and beverage market. One opportunity exists specifically in the nutrition snack market targeting children and teens. Few nutrition bar and nutritional drink products addressing children's nutrition have been developed (Levesque 2013).

In addition to presenting an innovative pedagogy for engaging students in food and agricultural sciences, this three-year research project was designed to create a replicable framework for the curriculum that may be used by other universities. The in-class experiential course included lectures by faculty and industry leaders, hands-on

culinary demonstrations, recipes substitution exercises (i.e. replacing salt with seasonings and spices), and exploration of packaging fundamentals and design. These activities will be introduced through web modules and videos for application by other university agricultural programs. The evaluation tools utilized in this research project will provide an intermediate assessment of the newly developed curriculum impact on students. Edits and improvements to the curriculum will continue prior to dissemination.

USDA Higher Education Challenge Grant Project

As a research institution, Clemson University has a constant and persistent goal of innovation both in the classroom and throughout the university experience. Part of this goal is achieved through partnership with industry members and governmental agencies. This research was funded by the United States Department of Agriculture, National Institute of Food Agriculture (USDA-NIFA), Secondary Agriculture Education Challenge Grants Program (project title: "Bundling of Culinology, Nutrition and Packaging in Undergraduate Applied Niche Research", award number: 2012-70003-19969). As such, it was expected that the research would address national needs that aligned with emerging agricultural sciences. In the case of this project, the national need was the development of possible solutions for declining childhood nutrition. The central tenets of the USDA Higher Education Challenge (HEC) grant program were woven into the structure, goals, and outcomes of the course that was developed as part of this research project. The course was titled Applied Interdisciplinary Product Development (AIPD).

The aim of this project was to establish a cohesive, replicable framework for implementing a cross-disciplinary curriculum to improve the industry-readiness of graduates in the food and agricultural sciences. The project had four primary objectives: (1) develop and implement a cross-disciplinary curriculum for food and agricultural sciences with an emphasis on the development of healthy food products for children, (2) develop a marketing niche to expand the pipeline for recruiting and retaining under-represented students into the Department of Food, Nutrition, and Packaging Sciences, (3) demonstrate overall gains in knowledge, cultural competency, experience, attitude, critical thinking, and problem-solving skills of graduates with accumulated experiential learning, and (4) create web-based modules and materials for replication of the components covered in the curriculum to be used in future applications. The results and lessons learned from the AIPD course will aid in the development of educational materials that will be developed and disseminated to other universities for implementation into their own agricultural education programs.

Sophomore students in the FNPS department were recruited for the AIPD course beginning in the September 2012. The two-semester course was offered twice; first during Spring 2013 and Fall 2013, and again during Fall 2013 and Spring 2014. Evaluation tools employed during this project included a Subject Knowledge Assessment (SKA), an Exit Questionnaire (EQ), a Students Satisfaction Inventory (SSI), a Creative Inquiry Evaluation (CIE), a university-administered Educational Testing Service (ETS) Profile, and the National Survey of Student Engagement (NSSE). The involvement of FNPS students that participated in the AIPD course will extend beyond the conclusion of

the course. During the Spring 2015, student focus groups will be conducted in order learn if and how a student's participation in the AIPD course has affected their university experience and industry readiness. Faculty members that interacted with these students following their participation in AIPD course will also be surveyed. A period of time after the students have graduated and left the FNPS department, Clemson University Career, Alumni, and Employer surveys will be used to evaluation the students' entry into industry. Results of this project will be disseminated through conference workshops beginning in the Fall 2015.

The key deliverable for this project is a completely developed two-semester, interdisciplinary course curriculum focused on new food product development as it relates to childhood nutrition. Other deliverables include online modules for replication of course components at Clemson University and other universities. Six other key outcomes of this project included (1) increases in discipline knowledge as measured by the subject knowledge assessment, (2) higher levels of employment and employee satisfaction of project participants as compared to other alumni of the FNPS department, (3) increases in critical thinking, reading, writing, and mathematic skills of the project participants, (4) hone communication and presentation skills, (5) increased level of student engagement in the FNPS department, and (6) increases in positive experiential learning leading to higher levels of student satisfaction and industry readiness.

Materials and Methods

Participants

Recruiting for the initial offering of the AIPD course began in September 2012. In order to recruit participants, short presentations about the course were given in introductory courses within the FNPS department at Clemson University. The presentations outlined the goals and activities of the course. Students were asked to provide contact information if they were willing to participate.

Research participants in both the treatment and control groups were required to be enrolled in the department with a declared major in either food science (with an emphasis in human nutrition or Culinology) or packaging science. Both the treatment and control groups were composed of at least 70% sophomore-level (second year) undergraduate students. Both groups represented convenience samples, not random samples. Each control group student met individually with the graduate research assistant at the beginning of the first semester and again at the end of the second semester to complete evaluation tools. Treatment group participants completed the evaluation tools during Initial class lecture time.

There were 37 students in the treatment group and 31 students in the control group. Significant differences did not exist (α=0.05) between the treatment and control groups based on major (P=0.4210), class standing (P=0.9510), gender (P=1.0000), age (P=0.8580), ethnicity (P=1.0000), or grade point average (P=0.4880) based on Fisher's Exact Test. The distribution of majors, emphasis areas, and class standing of students in the treatment and control groups is shown in Table 2.1. The course was offered twice to

accommodate the number of research participants. Therefore, the treatment and control groups each consisted of two separate cohorts. Significant differences did not exist (α=0.05) between the first and second cohort of the treatment group or between the first and second cohort of the control group based on major, class standing, gender, age, ethnicity, or grade point average. Data collected from the cohorts of each group were combined for research purposes. The Clemson University Institutional Review Board provided the approval for the use of human subjects in this study (PPN 2012001075).

Table 2.1 Major and Class Standing of Participants in Treatment and Control Groups

Group	Major/Emphasis Area			Class Standing			
	Food Science		Packaging Science	Freshman	Sophomore	Junior	Senior
	Nutrition	Culinology ®					
Treatment	19	9	9	3	29	4	1
Control	18	3	10	2	23	5	1

Teaching Staff

This USDA HEC grant-funded project was conceptualized, designed, and taught by three faculty members in the FNPS department at Clemson University. Associate professor Dr. Margaret Condrasky's research interests include culinary nutrition for children and adults, Culinology ®, and product development. Dr. Duncan Darby, an associate professor and associate director of the Center for Flexible Packaging at Clemson University, focuses on research concerning materials and processes used for manufacturing flexible packaging and the applications of flexible packaging. Senior lecturer Dr. Aubrey Coffee's research interests include sensory evaluation, culinary arts, baking and pastry, and culinary science. Alexa Weeks, a Food, Nutrition, and Culinary Science graduate student was the research assistant for this project. She attended all

classes and labs, organized activities, facilitated the product development process, mentored undergraduate students, and provided additional support for all teams.

Course Description

The course was taught over two semesters. The first semester included introductory lectures on food science, childhood nutrition, sensory evaluation, basic culinary skills, packaging science, materials, and food product development. Other activities included culinary and packaging lab tours, a visit to a local elementary school, an evaluation of current products marketed towards children, healthy cooking demonstrations, industry visits, and practice ideation activities. Descriptions of each of first semester activities are shown in Table 2.2.

During the second semester, the students were placed into groups to develop products that focused on childhood nutrition. Each group consisted of at least one food science (nutrition), one food science (Culinology), and one packaging science student. Additional faculty members of the department often participated as consultants for the student groups during the product development in the second semester. Research interests of these department members included shelf life testing, food safety, food manufacturing operations, packaging and graphic design, and childhood nutrition. Descriptions of each of second semester activities are shown in Table 2.3.

Clemson University designed a program to encourage undergraduate research called Creative Inquiry (CI). Depending on their major, students may be required to earn

a certain amount of hours by participating in a CI. Students in the treatment group earned four hours of CI credits.

At minimum, students in the treatment group met once a week for 50 minutes and every other Friday for three hours. During the first semester, Mondays were designated as class lecture time and Fridays were designated as field trip and other experiential learning time. During the second semester, Mondays were designated as group work or consultation days and Fridays were designated as lab time during which students developed their products.

As part of their responsibilities for the class, treatment group students were required to track project progress in a lab notebook, submit a final project report, and present their products at the conclusion of the course to members of the FNPS and CI departments. Treatment students received grades for the course. During the first semester, grades were determined through evaluation of weekly activities and ideation assignments (15%), reflection (15 %), comprehensive semester experience (10 %), teaming (35%), and participation in field and lab activities (25%). During the second semester, grades were determined through evaluation of the final group project (50%), completeness of the group lab notebook (25%), peer evaluations (15%), and attendance (10%). Grading for the final project report was determined by evaluation the nutritional profile, demonstration of culinary skill, packaging aspects, focus group information, market analysis, originality of concept, and technical writing skills.

Table 2.2 Descriptions of First Semester Activities		
Type of Activity	Title of Activity or Presentation	Description
Subject Area Introductions	Introduction to Nutrition, Culinology®, Sensory Evaluation, and Packaging Science	During the first class period, brief (approximately 10-minute) presentations about the subject areas were given by each of the three instructors.
Lectures	Childhood Nutrition, Sensory Evaluation, Packaging Science, and Tools for Market Research	Each of these lectures were given during a 50-minute class period. The lectures provided the foundational knowledge for each subject area that students would require for the AIPD course.
Assignments	Supermarket Product Assignment	Students were asked to visit a local grocery store and purchase a kid's food product. Then, they were asked to bring the product to class and describe its key features.
	Ideation Activities	In these activities, student groups were given scenario and asked to develop three concepts for a retail or foodservice food item that would fit the scenario. For one of the concepts, students were asked to elaborate on the food science, packaging, culinary, nutrition, and marketing aspects of the concept. These activities allowed the students to practice ideating concepts without fully developing them.
	Overview of second semester project	At the conclusion of the first semester, student groups were asked to present a concept that they would develop during the second semester. The presentations included a recipe, ideas for packaging, and a market analysis, which included market demand and justification for potential success of the product.
Field Trips	Lunch at a Local Restaurant	Students met at a local restaurant for lunch. They were only allowed to order items from the kid's menu. Before eating their entrees, students were asked to estimate the amount of calories, protein, carbohydrates, fat, and sodium for the dish.

	Elementary Cafeteria and Kitchen Tour	Students were taken to a local elementary school for a tour of the kitchen facilities. They were also able to eat lunch with elementary school students.
	Industry Visits	Students were taken to the corporate headquarters of two national foodservice restaurants chains: Denny's in Spartanburg, SC and Popeyes Louisiana Kitchen in Atlanta, GA
Culinary Demonstrations	Demonstration and Tasting of On-Trend Dishes	Culinary science upperclassmen demonstrated various dishes for students to taste and evaluate. Dishes included a quinoa salad, a kale and sweet potato salad, and a low-sodium Southwestern chicken salad.
Industry Interview	Interview with a Professional Nutritionist and Culinary Scientist	Students participated in a video conference and interview with Dr. Marilyn Schnepf, a nutritionist, culinary scientist, and faculty member at the University of Nebraska, Lincoln.
Department Lab Tours and Introductions	Culinary Skills Demonstration and Kitchen Lab Tour, Packaging Lab Tours, and Food Science Lab Tour	In order to enable the students to become more acquainted with the department labs and facilities, they were taken on tours of labs designated for each subject area.

Table 2.3 Descriptions of Second Semester Activities

Type of Activity	Title of Activity or Presentation	Description
Lectures	Product Development Toolkit	This lecture outlined the basic steps of the food product process that the students would be expected to follow as part of the AIPD course.
Assignments	Group Product Development Project	The interdisciplinary student groups developed their concepts for health food products for children during the second semester.
	Lab Notebooks	During the second semester product development, each group was required to keep track of their progress in a lab notebook. Progress notes included information about progress between classes, recipe and formulation trials in culinary labs, key takeaways from consultations, and meeting notes.

	Final Report	Each student group was required to submit a final report for their product at the conclusion of the AIPD course. The final report included a market analysis, a gold standard recipe, a semi-commercialized formula, focus group procedure and subsequent modifications, and packaging.
	Final Presentation	At the conclusion of the semester, each student group presented their concepts (including product samples) to fellow students, instructors, and members of the FNPS department.
Focus Group	Product Focus Group at a Local Elementary School	Student groups presented their concepts to 20 elementary school students to gain feedback about the dishes and suggestions for improvement.
Department Faculty Consultations	Subject Matter Specialist Consultations by Department Members	Faculty members in the FNPS department periodically visited the AIPD class to provide feedback and critiques for each group project. FNPS faculty members included Dr. Jesch (sports nutrition), Dr. Coffee (sensory science), Dr. Northcutt (food safety), Dr. Cooksey (food packaging), Erin Snyder (graphic design), and Dr. Barron (food manufacturing operations).

Evaluation Tools

Subject Knowledge Assessment (SKA)

All research participants completed the SKA before and after the course. The SKA consisted of 30 multiple choice and 15 free response questions on food science, nutrition, packaging science, and general product development topics. Subject matter experts in the FNPS department designed the SKA. The test-retest reliability of the SKA was measured before the course began. For the test, KR-20 was 0.64. For the retest, KR-20 was 0.75. The participant scores on the SKA did not count toward overall course grades. Prior to analysis, the normality assumption was verified.

Participants in both the treatment and control groups completed the SKA before the course (pre-) and after the course (post-). The difference between the pre- and post-scores was determined by subtracting the pre-score from the post-score for each individual participant. The mean difference value (MDV) represents the average difference in scores for each group and subject area. The MDV was used as the primary measurement of performance comparison between the two groups. The differences between the treatment and control groups' MDV for each subject area were analyzed using a Paired Sample Satterthwaite *t*-test (α=0.05).

Exit Questionnaire (EQ)

At the conclusion of the course, all of the research participants completed an EQ, which measured the level of agreement (where 1 = "strongly disagree", 3 = "neither disagree or agree", and 5 = "strongly agree") with statements pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The difference between the treatment and control groups' level of agreement with each statement was analyzed using a two-sided Wilcoxon rank-sum *t*-test (α=0.05). At the conclusion of the EQ, participants in the treatment group were asked to suggest improvements to the AIPD course. This qualitative data was analyzed and coded by three trained reviewers. Dr. Sarah F. Griffin, an associate professor in Public Health Sciences at Clemson University, trained the reviewers through a workshop, which included practice coding. During the primary analysis, the reviewers determined key themes of the responses and codes were assigned to each theme. During the secondary analysis,

reviewers coded each response independently and then compared their codes. The interrater reliability scores of the three reviewers were determined using Cohen's kappa coefficient. The interrater reliability scores were 0.72, 0.72, and 0.86, which were deemed acceptable.

Final Product Reports and Presentations

As part of the product development task, all groups were asked to complete a product report, which included a market analysis, a gold standard recipe, a commercial formula, a nutritional profile (nutrition facts panel, ingredient declaration, allergens, nutrient claims), packaging information (design, graphics, materials), focus group results, and a product photo. Descriptions, pictures, and package graphics of each product can be found in Appendix H.

Results

Subject Knowledge Assessment (SKA)

MDV and standard error in the overall scores as well as the scores for each subject area of the SKA are shown in Table 2.4. Significant differences existed (α=0.05) between the treatment and control groups MDV for the overall SKA and in all subject areas except for the packaging subject area. The general knowledge subject area exhibited the largest standard error for both groups.

Table 2.4 Mean Difference Values (MDV) and Standard Error of Overall and Subject Area Scores of Treatment and Control Groups			
Subject Area	Mean Difference Values (MDV)		P Value
	Treatment	Control	
Overall	14.66 ± 1.38	3.98 ± 1.86	<0.0001*
Food Science	21.34 ± 2.27	-4.07 ± 3.21	<0.0001*
Nutrition	17.41 ± 2.55	7.96 ± 2.92	0.0178*
Packaging	9.37 ± 2.64	10.75 ± 3.05	0.7341
General	13.06 ± 3.24	0.81 ± 3.31	0.0102*

*MDV were significantly different (α=0.05)

Exit Questionnaire (EQ)

Shown in Table 2.5 are the results of the EQ, which are the mean scores for the level of agreement (where 1 = "strongly disagree" and 5 = "strongly agree") with statements pertaining to product development skills, pedagogy, department engagement, and industry readiness for both the treatment and control groups.

Results indicated that treatment group students felt significantly more confident than the control group at generating ideas for new products (*P*=0.0025), collecting marketing information and conducting a market analysis (*P*=<0.0001), developing a gold standard recipe (*P*=<0.0001), developing a formula (*P*=<0.0001), applying changes to a recipe or formula to make it healthier (*P*=<0.0001), collecting commercial ingredients and/or commercial materials (*P*=0.0003), developing healthy food products for children (*P*=0.0001), and collaborating with students in other fields of study (*P*=<0.0001).

The treatment group also felt significantly more connected to the Food, Nutrition, and Packaging Science department (*P*=<0.0001) and more able to learn from hands-on experiences (*P*=<0.0035).

No significant difference existed between the treatment and control groups in terms of level of confidence in estimating cost for a new product (*P*=<0.3505) or designing packaging for new products (*P*=<0.3916).

Although results for statements pertaining to industry readiness ('I feel confident interacting and networking with industry professionals', 'I feel confident that I will meet the expectations of my future employer', and 'I feel confident being an advocate for my industry and/or field of study') were not significantly different between the groups, the means for both groups tended towards agreement with these statements.

Table 2.5 Means Scores for Level of Agreement to EQ Statements by Treatment and Control Groups

Exit Questionnaire (EQ) Statements	Treatment Group**	Control Group**	P Value
I feel confident generating ideas for new products.	4.27 ± 0.70	3.61 ± 0.92	0.0025*
I feel confident collecting marketing information and conducting a market analysis.	4.08 ± 0.81	2.90 ± 0.94	<0.0001*
I feel confident developing a gold standard recipe.	4.11 ± 0.75	2.55 ± 1.03	<0.0001*
I feel confident developing a formula.	4.17 ± 0.79	2.61 ± 0.92	<0.0001*
I feel confident applying changes to a recipe or formula to make it healthier.	4.53 ± 0.51	3.58 ± 1.09	<0.0001*
I feel confident collecting commercial ingredients and/or commercial materials.	3.94 ± 0.79	2.94 ± 1.03	0.0003*
I feel confident estimating cost for a new product.	3.03 ± 1.03	2.77 ± 0.96	0.3505
I feel confident designing packaging for new products.	3.19 ± 1.17	2.94 ± 1.15	0.3916
I feel confident developing healthy food products for children.	4.53 ± 0.51	3.26 ± 1.29	0.0001*
I learn more from hands-on experiences than lectures.	4.81 ± 0.47	4.35 ± 0.71	0.0035*

I feel confident collaborating with students that are not in my major or field of study.	4.75 ± 0.55	4.16 ± 0.52	<0.0001*
I feel connected to the Food, Nutrition, and Packaging Science department.	4.81 ± 0.40	4.10 ± 0.65	<0.0001*
I feel confident interacting and networking with industry professionals.	4.00 ± 0.83	3.74 ± 0.96	0.3137
I feel confident entering industry with my current level of knowledge and skills.	3.11 ± 1.14	2.90 ± 0.87	0.5082
I feel confident that I will meet the expectations of my future employer.	4.25 ± 0.65	4.03 ± 0.60	0.1566
I feel confident being an advocate for my industry and/or field of study.	4.33 ± 0.63	4.06 ± 0.63	0.0887

*EQ responses for treatment and control groups were significantly different (α=0.05)
**1=Strongly Disagree and 5=Strongly Agree

Treatment group students were asked to suggest for improvements to the course. Shown in Table 2.6 are key themes that emerged during qualitative data analysis as well as excerpts from student responses. Key themes for suggested improvements to the course included (1) more clarity in terms of course description, goals for the course, and time commitment, (2) more information and hands-on experience in packaging science, (3) more speakers and activities focusing on nutrition, (4) begin product development in the lab during the first semester, (5) more deadlines, and (6) more preparation in individual subject areas.

Table 2.6 Suggestions for Course Improvement		
More clarity in terms of course description, goals for the course, and time commitment	14	"I would change how it was advertised to students because I had no idea until the end of first semester that we would be developing a product during the second semester." "I think we were all just confused with the requirements for our product at the beginning of this semester and we didn't know what our end product was supposed to be/contain." "Maybe give a clearer explanation of what the end goals are earlier in the course." "I would devise a more concrete syllabus so that the students would know what was expected of them at every step. Also devising a timeline so that students can reach certain steps/goals throughout the semester." "I would just let the students know that a lot of time and effort goes into this project."
More information and hands-on experience in packaging science	7	"I would have liked to play a larger role in the package development, worked closer with the grad students on design, helped print our label, worked with packaging faculty about what materials to use, etc." "More packaging aspects and visit a packaging facility."
Nutrition speakers and activities	3	"I would incorporate more speakers and activities that focus on nutrition."
Begin development during the first semester, which would include more lab time	7	"I would add some lab time, and start some of our second semester work in the first semester." "I would also make better use of the 1st semester. While the activities and lecture were very beneficial, the students should be brainstorming and be in the first stages of the product development way before the last few weeks of the semester." "Labs needed in first semester."
More deadlines	3	"Deadlines might help with assignments." "Deadlines, so we can move on and focus on [other] things/address more problems."
More preparation in individual subject areas	2	"Maybe during the first semester, have people focus on gaining knowledge in their own major that would be useful for the development stage. Then have everyone come together and share his or her knowledge in the second semester."

n_p: number of participants that commented on the theme

Student Attrition

Some student groups required reorganization at the beginning of the second semester of the course due to student attrition. Six students were lost from the treatment group and seven students were lost from control group. Reason for student attrition included student decision to switch majors (into another department), schedule conflicts during the second semester, or unwillingness to commit because CI hour requirements had been fulfilled. Reasons for student attrition from the control group included student decision to switch majors or unwillingness to complete post-evaluation tools at the conclusion of the second semester. When possible, students lost from either group were asked to complete the post-evaluation tools. Data from these students was not included in the final analysis.

Discussion and Recommendations

Subject Knowledge Assessment (SKA)

The MDV were significantly different between the treatment and control groups in the overall score and in every subject score area except packaging science. Although the MDV for both groups in this subject area was not significantly different, both groups showed improvement in packaging science knowledge. By the end of their sophomore year, packaging science students will have taken six courses in the department, many of which include experiential elements such as labs. It is possible that the packaging science information that was presented as part of this course was reiterative and therefore did not yield a significant increase in the packaging science knowledge of the treatment group

over the control group, especially those enrolled in packaging science. The relatively small proportion of packaging science students in both groups (and the small total sample size) may have played a role in the level of packaging science knowledge as well.

Although nutrition and Culinology® students gained competency in packaging subject knowledge through the AIPD course, they are cognizant of the limitations of their knowledge, even at the conclusion of the course. Many were aware that they were not yet fully competent in the packaging science component of product development.

The greatest increase in mean score occurred in the food science subject by the treatment group. In this same subject area, the only negative MDV was observed in the control group score. By the end of the sophomore year, food science students will, at most, have taken three classes (six credit hours) within the department. Some food science participants in the treatment group stated that they had no prior courses focused on nutrition or Culinology®. For them, this course served as an introduction to both subject areas as well as packaging science.

The second greatest gap in MDV occurred in the general knowledge subject area. This section included questions specific to product development. The product development courses currently offered in the FNPS department are offered at the junior- and senior-level. For students in both majors, the AIPD course served as an introduction to the product development process, which could explain the substantial gap in MDV between the treatment and control groups.

Exit Questionnaire (EQ)

Participants were asked to indicate their level of agreement (where 1 = "strongly disagree" and 5 = "strongly agree") with statements pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The mean scores between the treatment and control groups were significantly different in seven of the nine statements pertaining to product development knowledge and skills, both statements pertaining to pedagogy, and the statement pertaining to department engagement. The treatment group exhibited the greatest level of agreement with the statement "I feel connected to the Food, Nutrition, and Packaging Science department." However, the response level for both groups tended toward agreement to this statement.

The lowest level of agreement was observed in three statements: "I feel confident estimating cost for a new product," "I feel confident entering industry with my current level of knowledge and skills," and "I feel confident designing packaging for a new project." In the case of the first statement, cost analysis of a commercial formula was a topic that was introduced but not required as part of the final product. In the case of the second statement, it was expected that sophomores would not be fully prepared to enter industry. However, it was believed that these students would feel confident beginning an internship or co-op in industry. In the case of the third statement, the lack of confidence and knowledge gained in packaging science was a theme throughout the results.

The greatest gap between the level of agreement of the treatment and control groups occurred with the statements "I feel confident developing a gold standard recipe" and "I feel confident developing a formula," which reflected success in the project goal to

increase self-efficacy of students' skills associated with product development. Overall, the level of agreement of control group tended toward neutrality for many of the statements.

Treatment group suggestions provided meaningful insights into the course design and implementation. Beginning in the Fall 2014, videos and presentation modules designed to capture elements of the AIPD course will be developed for other university agricultural education programs. Treatment group suggestions will be applied to these items before dissemination to other universities.

Other recommendations for improvement to AIPD course include a reexamination of the evaluation tools and CI credit allotment. It was suggested that the SKA be reorganized to include a more even distribution of questions in each subject area. Also, consistent multiple choice question format and greater clarity in free response questions could lead to better quality responses from participants. Students earn four CI credits for their participation in the AIPD course, two per semester. It was suggested that students be awarded a greater number of credits during the second semester than in the first semester because of the increase in time commitment and effort. This may be achieved by awarding one or two credit in the first semester and three credits in the second semester.

The knowledge gleaned through this research project will extend beyond the walls of the FNPS department and Clemson University. As part of the USDA HEC grant, the progress of these students during the remainder of their undergraduate career and entrance into the industry will be monitored and assessed. The results of this portion of the research project will be built upon through pre-graduation focus groups, faculty focus

groups, alumni surveys, career surveys, and employer surveys. The results and lessons learned from the AIPD course will aid in the development of materials that will be distributed to other universities for implementation into their own agricultural education programs. Lessons learned through this study may be applied to future research concerning student engagement, recruitment of students into the agricultural education pipeline, and enhancing student competency in the area of childhood nutrition.

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CHAPTER THREE

FOOD, NUTRITION, CULINARY, AND PACKAGING SCIENCE UNDERGRADUATE RESEARCH, EXPERIENTIAL LEARNING, AND PRODUCT DEVELOPMENT FOCUSING ON CHILDHOOD NUTRITION

Abstract

The objective of this research project was to develop a two-semester Applied Interdisciplinary Product Development (AIPD) course for sophomore students in the Food, Nutrition, and Packaging Science (FNPS) department at Clemson University. It was postulated that this course would increase students' confidence in skills pertaining to product development of food products and childhood nutrition, increase their sense of connection with the department, and would better prepare them to enter industry than students that did not participate in the course. Research participants in both the treatment and control groups were required to be enrolled in the department with a declared major in either food science (with an emphasis in human nutrition or Culinology) or packaging science. Both the treatment and control groups were composed of at least 70% sophomore-level (second year) undergraduate students. There were 37 students in the treatment group and 31 students in the control group. Significant differences did not exist (α=0.05) between the treatment and control groups based on major (P=0.4210), class standing (P=0.9510), gender (P=1.0000), age (P=0.8580), ethnicity (P=1.0000), or grade point average (P=0.4880) based on Fisher's Exact Test. A Subject Knowledge Assessment (SKA) was used to evaluate the mean difference value (MDV) of food science, nutrition, packaging science, and general product development knowledge gained through the AIPD course. The differences between the treatment and control

groups' MDV for each subject area were analyzed using a Paired Sample Satterthwaite *t*-test (α=0.05). An Exit Questionnaire (EQ) was used to evaluate attitudes pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The difference between the treatment and control groups' level of agreement with each statement was analyzed using a two-sided Wilcoxon rank-sum *t*-test (α=0.05). The Student Satisfaction Inventory (SSI) is an evaluation tool employed by the Office for Institutional Effectiveness and Assessment at Clemson University. The SSI evaluates a student's level of importance and resultant satisfaction with various aspects of their college or university experience. For this research study, the SSI was used to evaluate responses of the treatment group before and after the AIPD course. The results of the inventory were independently analyzed by Noel-Levitz in Coralville, Iowa. SKA results indicated that the MDV were significantly different between the treatment and control groups in the overall score and in every subject score area except packaging science. EQ quantitative results indicated that mean scores between the treatment and control groups were significantly different in seven of the nine statements pertaining to product development knowledge and skills, both statements pertaining to pedagogy, and the statement pertaining to department engagement. EQ qualitative results indicated that the response to working in interdisciplinary teams was exceptionally positive. In general, students embraced the two-semester course format and experiential elements. Some students commented on the desire for more structure, greater clarity in objectives, and well-defined deadlines for each portion of the final project. For the SSI evaluation tool, the only significant difference that existed was in the category of institutional

effectiveness. The level of satisfaction of the item "The instruction in my major field is excellent." was significantly lower in the post-response of the treatment group than the pre-response. Overall, the research project was considered a successful intervention for engaging sophomores in the FNPS department at Clemson University. The evaluation tools generally supported the conclusion that the AIPD course provided the students an opportunity to learn more about department capabilities, interact with faculty members, and learn skills pertaining to the development of healthy products for children.

Introduction

The objective of this research project was to develop a two-semester course on product development for sophomore students in the Food, Nutrition, and Packaging Science (FNPS) department at Clemson University. It was believed that this course would increase students' confidence in skills pertaining to product development and childhood nutrition, increase their sense of connection with the department, and would better prepare them to enter industry than students that did not participate in the course. Although sophomore-level students may not have all of the skills and knowledge necessary to fully commercialize a product, an introductory course on culinary skills, nutrition, and packaging as it pertains to product development can provide a means to engage students during a time when they may feel least connected to the university.

The inquiry-based structure of the course was designed as a means to promote student self-efficacy in both product development and undergraduate research. Students were given the opportunity to design products that catered to specific health needs or

market demands of their choice. Features of these products included enhanced protein quality, appropriate portion sizes, gluten-free, vegetarian, and minimally-processed components. With minimum limitations or restrictions on concepts, students were encouraged to develop healthy and innovative products so long as the market demand was justified. The student lead teams were held to a greater degree of accountability for their success in terms of education gleaned and value of experience gained.

The recently merged FNPS department at Clemson University is uniquely positioned to become a leader in preparing graduates for dynamic careers in the food and agricultural sciences. The merger has created an opportunity for interdisciplinarity in curriculum and course structure. Students involved in this research project represented the two majors in the department: food science and packaging science. Participating emphasis areas within these majors included Culinology®, nutrition and dietetics, food and healthcare packaging, and package design, thus creating a somewhat representative sample of the entire department population. The course curriculum was design to integrate all fields of study as well as emulate the cross-functionality of the food product development industry environment. It was believed that modernizing the curriculum to a level applicable with industry will better prepare graduates, enhance efficiency in the workplace, and provide a competitive edge for the university and its offering of food and agricultural sciences.

As a research institution, Clemson University has a constant and persistent goal of innovation both in the classroom and throughout the university experience. Part of this goal is achieved through partnership with industry members and governmental agencies.

This research was funded by the United States Department of Agriculture, National Institute of Food Agriculture (USDA-NIFA), Secondary Agriculture Education Challenge Grants Program (project title: "Bundling of Culinology, Nutrition and Packaging in Undergraduate Applied Niche Research", award number: 2012-70003-19969). As such, it was expected that the research would address national needs that aligned with emerging agricultural sciences. In the case of this project, the national need was solutions for declining childhood nutrition. In addition to presenting an innovative pedagogy for engaging students in food and agricultural sciences, this three-year research project aimed to create a replicable framework for the curriculum that may be used by other universities. The in-class experiential course included lectures by faculty and industry leaders, hands-on culinary demonstrations, recipes substitution exercises, and exploration of packaging fundamentals and design. These activities will be introduced through web modules and videos for application by other university agricultural programs. The evaluation tools utilized in this research project will provide an intermediate assessment of the newly developed curriculum before dissemination.

Materials and Methods

Research Participants

In order to recruit participants, short presentations about the course were given in introductory courses within the FNPS department at Clemson University. The presentations outlined the goals and activities of the course. Students were asked to provide contact information if they were willing to participate.

Research participants in both the treatment and control groups were required to be enrolled in the department with a declared major in either food science (with an emphasis in human nutrition or Culinology) or packaging science. Both the treatment and control groups were composed of at least 70% sophomore-level (second year) undergraduate students. Both groups were selected by convenience. Each control group student met individually with the graduate research assistant at the beginning of the first semester and again at the end of the second semester to complete evaluation tools. There were 37 students in the treatment group and 31 students in the control group. Significant differences did not exist (α=0.05) between the treatment and control groups based on major (P=0.4210), class standing (P=0.9510), gender (P=1.0000), age (P=0.8580), ethnicity (P=1.0000), or grade point average (P=0.4880) based on Fisher's Exact Test. The distribution of majors, emphasis areas, and class standing of students in the treatment and control groups is shown in Table 3.1. The course was offered twice to accommodate the number of research participants. Therefore, the treatment and control groups each consisted of two separate cohorts. Significant differences did not exist (α=0.05) between the first and second cohort of the treatment group or between the first and second cohort of the control group based on major, class standing, gender, age, ethnicity, or grade point average. Data collected from the cohorts of each group were combined for research purposes. The Clemson University Institutional Review Board provided the approval for the use of human subjects in this study (PPN 2012001075).

Table 3.1 Major and Class Standing of Participants in Treatment and Control Groups							
Group	Major/Emphasis Area			Class Standing			
	Food Science		Packaging Science	Freshman	Sophomore	Junior	Senior
	Nutrition	Culinology ®					
Treatment	19	9	9	3	29	4	1
Control	18	3	10	2	23	5	1

Course Description

The course was taught over two semesters. The first semester included introductory lectures on food science, childhood nutrition, sensory evaluation, basic culinary skills, packaging science, materials, and product development. Other activities included culinary and packaging lab tours, a visit to a local elementary school, an evaluation of current products marketed towards children, healthy cooking demonstrations, industry visits, and practice ideation activities. During the second semester, the students were placed into groups to develop products that focused on childhood nutrition. Each group consisted of at least one food science (nutrition), food science (Culinology), and packaging science student. As part of the product development task, all groups were asked to complete a product report, which included a market analysis, a gold standard recipe, a commercial formula, a nutritional profile (nutrition facts panel, ingredient declaration, allergens, nutrient claims), packaging information (design, graphics, materials), focus group results, and a product photo.

The course was team-taught by three professors in the FNPS department at Clemson University. Other members of the department often participated as consultants for the student groups during the product development in the second semester. Clemson University has designed a program to encourage undergraduate research called Creative Inquiry (CI). Depending on their major, students may be required to earn a certain

amount of hours by participating in a CI. Students in the treatment group earned four hours of CI credits.

Evaluation Tools

Subject Knowledge Assessment (SKA)

All research participants completed the SKA before and after the course. The SKA consisted of 30 multiple choice and 15 free response questions on food science, nutrition, packaging science, and general product development topics. The test-retest reliability of the SKA was measured before the course began. For the test, KR-20 was 0.64. For the retest, KR-20 was 0.75. The participant scores on the SKA did not count toward overall course grades. Prior to analysis, the normality assumption was verified.

Participants in both the treatment and control groups completed the SKA before the course (pre-) and after the course (post-). The difference between the pre- and post-scores was determined by subtracting the pre-score from the post-score for each individual participant. The mean difference value (MDV) represents the average difference in scores for each group and subject area. The MDV was used as the primary measurement of performance comparison between the two groups. The differences between the treatment and control groups' MDV for each subject area were analyzed using a Paired Sample Satterthwaite *t*-test (α=0.05).

Exit Questionnaire (EQ)

At the conclusion of the course, all of the research participants completed an EQ. The EQ consisted of two sections. The first section measured the level of agreement (where 1 = "strongly disagree", 3 = "neither disagree or agree", and 5 = "strongly agree") with statements pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The difference between the treatment and control groups' level of agreement with each statement was analyzed using a two-sided Wilcoxon rank-sum *t*-test (α=0.05). The second section consisted of free response questions regarding motivation for participation and feedback on the course structure and design. This qualitative data was analyzed and coded by three trained reviewers. Dr. Sarah F. Griffin, an associate professor in Public Health Sciences at Clemson University, trained the reviewers through a workshop, which included practice coding. During the primary analysis, the reviewers determined key themes for each question and codes were assigned to each theme. During the secondary analysis, two reviewers coded each response independently and then compared their codes. The interrater reliability scores of the three reviewers were determined using Cohen's kappa coefficient. The interrater reliability scores were 0.72, 0.72, and 0.86, which were deemed acceptable.

Student Satisfaction Inventory (SSI)

All research participants completed a student satisfaction inventory (SSI) before and after the course. The SSI is an evaluation tool employed by the Office for Institutional Effectiveness and Assessment at Clemson University. The SSI evaluates a

student's level of importance and resultant satisfaction with various aspects of their college or university experience. Therefore, the questions were not specific to the course. The results of the inventory were independently analyzed by Noel-Levitz in Coralville, Iowa. Noel-Levitz is higher education consulting firm that provides insights for universities in order to improve enrollment and student success.

Results

Subject Knowledge Assessment (SKA)

MDV and standard error in the overall scores as well as the scores for each subject area of the SKA are shown in Table 3.2. Significant differences existed (α=0.05) between the treatment and control groups MDV for the overall SKA and in all subject areas except for the packaging subject area. The general knowledge subject area exhibited the largest standard error for both groups.

Table 3.2 Mean Difference Values (MDV) and Standard Error of Overall and Subject Area Scores of Treatment and Control Groups

Subject Area	Mean Difference Values (MDV)		P Value
	Treatment	Control	
Overall	14.66 ± 1.38	3.98 ± 1.86	<0.0001*
Food Science	21.34 ± 2.27	-4.07 ± 3.21	<0.0001*
Nutrition	17.41 ± 2.55	7.96 ± 2.92	0.0178*
Packaging	9.37 ± 2.64	10.75 ± 3.05	0.7341
General	13.06 ± 3.24	0.81 ± 3.31	0.0102*

*MDV were significantly different (α=0.05)

Figure 3.1 shows a graphical representation of the MDV in the overall SKA and individual subject area scores of the treatment and control groups. The error bars shown

on the graph represent the standard error for each category. The food science subject area scores for the control group presented the only negative MDV for either group or subject area.

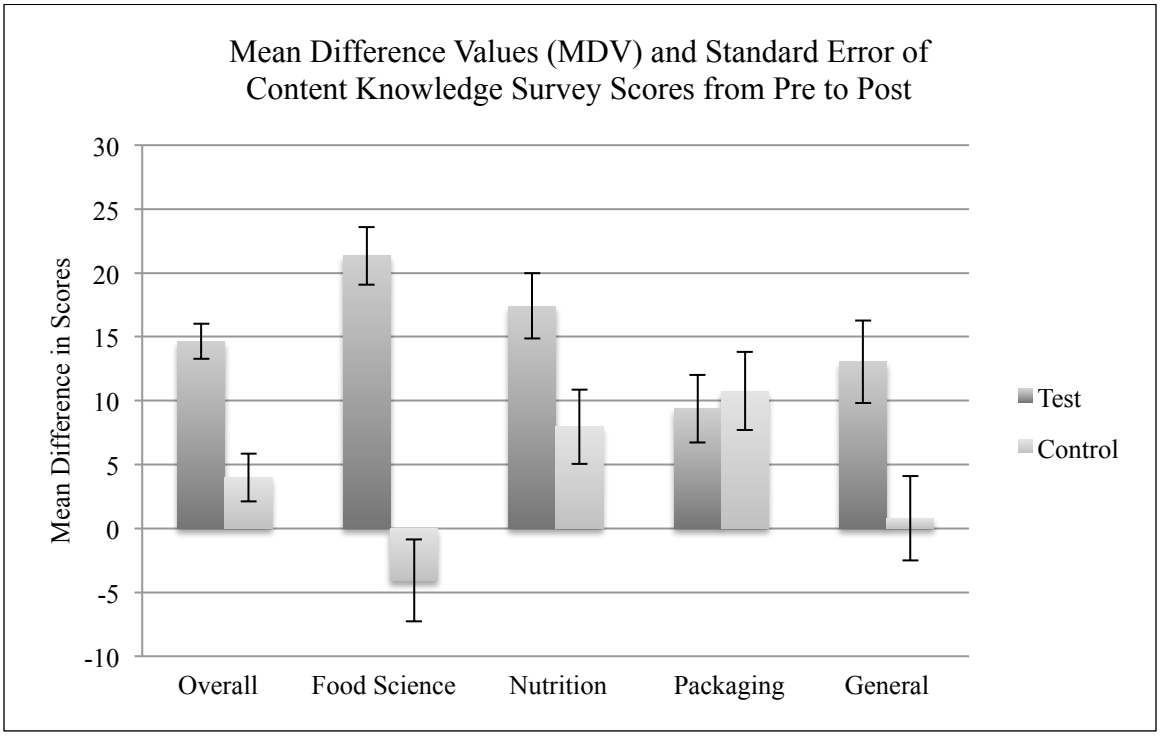

Figure 3.1 Mean Difference Values (MDV) and Standard Error of Overall and Subject Area Scores of Treatment and Control Groups

Exit Questionnaire (EQ)

The EQ consisted of two sections. Shown in Table 3.3 are the results of the first section, which are the mean scores for the level of agreement (where 1 = "strongly disagree" and 5 = "strongly agree") with statements pertaining to product development skills, pedagogy, department engagement, and industry readiness for both the treatment and control groups.

Results indicated that treatment group students felt significantly more confident than the control group at generating ideas for new products (P=0.0025), collecting marketing information and conducting a market analysis (P=<0.0001), developing a gold standard recipe (P=<0.0001), developing a formula (P=<0.0001), applying changes to a recipe or formula to make it healthier (P=<0.0001), collecting commercial ingredients and/or commercial materials (P=0.0003), developing healthy food products for children (P=0.0001), and collaborating with students in other fields of study (P=<0.0001).

The treatment group also felt significantly more connected to the Food, Nutrition, and Packaging Science department (P=<0.0001) and more able to learn from hands-on experiences (P=<0.0035).

No significant difference existed between the treatment and control groups in terms of level of confidence in estimating cost for a new product (P=<0.3505) or designing packaging for new products (P=<0.3916).

Although results for statements pertaining to industry readiness ('I feel confident interacting and networking with industry professionals', 'I feel confident that I will meet the expectations of my future employer', and 'I feel confident being an advocate for my industry and/or field of study') were not significantly different between the groups, the means for both groups tended towards agreement with these statements.

Table 3.3 Means Scores for Level of Agreement to EQ Statements by Treatment and Control Groups			
Exit Questionnaire (EQ) Statements	Treatment Group**	Control Group**	P Value
I feel confident generating ideas for new products.	4.27 ± 0.70	3.61 ± 0.92	0.0025*
I feel confident collecting marketing information and conducting a market analysis.	4.08 ± 0.81	2.90 ± 0.94	<0.0001*
I feel confident developing a gold standard recipe.	4.11 ± 0.75	2.55 ± 1.03	<0.0001*
I feel confident developing a formula.	4.17 ± 0.79	2.61 ± 0.92	<0.0001*
I feel confident applying changes to a recipe or formula to make it healthier.	4.53 ± 0.51	3.58 ± 1.09	<0.0001*
I feel confident collecting commercial ingredients and/or commercial materials.	3.94 ± 0.79	2.94 ± 1.03	0.0003*
I feel confident estimating cost for a new product.	3.03 ± 1.03	2.77 ± 0.96	0.3505
I feel confident designing packaging for new products.	3.19 ± 1.17	2.94 ± 1.15	0.3916
I feel confident developing healthy food products for children.	4.53 ± 0.51	3.26 ± 1.29	0.0001*
I learn more from hands-on experiences than lectures.	4.81 ± 0.47	4.35 ± 0.71	0.0035*
I feel confident collaborating with students that are not in my major or field of study.	4.75 ± 0.55	4.16 ± 0.52	<0.0001*
I feel connected to the Food, Nutrition, and Packaging Science department.	4.81 ± 0.40	4.10 ± 0.65	<0.0001*
I feel confident interacting and networking with industry professionals.	4.00 ± 0.83	3.74 ± 0.96	0.3137
I feel confident entering industry with my current level of knowledge and skills.	3.11 ± 1.14	2.90 ± 0.87	0.5082
I feel confident that I will meet the expectations of my future employer.	4.25 ± 0.65	4.03 ± 0.60	0.1566
I feel confident being an advocate for my industry and/or field of study.	4.33 ± 0.63	4.06 ± 0.63	0.0887

*EQ responses for treatment and control groups were significantly different (α=0.05)
**1=Strongly Disagree and 5=Strongly Agree

The second section of the EQ consisted of free response questions. Treatment group students were asked to indicate their motivation for participation in the research course, how their participation affected their engagement with the department, the advantages and disadvantages of participating in the course as a sophomore-level student, the benefits (if any) of interaction with students in other majors, the benefits (if any) in terms of overall gains in knowledge, the benefits (if any) in terms of overall gains in product development experience, and suggestion for improvements to the course.

In response to motivation for participation in the course, three key themes emerged: (1) to gain knowledge in product development, healthy cooking, food industry, or other fields of study, (2) to gain hands-on experience in product development, and (3) interact with faculty and students in other majors.

In response to engagement with the department, three key themes emerged: the students were able to (1) interact with department members and students, (2) gain knowledge in other fields of study, and (3) gain hands-on experience in culinary and packaging labs.

In response to advantages of taking the course as a sophomore-level student, three key themes emerged: (1) students were able to gain experience in their own field of study and career opportunities, (2) students had the opportunity to prepare for future courses, and (3) students were able to gain a competitive advantage over other sophomore students in terms of overall knowledge.

In response to disadvantages of taking the course as a sophomore-level student, one key theme emerged: students felt they lacked prior knowledge or applicable courses.

In response to the benefits (if any) of interaction with students in other majors, two key themes emerged: the students gained (1) knowledge in other fields of study and (2) experience collaborating or working on a cross-functional product development team.

In response to the benefits (if any) in terms of overall gains in knowledge, two key themes emerged: the students gained knowledge in (1) product development process and (2) nutrition, especially children's nutrition.

In response to the benefits (if any) in terms of overall gains in product development experience, two key themes emerged: the students gained (1) knowledge in product development process, resources, and methods and (2) cross-functional and problem-solving experience.

And finally, key themes in suggestions for improvements to the course included (1) more clarity in terms of course description, goals for the course, and time commitment and (2) more information and hands-on experience in packaging science.

Table 3.4 Key Themes Found in Treatment Group Participant Responses

Key Themes	n_p	Participant Comments
Motivation for Participation		
To gain knowledge in product development, healthy cooking, food industry, or other fields of study	30	"My motivation was to learn more about packaging science, nutrition, and food science and product development." "Childhood nutrition and healthy cooking interests me greatly." "The opportunity to work with other majors/concentrations appealed to me and I'm concerned about children's health and wanted to know more about product development." "I wanted to have a better understanding of my options in this industry and build relationships with the faculty in this department."

To gain hands-on experience in product development	8	"To see what my profession might be like and to get some hands on experience working with the other emphasis options of my major." "It sounded very interesting and seemed like it would let me apply my nutrition knowledge."
Interact with faculty and students in other majors	8	"My motivation to take this course was the opportunity to work on a cross-functional team to develop a product. This experience will be valuable in the future." "I was excited to have an opportunity to work with other departments (packaging and nutrition) to formulate an idea." "I wanted to learn more about how the nutrition and food science part play into packaging."
Department Engagement		
Able to interact with department members and students	24	"I got to know faculty that connected me to the department and learned from all the guest speakers." "This course allowed me to meet various faculty members in the department and become more knowledgeable about the department as a whole." "The class has made me feel more involved because I have gotten to meet many of the faculty that I would not meet until later and I have gotten to learn from my peers."
Able to gain knowledge in other fields of study	15	"I have gotten to experience all three areas of nutrition, Culinology, and packaging. I feel like I know much more about all three areas after taking this course." "This course has made me feel more involved with the Food, Nutrition, and Packaging Science Department because this project was a weekly responsibility that gave the opportunity to be creative across the majors." "It's made me more involved by giving me more connections and showing me how other majors can intertwine with my own."
Able to gain hands-on experience in culinary and packaging labs	9	"This course has made me feel more involved because I got a lot of hands on experience through working in the kitchen and with individuals from other majors." "It has made me feel more involved by working in the research kitchen." "Being in the kitchen working on a project gave us purpose."
Advantages as a Sophomore Student		
Able to gain experience in one's own field of study and career opportunities	20	"It allowed me to see what other parts of food science I would be interested to take classes in in the future." "It helped me realize that this really is the kind of work I'd like to do as I get older." "It really got me passionate about my field and helped me

		meet faculty early on. Since I haven't taken a nutrition class yet, it helped reaffirmed for me that it's definitely something I'm interested in and I'm in the right major."
Opportunity to prepare for future courses or future application	10	"To take what I learned from the other majors and apply it to my future courses." "It gives you a better idea for future classes as well as career opportunities."
Able to gain a competitive advantage over other sophomore students in terms of overall knowledge	6	"You get more hands-on experience to the major that you would not normally get at the sophomore level." "I think I will be more prepared going into higher level courses because most sophomores can't say they've experienced working with other majors to develop a product. "As a sophomore, I had not taken many classes in the department and did not have a lot of knowledge concerning my major. This course pushed me ahead of other classmates not in this CI by introducing various key aspects about food science and nutrition."
Disadvantages as a Sophomore Student		
Lack of prior knowledge or applicable courses	24	"At this point, we are not as knowledgeable as seniors. However, taking this now allowed us to reach out to professors and others for help more easily." "As a sophomore, I hadn't taken many classes within my major so I had little to no knowledge in regards to food science and nutrition." "While it was advantageous for my standing in other classes, it was disadvantageous for my previous knowledge for this class. I came into this class knowing little about food science so it was difficult to perform well with little previous knowledge." "I did not have as much knowledge of packaging materials or experience I would have as a junior/senior."
Benefits of Interaction with Student in Other Majors		
Gained knowledge in other fields of study	25	"I liked learning from other students. I learned a lot about culinary skills, like how to cut things correctly. I also learned about nutrition and how to make our product healthier." "It helped me see what the different majors were like and it made me realize what I may be doing in the future." "I learned a little more about the other majors, what you can do with them, and how they apply to me." "We were able to teach each other what we needed to know to develop our product successfully."

Gained experience collaborating and/or working on a cross-functional product development team	24	"In real life, you have to work with all types of people and this class was a preview of that." "I learned a little about how you have to consider all aspects of product development, not just your area." "I was able to think about the product from their perspectives. For instance, adding brown sugar to a dry mix to achieve a better flavor is great from a culinary standpoint. But it's a problem as far as packaging and nutrition go." "I saw the food development process from many different angles through the students in other majors. I learned how each major contributes to creating the product." "It was nice to work with students from other majors to see their initial approaches to the same project. We all had different ideas so communication was very important when dealing with different backgrounds." "Working with students from other majors was beneficial in helping me realize the importance of other areas in product development (nutrition is not only focus). It also taught me how to collaborate with others and developed my understanding of how I can be most beneficial as a member of a group. It also allowed me to learn about other areas of this department and increased my understanding of the importance of collaboration in the real world industry.
Benefits in Terms of Overall Gains in Knowledge		
Gained knowledge in the product development process	22	"I can now say I know how to develop a product. I know how to determine if it will be successful in the market, I know some basics of packaging and I know more about nutritional requirements for children." "It has helped me learn an overview of the product development process." "I learned what it takes to develop products from ideas to the final product." "I think just be realizing that a nutritionist can't just develop a product. The nutritionist can decide what's healthy but the culinary student has to see if what's healthy is feasible and packaging student has to figure out the proper packaging and we all have to work together."
Gained knowledge in nutrition, especially children's nutrition	8	"This course has taught me a lot about children nutrition and menu items." "I learned about the food standards in school and how meals have to be prepared to meet those." "This course furthered my knowledge of nutrition and its role in food and product development."

Benefits of Course in Terms of Overall Gains in Product Development Experience		
Gained knowledge in product development process, resources, and methods	33	"I thought this course gave a great foundation to the process of product development." "Not only did we develop a product, we went to places and learned their methods." "This course helped me by showing a basic process of product development. I learned a lot about brainstorming ideas, researching the market, and trial/error." "I learned the process behind product development and how intricate and detailed it really is." "I learned about all the steps from idea generation to a nationwide product launch. I never knew there were so many steps to this process." "This course has made me confident in my abilities and understanding of product development to make me a beneficial member of a product development team in the future."
Gained cross-functional and problem-solving experience	8	"What to expect and how to overcome blocks when it comes to product development experience." "Because I went through all of the steps, I see how each piece plays an important role in the final product (marketing, food science, culinary, nutrition, packaging)."
Suggestions for Course Improvement		
More clarity in terms of course description, goals for the course, and time commitment	14	"I would change how it was advertised to students because I had no idea until the end of first semester that we would be developing a product during the second semester." "I think we were all just confused with the requirements for our product at the beginning of this semester and we didn't know what our end product was supposed to be/contain." "Maybe give a clearer explanation of what the end goals are earlier in the course." "I would devise a more concrete syllabus so that the students would know what was expected of them at every step. Also devising a timeline so that students can reach certain steps/goals throughout the semester." "I would just let the students know that a lot of time and effort goes into this project."
More information and hands-on experience in packaging science	7	"I would have liked to play a larger role in the package development, worked closer with the grad students on design, helped print our label, worked with packaging faculty about what materials to use, etc." "More packaging aspects and visit a packaging facility."

n_p: number of participants that commented on the theme

Table 3.5 shows key themes and selected excerpts from responses given by the control group. Control group students were asked to indicate their motivation for participation in the research study and how their participation affected their engagement with the department. Most control group students were motivated to participate in the study because of a desire to (1) provide assistance for department, faculty, graduate researcher, and/or research project, (2) become involved in the department and/or college, or (3) include the study as part of their resume. Although they had minimal responsibilities as a control group participant, many of these students still felt an increased sense of engagement with the FNPS Department at Clemson University because they were able to (1) contribute information for department, graduate researcher, and/or research project and (2) interact with department and faculty members responsible for coordinating the study and administering evaluation tools. This information was collected in order to better understand how control group members could be recruited and motivated to continually participate in a two-semester research project.

Table 3.5 Key Themes Found in Control Group Participant Responses		
Key Themes	n_p	Participant Comments
Motivation for Participation		
Provide assistance for department, faculty, graduate researcher, and/or research project	9	"I wanted to support the creative inquiry involved and be a part of an actual research experiment." "I like to help people out with research, because I know sometimes not many people will want to."
Involvement in the department and/or college	7	"I was looking to become involved with CAFLS and specifically the Food Science department. Participating in this study seemed like one way to do this." "Felt it would be a good opportunity to become more involved in my major."
Resume builder	7	"Being able to say you participated in a research study is good for resumes." "To build my resume for applying for dietetic internship."
Department Engagement		
Able to contribute information for department, graduate researcher, and/or research project	16	"My participation will hopefully help improve the department." "I feel that my feedback and everyone else's is vital to accurately complete studies." "I feel like I am contributing to a beneficial research project for our college." "Instead of just attending classes in this department I was able to provide some info/feedback for the department to work with."
Able to interact with department and faculty members	9	"The study has made me feel more involved within the department because I have gotten the opportunity to meet with professors and staff." "I've done more than just go to class and I've met some people in the department that I wouldn't have." "It has given me a chance to get to know the faculty."

n_p: number of participants that commented on the theme

Student Satisfaction Inventory (SSI)

The SSI evaluates a student's level of importance and resultant satisfaction with various aspects of their college or university experience, as well as the gap that exists between the two parameters. Therefore, the questions were not specific to the AIPD course. The results of the SSI were independently analyzed by Noel-Levitz higher education consulting in Coralville, Iowa. The items in the SSI were grouped into 12 categories; academic advising, campus climate, campus life, campus support services, concern for the individual, instructional effectiveness, recruitment and financial aid, registration effectiveness, responsiveness to diverse populations, safety and security, service excellence, and student centeredness. Only the categories of concern for the individual and instructional effectiveness were utilized for this research project. For each category, an analysis was conducted to compare the pre- and post-responses of the treatment group, as shown in Tables 3.6 and 3.7.

For the analysis, the difference in the level of satisfaction between the pre- and post-SSI for each item was evaluated in order to determine if a significant difference existed ($\alpha = 0.05$). The only significant difference that existed was in the category of institutional effectiveness. The level of satisfaction of the item "The instruction in my major field is excellent." was significantly lower in the post-response than the pre-response. Again, the SSI is meant as an evaluation of the entire university (or in this case, the entire department), not exclusively to the AIPD course.

Table 3.6 Comparison of Responses of the Treatment Group in the Category of Concern for the Individual					
Statement/Item	Pre-SSI		Post-SSI		Mean Difference
	Importance	Satisfaction	Importance	Satisfaction	
Overall Concern for the Individual	6.42	5.64	6.48	5.65	0.01
Faculty care about me as an individual.	6.36	5.44	6.54	5.68	0.24
My academic advisor is concerned about my success as an individual.	6.39	5.61	6.51	5.59	-0.02
Counseling staff care about students as individuals.	6.42	5.40	6.49	5.41	0.01
Faculty are fair and unbiased in their treatment of individual students.	6.61	5.58	6.65	5.62	0.04
Residence hall staff are concerned about me as an individual.	6.15	5.70	6.06	5.63	-0.07
The institution shows concern for students as individuals.	6.58	6.08	6.57	5.97	-0.11

*Responses for satisfaction were significantly different (α=0.05)

Table 3.7 Comparison of Responses of the Treatment Group in the Category of Instructional Effectiveness					
Statement/Item	Pre-SSI		Post-SSI		Mean Difference
	Importance	Satisfaction	Importance	Satisfaction	
Overall Instructional Effectiveness	6.61	5.95	6.57	5.82	-0.13
Faculty care about me as an individual	6.36	5.44	6.54	5.68	0.24
The content of the courses within y major is valuable.	6.78	6.11	6.89	5.89	-0.22
The instruction in my major field is excellent.	6.78	6.09	6.73	5.50	-0.59*
Faculty are fair and unbiased in their treatment of individual students.	6.61	5.58	6.65	5.62	0.04
I am able to experience intellectual growth here.	6.69	6.42	6.59	6.24	-0.18
There is a commitment to academic excellence on this campus.	6.69	6.44	6.70	6.30	-0.14
Faculty provide timely feedback about student progress in a course.	6.67	5.28	6.51	5.03	-0.25
Faculty take into consideration student differences as they teach a course.	6.25	5.39	6.27	5.30	-0.09
The quality of instruction I receive in most of my classes is excellent.	6.64	6.08	6.57	5.95	-0.13

Adjunct faculty are competent as classroom instructors.	6.34	5.91	6.33	5.79	-0.12
Faculty are usually available after class and during office hours.	6.67	6.19	6.51	6.19	-0.00
Nearly all of the faculty are knowledgeable in their field.	6.75	6.17	6.54	6.16	-0.01
There is a good variety of courses provided on the campus	6.74	6.56	6.62	6.30	-0.26
Graduate teaching assistants are competent as classroom instructors.	6.58	5.58	6.57	5.57	-0.01

*Responses for satisfaction were significantly different (α=0.05)

Discussion

Subject Knowledge Assessment (SKA)

The results of the SKA were mostly consistent with expectations. The MDV were significantly different between the treatment and control groups in the overall score and in every subject score area except packaging science. Although the MDV for both groups in this subject area was not significantly different, both groups showed improvement in packaging science knowledge. By the end of their sophomore year, packaging science students will have taken six courses in the department, many of which include experiential elements such as labs. It is possible that the packaging science information that was presented as part of this course was reiterative and therefore did not yield a

significant increase in the packaging science knowledge of the treatment group over the control group, especially those enrolled in packaging science. The relatively small proportion of packaging science students in both groups (and the small total sample size) may have played a role in the level of packaging science knowledge as well.

Although nutrition and Culinology® students gained competency in packaging subject knowledge through the AIPD course, they are cognizant of the limitations of their knowledge, even at the conclusion of the course. Many were aware that they were not yet fully competent in the packaging science component of product development.

The greatest increase in mean score occurred in the food science subject by the treatment group. In this same subject area, the only negative MDV was observed in the control group score. By the end of the sophomore year, food science students will, at most, have taken three classes within the department. Some food science participants in the treatment group stated that they had no prior courses focused on nutrition or Culinology®. For them, this course served as an introduction to both subject areas as well as packaging science.

The second greatest gap in MDV occurred in the general knowledge subject area. This section included questions specific to product development. The product development courses currently offered in the FNPS department are offered at the junior- and senior-level. For students in both majors, the course served as an introduction to the product development, which could explain the substantial gap in MDV between the treatment and control groups.

Exit Questionnaire (EQ)

The EQ consisted of two sections. In the first section (quantitative), participants were asked to indicate their level of agreement (where 1 = "strongly disagree" and 5 = "strongly agree") with statements pertaining to product development knowledge and skills, pedagogy, department engagement, and industry readiness. The second section (qualitative) consisted of free response questions pertaining to various aspects of the course design and implementation.

In the first section, the mean scores between the treatment and control groups were significantly different in seven of the nine statements pertaining to product development knowledge and skills, both statements pertaining to pedagogy, and the statement pertaining to department engagement. The treatment group exhibited the greatest level of agreement with the statement "I feel connected to the Food, Nutrition, and Packaging Science department." However, the response level for both groups tended toward agreement to this statement.

The lowest level of agreement was observed in three statements: "I feel confident estimating cost for a new product," "I feel confident entering industry with my current level of knowledge and skills," and "I feel confident designing packaging for a new project." In the case of the first statement, cost analysis of a commercial formula was a topic that was introduced but not required as part of the final product. In the case of the second statement, it was expected that sophomores would not be fully prepared to enter industry. However, it was believed that these students would feel confident beginning an

internship or co-op in industry. In the case of the third statement, the lack of confidence and knowledge gained in packaging science was a theme throughout the results.

The greatest gap between the level of agreement of the treatment and control groups occurred with the statements "I feel confident developing a gold standard recipe" and "I feel confident developing a formula," which reflected success in the project goal to increase self-efficacy of students' skills associated with product development. Overall, the level of agreement of control group tended toward neutrality for many of the statements.

The second section of the EQ provided meaningful insights into the course design and implementation. Treatment group participants gleaned a substantial amount of knowledge in the areas of product development, childhood nutrition, and the research process. However, many students did not deem the amount of packaging science that was incorporated into the curriculum and activities as sufficient.

The response to working in interdisciplinary teams was exceptionally positive. In general, students embraced the two-semester course format and experiential elements. Some students commented on the desire for more structure, greater clarity in objectives, and well-defined deadlines for each portion of the final project. To provide such structure would be counter intuitive to the inquiry-based experiential learning structure. The aim of this type of learning is to allow the students to define their own path in order to solve a problem or address a scenario.

It was very revealing to observe the overwhelming number of control group students that were motivated to participate in the research project because of a genuine

desire to provide assistance and information for the sake of research. It is encouraging to see students in the agricultural field actively supporting research without compensation. Many control group participants also felt a greater sense of engagement with the department through interaction with the graduate researcher and the faculty members conducting the research.

Student Satisfaction Inventory

The SSI gauges a student's level of importance and resultant satisfaction with various aspects of their college or university experience, as well as the gap that exists between the two parameters. The SSI consists 73 of these types of questions, each of which the student is required to answer twice (once for importance and once for satisfaction). The only response that was significantly different between the treatment and control groups was the level of satisfaction with the quality of instruction in the student's major field of study. The treatment group was significantly less satisfied with this element of their university experience. These results appear to be in disagreement with results of the EQ. However, the SSI references the quality of instruction in the student's major field of study while the EQ references level of student engagement with the FNPS department.

This evaluation tool addresses various aspects of the entire university experience, which made the SSI too broad to be notably valuable. Only a select number of questions could be directly applied to the evaluation of pedagogy and engagement facets of this research project. The period between the pre- and post-SSI was relatively short compared

to the period between evaluations when this same SSI is utilized by Clemson University. This, as well as traits characteristic of the "sophomore slump" (disengagement, dissatisfaction with the collegiate experience, developmental confusion, major and career indecision, and failure to meet academic progress expectations) may have attributed to the similarity in pre- and post-responses.

Survey fatigue (or over-surveying) occurs when a participant becomes overwhelmed with the number of questions, which can cause decline in the quality of the participant responses. Survey fatigue was a serious concern for this evaluation tool because of the number of responses the participants were asked to provide. An abbreviated version of this evaluation tool may have proven more effective at gauging student satisfaction and importance with components more closely aligned with the AIPD course design and implementation.

The SSI was primarily used because of a commitment to the USDA to use this evaluation tool as part of the overall grant project. It will be employed again as the treatment participants approach graduation. The analysis will then be repeated to further understand how participation in the research project has affected student satisfaction in the categories of concern for the individual and instructional effectiveness. Other categories assessed by the SSI (academic advising, campus climate, campus life, campus support services, recruitment and financial aid, registration effectiveness, responsiveness to diverse populations, safety and security, service excellence, and student centeredness) may also be utilized as the USDA grant project continues. Information gleaned in these categories may provide additional clarification on the importance of certain aspects of the

university experience as well as further elaborate on possible improvements undergraduate satisfaction of experiential learning techniques.

Limitations

Limitations for this research included attendance, time constraints, and the varying degree of student motivation for the class and the project. Although the attendance for the class was considered adequate, treatment group participant suggestions for activities that were in fact part of the curriculum indicated that the student most likely missed that particular class. Attendance was included as a portion of the final grade but may not have been incentive enough to improve attendance. The students convened once a week in a classroom and every other Friday for out-of-classroom activities or to work in the culinary lab. Where some students found the time commitment to be overwhelming others requested additional lab time to work on their projects, which indicated variation in motivation and commitment to the success of the final project. This variation was attributed to the specific learning style and overall attitude of the student.

Conclusions

This course utilized inquiry-based experiential learning to engage sophomore-level students in undergraduate research and the product development process. Interdisciplinary teams of students were able to directly apply nutrition, culinary, and packaging science knowledge and skills as they developed healthy products for children.

Overall, the research project was considered a successful intervention for engaging sophomores in the FNPS department at Clemson University. The evaluation tools generally supported the conclusion that the AIPD course provided the students an opportunity to learn more about department capabilities, interact with faculty members, and learn skills pertaining to the development of healthy products for children.

Recommendations

When adapting the curriculum for dissemination to other universities for use in their agriculture and food science programs, it is suggested that the AIPD course outline, curriculum, and lectures undergo review for continuous improvement. Additional emphasis is suggested for food packaging information and activity integration.

There are opportunities for improvement of the evaluation tools. Additional evaluation tools or modification of existing evaluation tools to better measure student motivation to exceed the basic requirements of the course (i.e. class and lab time, minimum project requirements) could provide insight into how better engage students in experiential learning. Consistent format, proportion of subject area questions, and the total number of questions in the SKA are all features that can be optimized. Many evaluation tools are employed throughout the course of this grant research project. As mentioned, survey fatigue is a concern for the participants. A break between surveys or separation of surveys into different class periods is recommended as means to maintain the integrity and quality of responses.

LIMITATIONS

Various limitations were observed throughout the research project. Overall, there were 68 participants, 37 in the treatment group and 31 in the control group. A larger random sample of sophomore students in the FNPS department is desirable over the smaller convenience sample that was recruited. Furthermore, the distribution of the majors for both groups was skewed toward food science students with an emphasis in nutrition, which may have played a role in the evaluation tool results.

Resource availability in terms of commercial processing equipment, bench top tools, and professional scientific laboratory instruments occasionally limited student project scope. As the needs of undergraduate students expand, resource availability will also require expansion. On occasion, a desired piece of equipment existed within a laboratory in the department but was unavailable to treatment group participants.

Although some faculty members periodically participated as subject matter consultants for the treatment student groups, a goal is to include the majority of department faculty in this effort. Because of the periodic development of new initiatives (such as this one), it can become difficult for faculty members to balance support of innovative and existing programs.

The AIPD course was team taught by three faculty members from the FNPS department. Team teaching carries its own set of challenges. Coordinating the schedules and time commitments of all faculty members was difficult. Maintaining a consistent level of engagement from all faculty members during lectures and student activities was

not always achieved (especially during class periods that did not directly apply to a faculty member's subject area or research interest). Some type of consistency, whether it's the presence of a faculty member or graduate mentor, can provide a sense of stability for the students throughout the two-semester course.

The food science and technology degree program in the Food, Nutrition, and Packaging Science department at Clemson University is accredited by both the Institute of Food Technologists (IFT) and the Academy for Nutrition and Dietetics (AND). The Culinology® emphasis track is also approved by the Research Chefs Association (RCA). The requirements of these trade organizations can limit the extent of change in existing courses or addition of innovative courses without the need for review of the accreditation. Where some students found the time commitment to be overwhelming others requested additional lab time, especially during the second semester product development. This indicated a variation in motivation and commitment by the individual students. The level of buy-in of the students was directly linked to the success of the final product. Beyond engagement in the AIPD course, it has been hypothesized that the generational gap between millennial students and farm life has caused a growing disinterest with the agricultural sciences in general. As we as a society begin reconnect with our agricultural roots (largely attributed by farm-to-table initiatives), it is hoped that the engagement of undergraduate students with food and agricultural sciences will increase.

CONCLUSIONS

At the onset of the research project, six key outcomes for the treatment students were outlined for this research project: (1) increases in discipline knowledge as measured by the subject knowledge assessment, (2) higher levels of employment and employee satisfaction of project participants as compared to other alumni of the FNPS department, (3) increases in critical thinking, reading, writing, and mathematic skills of the project participants, (4) hone communication and presentation skills, (5) increased level of student engagement in the FNPS department, and (6) increases in positive experiential learning leading to higher levels of student satisfaction and industry readiness. Five of these six outcomes were observed during this initial phase of the research project. The second outcome will be measured after the students complete their undergraduate degree. Many of these outcomes were measured through participant responses to the Exit Questionnaire (EQ). Additionally, the EQ provided insights pertaining to the success of the pedagogical techniques as well as the efforts to increase student engagement with the FNPS department. Another evaluation tool, the Subject Knowledge Assessment (SKA), denoted the substantial growth in food science subject knowledge and knowledge of the product development process as well as improvements in packaging science subject knowledge. These positive outcomes indicated the success of AIPD as an innovative interdisciplinary pedagogy for engaging students in food and agricultural sciences and as a means to increase undergraduate skills pertaining to the product development process.

The project offers a unique and modern approach to curriculum that combines hands-on learning, analytical thinking, as well as faculty and industry engagement while interweaving several individual fields of study. The potential impact of this research project is not only on a localized educational front but also flows into industry and eventually to consumers, creating a domino effect to help in the fight again childhood obesity. Direct effects of this research study on undergraduates will increase student readiness for internships and co-ops and successively augment the effectiveness of the next generation of leaders in the food and agricultural industry.

Strengths of this AIPD course were high retention/course completion rates, high overall student satisfaction, and innovative food products created by the student groups. Because of the longevity of the course, instructors had a greater vested interest in the educational success of the students. The collective support for students over a period of two semesters increased the students' sense of value to faculty and the FNPS department. Some success can also be attributed to the peer mentorship and consistent presence of the graduate researcher. The integration of technology, particularly computer programs associated with graphic design, provided an additional means of engagement through experiential learning. The active collaboration between the department and local school districts assists in the project goals.

The knowledge gleaned through this research project will extend beyond the walls of the FNPS department and Clemson University. Outcomes of this research will be of significant interest to professional organizations such as the Research Chefs Association (RCA), the Institute of Food Technologists (IFT) and the North American Colleges and

Teachers of Agriculture (NACTA). Information pertaining to elements of this research project has already been presented at annual conferences for RCA, NACTA, and FNCE. Dissemination of the successful pedagogy and lessons learned through this research project will continue to be presented in the coming years.

RECOMMENDATIONS

As this phase of the USDA HEC grant draws to a close, lessons learned can be applied to subsequent goals and key deliverables. Of these deliverables is the creation of a replicable framework of the AIPD course curriculum that may be utilized by other universities and agricultural education programs. As the pedagogy and curriculum of the AIPD course are transitioned into an online format, it will be important to find ways to maintain elements of experiential learning. Tools available through eLecture presentation programs such as Adobe Presenter™ can increase engagement of the distance learner. It may not be possible to retain elements of hands-on, interdisciplinary teamwork. However, retaining elements of interdisciplinary teaching is an achievable goal. As other universities begin to employ these online learning tools, there will be an additional opportunity to learn from their trials and best practices. These lessons learned can then be applied to further enhance curriculum for the AIPD course at Clemson University as well as other programs.

As undergraduates, it was well understood that students participating in this research study would not yet possess thorough knowledge of their chosen academic field. Stronger introductions to each of the subject areas are recommended. It was a tendency of the student groups to delegate tasks based on major field of study. More thorough initial introduction for each subject area may lead to greater student self-efficacy in subject areas outside of a student's major. Thus, when it comes time to delegate tasks, it is recommended that students at minimum attempt tasks in other disciplines.

Self-efficacy of the students in terms of presentation and communication skills is another area that has an opportunity for improvement. Focus on Creative Inquiry (FoCI) is an annual research symposium that provides undergraduate students at Clemson University with opportunity to present research findings and interact with other undergraduate researchers. More supported efforts can be made to send undergraduate students to conferences in order to present and advocate for their research. Additionally, directing students to culinary arts institutions to introduce culinary students and educators to the product development process will give the undergraduate student an opportunity to advocate for the food science industry as well as introduce potential Culinology® students to research and development. Partnership between Clemson University and culinary programs in the South Carolina upstate area is now even more possible because of the recent implementation of the Creative Inquiry program at Greenville Technical College (GTC). An opportunity may now exist to create a collaborative Creative Inquiry course between Clemson University and GTC that may lead to a stronger partnership between the two schools as well as enhancement of the recruitment pipeline.

A noteworthy opportunity also exists for industry partners to become more involved in undergraduate research. This enhanced partnership has the potential to be mutually beneficial. Undergraduate students will have the opportunity to work on real world scenarios and products, which may include additional funding. The student will also be able to apply this experience to subsequent internships and co-ops. Industry partners will have an opportunity to become greater stakeholders in undergraduate

education beyond the typical role of an advisory board member. Therefore, they will have a stronger vested interest in the student's success and potential as a future employee.

APPENDICES

Appendix A

Participant Consent Form for Treatment Group

Consent Form for Participation in Research
Clemson University
Culinology, Nutrition and Packaging in Undergraduate Applied Research

You are invited to participate in a research study conducted by Margaret Condrasky. The purpose of this research is to learn more about student knowledge, cultural competency, experience, attitude, critical thinking and problem-solving skills gained in a two course sequence. Members will include Food, Nutrition, and Packaging Science students who will work together on industry-driven lab activities.

Your participation will involve answering questions on standard University questionnaires that you take routinely; allowing the researchers to use all work completed during or for the course; as well as program specific items collecting the kinds of information described above. These program specific items may include surveys, audiorecorded focus group discussions, or videorecorded group interactions. Data will be collected over the course of the two-semester course sequence and at graduation time. Additionally, FNPS faculty who have taught you during your program of study will be asked to complete a survey about you at the end of the project. All research materials will be kept indefinitely for research purposes.

There are no known risks associated with this research, however it may be that answering some of the questions on the forms may seem personal. You do not need to answer any question which makes you feel uncomfortable. Your responses will help us understand the potential benefits of this new two-course sequence to students in the department

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. Your name will not appear on the surveys. The only people who will be able to see your answers to the questions will be the people conducting the research and those who oversee the way that Clemson University does research. Your confidentiality will be ensured by our locking of all materials in a file and destroying the forms at the conclusion of the project.

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. However, since the research study is an integral part of this course sequence, you will have to drop the course in order to stop taking part in the study. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study. If you decide not to take part or to stop taking part in this study, it will not affect your relationship with FNPS or your grades in any way (except that dropping the course will affect your grade for this course according to University policies on dropping courses).

If you have questions or concerns about this study or if any problems arise, please contact Margaret Condrasky at Clemson University mcondra@clemson.edu at 864-656-6554. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board irb@clemson.edu at 864-656-6460.

Consent

I have read this form and have been allowed to ask any questions I might have. I agree to take part in this study.

Participant's signature: _____ Date: _____

A copy of this form will be given to you.

Figure A-1: Consent form for treatment group participants

Appendix B

Participant Consent Form for Control Group

Consent Form for Participation in Research
Clemson University
Culinology, Nutrition and Packaging in Undergraduate Applied Research Control

You are invited to support a research study conducted by Margaret Condrasky as a control participant member. The purpose of this research is to learn more about student knowledge, cultural competency, experience, attitude, critical thinking and problem-solving skills during the program of study in the Food, Nutrition and Packaging Sciences Department.

Your participation will involve answering questions on standard University questionnaires that you take routinely; well as program specific items over the course of the program and at graduation time. These materials will be kept indefinitely for research purposes.

There are no known risks associated with this research, however it may be that answering some of the questions on the forms may seem personal. You do not need to answer any question which makes you feel uncomfortable. Your responses will help us understand the potential benefits to students in the department

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. Your name will not appear on the surveys. The only people who will be able to see your answers to the questions will be the people conducting the research and those who oversee the way that Clemson University does research. Your confidentiality will be ensured by our locking of all materials in a file and destroying the forms at the conclusion of the project.

If you have questions or concerns about this study or if any problems arise, please contact Margaret Condrasky at Clemson University mcondra@clemson.edu at 864-656-6554. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board irb@clemson.edu at 864-656-6460. Sign and return this consent form to participate in the study.

Signature: _____ Date: _____

Figure B-1: Consent form for control group participants

Appendix C

Subject Knowledge Assessment (SKA)

Name _____

Please select the best answer for the following multiple choice and True/False items.

1. Which has the highest amount of monounsaturated fat?
   a. Corn
   b. Canola
   c. Fish
   d. Palm
   e. Olive

2. The USDA's recommended portion size for a single serving of meat for the average 8 year old is?
   a. 2 to 4 ounces
   b. 5 to 7 ounces
   c. 6 to 9 ounces
   d. Less than 10 ounces

3. A majority of sodium in the American diet comes from:
   a. Eating out
   b. Adding salt at the table (salt shaker)
   c. Processed packaged foods
   d. Naturally found in foods

4. Which of the following is a better alternative to table salt for sodium reduction?
   a. Sea salt
   b. Kosher salt
   c. Non-iodized salt
   d. None of the above

5. Which of the following is a major source of saturated fat in children's diets?
   a. Full-fat dairy products
   b. Sugary cereals
   c. Peanut butter
   d. All of the above

6. Which of the following is a good source of iron in children's diets?
   a. Beans
   b. Leafy green
   c. Eggs
   d. All of the above

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7. Children should acquire an assortment of which of the following nutrients?
    a. Carbohydrates, proteins, fats, vitamins and minerals
    b. Carbohydrates, proteins, vitamins and minerals
    c. Carbohydrates, vitamins, minerals and fiber
    d. None of the above

8. Which of the following menus best emphasizes the addition of dark green and dark orange vegetables as well as whole grains to children's menus?
    a. Chicken tenders in a seasoned almond and whole-wheat flour crust and oven-fried with a side of sweet potato fries
    b. Fettuccine alfredo made with whole-wheat fettuccine and matchstick slices of zucchini with a sprinkling of sweet peas
    c. Whole-wheat pizza dough coated in a flavorful tomato sauce with added pumpkin puree and low-fat turkey pepperoni, spinach and cheese
    d. All of the above

9. Fats have more than twice the amount of calories in one gram than protein or carbohydrates.
    a. True
    b. False

10. Total daily fat intake should make up approximately what percentage of total calories?
    a. 5%
    b. 15%
    c. 25%
    d. 40%

11. You are asked to join a group of students to evaluate a new product developed for the purpose of increasing the consumption of fiber. The students are asked to give their opinion on this new product. What type of panel have you been asked to participate on?
    a. A descriptive panel
    b. A discriminative panel
    c. An affective panel

12. A market analysis would be found in the following:
    a. A business plan
    b. A business proposal
    c. A marketing plan
    d. All of the above

13. A gold standard is the same as a formula.
    a. True
    b. False

14. When writing a technical report the first person voice should be used.
    a. True
    b. False

15. The order for which product development should occur is:
    a. Testing, prototype, launch
    b. Market analysis, prototype, testing
    c. Testing, market analysis, launch
    d. Market analysis, development, testing

16. The primary product packaging material holds/touches the food product.
    a. True
    b. False

17. The secondary product packaging material holds/touches the food product.
    a. True
    b. False

18. When testing the shelf stability of a new food product the two main tests to consider are pH and texture.
    a. True
    b. False

19. A trend in food design and development is to provide for gluten free products which exclude:
    a. Rice, corn, and rye
    b. Wheat, rye, and barley
    c. Buckwheat, corn, and barley

20. Nutrition labeling/claims are created by the manufacturer to suit the product and package.
    a. True
    b. False

21. An entrée created for a vegan diner may contain:
    a. Cheese and nuts
    b. Seafood and greens
    c. Nuts and seeds
    d. Cheese but no meat
    e. Meat and Fruit

22. A functional product development team includes members from each of:
    a. Marketing, R & D, company president
    b. Operations, marketing, R & D
    c. Company president, marketing, sales

23. Marketing analysis is
    a. Completed by the president of a company to get heads up
    b. Expensive thus not necessary
    c. Completed early in the product development process

24. A peer review manuscript is one that is passed to colleagues for review and editing prior to submission to a journal
    a. True
    b. False

25. More than one may be true: Which of the following are common primary functions of food packaging?
a. Contain the product
b. Assist in dispensing of the product
c. Prevent consumer access to the product
d. Preserve the product
e. Promote world peace through the product
f. Communicate about the product
g. Keep the product from harming the environment

26. More than one may be true: Which of the following are the broad classes of materials available for packaging?
a. Metals
b. Tin
c. Glass
d. Composites
e. Corrugated
f. Ceramics
g. Polyethylene
h. Plastics

27. Pick the best answer: What is a transmission rate?
a. Measure of how long perishable foods will last in a package
b. Measure of efficiency of my car
c. Measure of how fast a material will travel through a package wall
d. Measure of how fast the sun's rays get here in vacuum
e. Measure of the time from packaging a food product until it reaches the consumer

28. More than one may be true: Which of the following are true of FDA and food packaging?
a. FDA does not care about packaging, as it is neither a food nor a drug
b. FDA has the authority to regulate food packaging
c. FDA approves packaging materials to be in food contact
d. FDA harasses packaging producers because they are big government
e. FDA does not approve packaging; they just set the regulations and measure against them
f. FDA has a mission to protect food consumers, so they are interested in food packaging

29. Pick one: In which class of material is aluminum can (predominantly)?
a. Metals
b. Tin
c. Glass
d. Composites
e. Corrugated
f. Ceramics
g. Polyethylene
h. Plastics

30. Pick one: In which class of material is a flexible tune pouch (predominantly)?
a. Metals
b. Tin
c. Glass
d. Composites
e. Corrugated
f. Ceramics
g. Polyethylene
h. Plastics

31. One or two sentences: You develop a product to be flavorful and nutritional, and to fight childhood obesity. It makes a big splash on the market. After it is on the market for 6 months, a television news show reports that they tested your product and found that some nutrient levels are half of what the label reports. What might have happened? If you have no idea, state so.

Use this for short answer questions 32 to 34. You test a product in two packages. One is metalized. The other has a clear, high oxygen barrier. The product is attractive, so your Marketing team prefers the clear package. After a shelf-life test, product testing shows the following:

Package / Time	Flavor	Vitamin A levels	Product softness
None / Fresh	Excellent	100 % RDA	Excellent
None / 3 months	Very rancid	10 % RDA	Hard
Metalized / 3 months	Somewhat rancid	90% RDA	Good
Clear / 3 months	Somewhat rancid	50% RDA	Hard

32. What does migration mean with respect to packaging and why is it important to food scientists, nutritionists and culinary scientists? If you have no idea, state so.

33. What does scalping mean with respect to packaging and why is it important to food scientists, nutritionists and culinary scientists? If you have no idea, state so.

34. Why do we see a difference in product softness between the metalized and clear barriers? If you have no idea, state so.

Short answer items continued:

35. How would you describe sensory evaluation?

36. Why is it important to consider the panelist when conducting a sensory test?

37. What are the elements of a scientific article?

38. Why is statistics important in sensory evaluation?

39. If you were asked to conduct a sensory panel, what would be your first three steps?

40. How would you define a peer-reviewed article?

41. When conducting scientific research, what steps should be followed?

42. What are some of the tools that can be used for marketing research?

43. What are the components of a formula?

44. Product formulation is required to assist the developer in what areas?

45. What are the activities/components within the product formulation process?

Subject Area Categories for Subject Knowledge Assessment (SKA) Questions	
Question	Subject Area
Which has the highest amount of monounsaturated fat?	Nutrition
The USDA's recommended portion size for a single serving of meat for the average 8 year old is?	Nutrition
A majority of sodium in the American diet comes from:	Nutrition
Which of the following is a better alternative to table salt for sodium reduction?	Nutrition
Which of the following is a major source of saturated fat in children's diets?	Nutrition
Which of the following is a good source of iron in children's diets?	Nutrition
Children should acquire an assortment of which of the following nutrients?	Nutrition
Which of the following menus best emphasizes the addition of dark green and dark orange vegetables as well as whole grains to children's menus?	Nutrition
Fats have more than twice the amount of calories in one gram than protein or carbohydrates.	Nutrition
Total daily fat intake should make up approximately what percentage of total calories?	Nutrition
You are asked to join a group of students to evaluate a new product developed for the purpose of increasing the consumption of fiber. The students are asked to give their opinion on this new product. What type of panel have you been asked to participate on?	Food Science
A market analysis would be found in the following:	General
A gold standard is the same as a formula.	Food Science
When writing a technical report the first person voice should be used.	General
The order for which product development should occur is:	Food Science
The primary product packaging material holds/touches the food product.	Packaging
The secondary product packaging material holds/touches the food product.	Packaging
When testing the shelf stability of a new food product the two main tests to consider are pH and texture.	Food Science
A trend in food design and development is to provide for gluten free products which exclude:	Nutrition
Nutrition labeling/claims are created by the manufacturer to suit the product and package.	Nutrition
An entrée created for a vegan diner may contain:	Nutrition
A functional product development team includes members from each of:	Food Science
Marketing analysis is	General
A peer review manuscript is one that is passed to colleagues for review and editing prior to submission to a journal	General
More than one may be true: Which of the following are common primary functions of food packaging?	Packaging Science
More than one may be true: Which of the following are the broad classes of materials available for packaging?	Packaging Science
Pick the best answer: What is a transmission rate?	Packaging Science
More than one may be true: Which of the following are true of FDA and food packaging?	Packaging Science
Pick one: In which class of material is aluminum can (predominantly)?	Packaging Science
Pick one: In which class of material is a flexible tune pouch (predominantly)?	Packaging Science

Appendix D

Exit Questionnaire (ES) for Treatment Group

Name: _____

Exit Questionnaire

Over the past two semesters, you have participated in a research project as either a test subject or a control subject. This survey will be used to evaluate your experience. Please thoughtfully and honestly respond to the following short answer and multiple-choice questions.

Basic Information

Major:

Please check one box for each of the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel confident generating ideas for new products.					
I feel confident collecting marketing information and conducting a market analysis.					
I feel confident developing a gold standard recipe.					
I feel confident developing a formula.					
I feel confident applying changes to a recipe or formula to make it healthier.					
I feel confident collecting commercial ingredients and/or commercial materials.					
I feel confident estimating cost for a new product.					
I feel confident designing packaging for new products.					
I feel confident developing healthy food products for children.					
I learn more from hands-on experiences than lectures.					
I feel confident collaborating with students that are not in my major or field of study.					
I feel connected to the Food, Nutrition, and Packaging Science department.					
I feel confident interacting and networking with industry professionals.					
I feel confident entering industry with my current level of knowledge and skills.					
I feel confident that I will meet the expectations of my future employer.					
I feel confident being an advocate for my industry and/or field of study.					

Please answer the following questions with 1-2 sentences:

1. What are your career goals? (Ex: job title and/or description, industry, company)

2. What was your motivation to take this course?

3. Has this course made you feel more or less involved in the Food, Nutrition, and Packaging Science Department? How so?

4. What was your class standing at the time you began this course? (i.e. freshman, sophomore, junior, senior)

5. What were the advantages of taking this course at that class standing?

6. What were the disadvantages of taking this course at that class standing?

7. What were you expecting to learn from this course?

8. Were your expectations met?

9. What activity or activities did you learn from the most during the first semester? Please list both the activity and what you learned.

10. What activity or activities did you learn from the most during the second semester? Please list both the activity and what you learned.

11. In what ways, if any, did you benefit from working with students from other majors?

12. How has this course helped you in terms of overall gains in knowledge?

13. How has this course helped you in terms of cultural competency?

14. How has this course helped you in terms of product development experience?

15. How has this course helped you in terms of critical thinking and/or problem-solving skills?

16. What changes, if any, would you make to this course?

Appendix E

Exit Questionnaire (ES) Control Group

Name: _____

Exit Questionnaire

Over the past two semesters, you have participated in a research project as either a test subject or a control subject. This survey will be used to evaluate your experience. Please thoughtfully and honestly respond to the following short answer and multiple-choice questions.

Basic Information

Major:

Please check one box for each of the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel confident generating ideas for new products.					
I feel confident collecting marketing information and conducting a market analysis.					
I feel confident developing a gold standard recipe.					
I feel confident developing a formula.					
I feel confident applying changes to a recipe or formula to make it healthier.					
I feel confident collecting commercial ingredients and/or commercial materials.					
I feel confident estimating cost for a new product.					
I feel confident designing packaging for new products.					
I feel confident developing healthy food products for children.					
I learn more from hands-on experiences than lectures.					
I feel confident collaborating with students that are not in my major or field of study.					
I feel connected to the Food, Nutrition, and Packaging Science department.					
I feel confident interacting and networking with industry professionals.					
I feel confident entering industry with my current level of knowledge and skills.					
I feel confident that I will meet the expectations of my future employer.					
I feel confident being an advocate for my industry and/or field of study.					

Please answer the following questions with 1-2 sentences:

1. What are your career goals? (Ex: job title and/or description, industry, company)

2. What was your motivation to participate in this research study?

3. Has your participation as a control group student in this research study made you feel more or less involved in the Food, Nutrition, and Packaging Science Department? How so?

4. What was your class standing at the time you began this study? (i.e. freshman, sophomore, junior, senior)

5. What were the advantages of participating in this study at that class standing?

6. What were the disadvantages of participating in this study at that class standing?

7. What changes, if any, would you make to this research study and how it was conducted?

Additional Comments:

Appendix F

Group Project Rubric

Group Project

The goal of this project is to combine all of the ideas and knowledge that you gained in the first semester of this course. We really want you to make this project your own. If you are interested in foodservice, you can design a new menu or dish. If you are interested in retail, you can develop a new product. If you are interested in utilizing a new type of packaging that could enhance the nutritional properties of a food product, try it! Explore a new concept, venture into uncharted territory, and learn something. Now is the time to try something different and innovative (rather than in industry when real money is at stake). Remember, your project must address childhood nutrition and the obesity epidemic.

Grading Rubric for Final Report

20 points – Nutritional profile
- How you addressed childhood nutrition and the obesity epidemic
- Nutrition Facts panel
- Ingredient declaration
- Allergens
- Health claims

20 points – Demonstration of culinary skill
- Visual appeal, flavor, texture
- Gold standard recipe
- Commercial formulation
- Presentation
- Photo of final product

20 points – Packaging
- This will vary depending on the project
- Photo of mock packaging and graphics

10 points – Focus group or sensory panel

10 points – Market analysis
- Demand
- Market environment, including competition

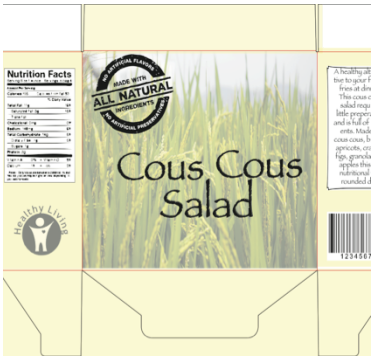
10 points – Innovative and original concept

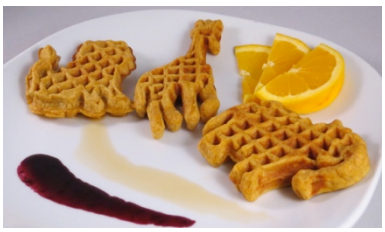
10 points – Technical writing skills
- Scholarly and peer reviewed sources
- Written formally, in the third person

At the end of the semester, you will submit a written report and give a group presentation (along with samples) of your product.

Appendix G

Student Product Descriptions, Photographs, and Packaging Graphics

Description	Product	Packaging
Cous Cous Salad: Whole wheat cous cous, blugar, fig, apricot, cranberry, apple, and granola salad dressed with mayo, honey, and yogurt		
Tiger Toppings, Black Bean Crumbles: Vegetarian black bean and textured vegetable protein pizza topping crumbles		
Sweet Potato Bread: Lightly spiced sweet potato bread with shredded carrot and zucchini.		

Veggie Pretzel Crisp: Tomato flavored pretzel crisps with an Italian style cream cheese dip.		
Supernova Scones: Star-shaped kale, sweet potato, and white whole wheat scones with clove and nutmeg.		
Unwrap-a-bowls, Fiesta de Vegetales: Quinoa and black bean mixture topped with a tomato-corn salsa and garnished with lettuce, shredded cheese, and crushed tortilla chips.		
Zooffles: Sweet potato, carrot, and apple sauce waffles with blueberry and apple juice reductions.		

Dino Bites: Whole wheat and coconut flour cookies with zucchini and carrots. A serving of cookies has half a serving of vegetables and is only 120 calories.		
Chicky Poppers: Crunchy garlic flavored, "pop in your mouth" chickpeas paired with a piece of fruit or milk. Groovy Granola Bar: Rolled oat granola bar filled with craisins and chocolate chips; with choice of either half a banana or a seasonal fruit cup and milk. Super Stuffed Peppers: A colorful bell pepper filled with a rice, tomato, and turkey blend paired with a piece of fruit and milk.