FOOD SCIENCE-BASED INSTRUCTION: THE PATHWAY TO GREATER INTEREST IN HIGH SCHOOL SCIENCE AND INCREASED ENROLLMENT IN UNIVERSITY FOOD SCIENCE PROGRAMS

by

AMY ROWLEY PEACOCK

(Under the Direction of Robert L. Shewfelt)

ABSTRACT

The food industry faces a shortage of graduates needed to fill scientific and technical positions available in the coming years, and university food science programs will not meet this demand. Although food science is a rapidly expanding profession, most students are not introduced to food science until the college years. To meet this challenge, university food science programs must increase the number of students enrolling in and graduating from their programs and maximize the knowledge and skills of those students. This study assessed high school and undergraduate student awareness of food science, determined the effect of food science-based instruction on high school students' attitudes toward science, identified factors influencing the selection of an undergraduate major in food science, and explored the use of active learning in undergraduate food science instruction. Student awareness of food science was low. Food science-based instruction had positive effects on students' attitudes toward science, and teacher perceptions of food science-based instruction were positive and supported the idea of further incorporating food science into the high school science curriculum. Undergraduate students enjoyed active learning exercises but showed resistance to change from traditional instruction. Students' course evaluation scores generally improved as a result of improvements made to the course; however, assessment scores did not improve following the use of active learning exercises. Incorporating food science into the high school science classroom has great potential to increase the number of students that choose food science as a major. To build upon recent efforts to incorporate food science into the high school classroom, university food science programs should develop curriculum materials, partner with science teachers, and provide a link between high schools and the food industry. Once students arrive on the college campus, it is important that university food science programs continue to attract students through courses and campus recruiting activities that target students with an interest in science. Beyond recruiting, undergraduate food science instruction should further explore maximizing the talents of future graduates by replacing traditional instructional methods with more active approaches that give students the skills needed to succeed in the industry.

INDEX WORDS: Active learning, Attitude toward science, Awareness of food science, Food Science-based instruction, Science education, Science literacy, Undergraduate food science instruction, Undergraduate major selection.

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For my husband,

my inspiration,

my motivation,

my best friend.

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CHAPTER ONE

INTRODUCTION

Agriculture is one of the nation's largest and most important industries, leading to a strong demand in the marketplace for college graduates with degrees in agricultural sciences (Donnermeyer and Kreps 1994). The United States Department of Agriculture estimated that there would be 52,000 annual job openings for graduates with food, agricultural, and natural resources degrees through the year 2010 (Goecker and others 2005). However, university programs will not meet this demand for graduates with food, agriculture, and natural resources degrees (Goecker and others 2005) as a result of declining enrollment in these programs (Donnermeyer and Kreps 1994).

Like the agricultural industry as a whole, the food industry—the nation's largest industry (Viera 1999)—faces a shortage of qualified graduates needed to fill the growing number of scientific and technical positions (Goecker and others 2005). Although food science is a rapidly expanding and viable profession (Lang 2007) employing tens of millions of people and grossing hundreds of billions of dollars annually (Viera 1999), most students are not introduced to food science until the college years (Lang 2007), at a time when they have most likely chosen and begun coursework in their major. To meet the challenges of the food industry, university food science programs need to increase the number of students enrolling in and graduating from their programs and to maximize the knowledge and skills of those students.

The first step in increasing student enrollment in university food science programs is to identify factors that influence students' selection of an undergraduate major in food science (Wildman and Torres 2001). Next, university food science programs must develop programs that reach students earlier in their educational careers (McEntire and Rollins 2007; National Research Council 1996a; Rawls 1995). Further, once students are enrolled, university food science programs must employ instructional strategies that best prepare students who have the professional knowledge and skills needed to succeed in the food industry (Institute of Food Technologists 2005).

Objectives

The objectives of this dissertation were

(1) to determine awareness of food science among undergraduate students;

(2) to determine the factors influencing the selection of an undergraduate major in food science;

(3) to compare these factors with factors influencing major selection of non-food science majors;

(4) to determine the effects of food science-based instruction on high school students' attitudes toward science, motivation to achieve in science, attitude toward the science curriculum, and science self-concept;

(5) to determine the effect of food science-based instruction on high schools students' awareness of food science and academic and career opportunities in the field;

(6) to determine teacher perceptions of implementation and effectiveness of food science-based instruction in the high school science classroom;

(7) to enhance student learning by incorporating active learning strategies into an undergraduate food chemistry course;

(8) to assess students' attitudes toward active learning; and

(9) to evaluate the effects of active learning techniques on student achievement of course learning outcomes.

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CHAPTER TWO

REVIEW OF LITERATURE

Undergraduate Major Selection

Factors Influencing Selection

To meet the demand for highly qualified scientists, engineers, and technologists in the agricultural sciences, colleges of agriculture must revise their methods of student recruitment (National Research Council 1996a). Effective student recruitment is based on knowledge of student populations and their decision-making process with regard to choosing a major (Wildman and Torres 2001). Research to identify factors influencing the selection of an agricultural major conducted at several colleges of agriculture identified prior experience in agriculture (Donnermeyer and Kreps 1994; Wildman and Torres 2001); influence of family, friends, and other role models (Donnermeyer and Kreps 1994; Jones 2003; Lindner and others 2004; Scofield 1994); and job considerations (Donnermeyer and Kreps 1994; Rawls 1995; Scofield 1994) as the primary factors influencing student selection of an agricultural major. Further, Tarpley and Miller (2004) found that students majoring in agricultural sciences were more likely to show interest in the natural sciences.

Recruitment Strategies

Researchers investigating factors influencing the selection of agricultural majors have proposed strategies to improve recruitment of students into agricultural majors. Prior experience with agriculture was the most significant factor in the choice of an agricultural major (Donnermeyer and Kreps 1994; Wildman and Torres 2001). Therefore, the most important recruitment strategy is to provide more students at the K-12 level, especially those students in urban settings, with some agricultural experience (National Research Council 1996a; Rawls

1995). One way to provide this experience is to integrate agricultural sciences into K-12 science classrooms. This approach would expose students to the agricultural sciences while providing teachers with a means to connect science content to real-world applications (McEntire and Rollins 2007; National Research Council 1996a). Colleges of agriculture should create and disseminate instructional materials that support this strategy (National Research Council 1996a). Because the influence of family, friends, and role models—including teachers and counselors—is significant, another strategy is provide these individuals with accurate information regarding agricultural sciences, so that this information can be passed on to students as they select a college major (Cole and Fano 1999; Lindner and others 2004; Rawls 1995).

Food Science in the High School Science Classroom

Integrating food science into the high school classroom has the potential to increase students' awareness of food science and to provide positive experiences on which they can base a decision to select an undergraduate major in food science (McEntire and Rollins 2007). However, before proposing any additions to today's standards-based high school science classrooms, one must be certain that the additions support the existing goals of science education.

Science, Technology, and Society

Americans live in a time when science and technology are critically important (Simpson and Anderson 1992), as economic growth and national security are driven by these endeavors (Bybee and Fuchs 2006; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine 2007; National Science Board 2003). The poor quality of science education is closely linked to declines in international economic competitiveness, rising unemployment, and a perceived weakening of military power (Atkin and Black 2003). Maintaining a society that is able to survive and grow within the competitive global economy requires a skilled and knowledgeable workforce and a citizenry capable of functioning in a complex, technical world (Bybee and Fuchs 2006; National Science Board 2006; National Science Board 2004; National Science Board 1999). Such a workforce drives discovery and innovation in science and technology (National Science Board 2003) and requires that workers have a sound understanding of science and mathematics (Bybee and Fuchs 2006; National Science Board 2006; National Science Board 2004). Policy makers, scientists, and educators agree that high school graduates need a basic understanding of these disciplines (National Research Council 2005) in order to function effectively as tomorrow's consumers, users, and producers of science (Simpson and Anderson 1992).

Unfortunately, many Americans lack the basic science understanding needed to function in a technical society. They are not science literate (Rutherford and Ahlgren 1990). As defined by Rutherford and Ahlgren (1990) in *Science for All Americans*, a "science-literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." According to the *National Science Education Standards*, science literacy is "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Research Council 1996b).

Science literacy and an appreciation for science are not being cultivated during the high school years (National Research Council 2005). The United States sends more than 45 million children to schools (Shavelson and Towne 2002); however, most high school students in the United States do not enroll in advanced science classes (National Science Board 1999). Only one-quarter of students enroll in physics courses, and only one-half of students enroll in chemistry courses (National Science Board 1999). For the graduating class of 2006, only 22 states and the District of Columbia required at least three years of math and science to graduate, and only one state, Alabama, required four years of both math and science (U.S. Department of Education 2006). Unfortunately, reduced enrollment in basic science courses has a direct effect on students' achievement in science; results from the 2000 and 2005 administrations of the National Assessment of Educational Progress in science indicate a positive relationship between the number of basic science courses taken and NAEP science scores (Grigg and others 2006). At the same time, fewer students are entering into science and technology careers, while the number of jobs requiring those skills is increasing (National Science Board 2003). For science to thrive, all Americans must be science literate. They must understand and value the relationship between science, technology, and society (Simpson and Anderson 1992). Further, society must educate its students to enjoy, believe in, and value science (Simpson and Anderson 1992), for the future health and competitiveness of the nation depends upon the preparation of its students (National Science Board 1999).

Secondary Science Education in the United States

Although the K-12 educational system is relied upon to produce science literate students, the poor quality of science and mathematics education in many schools in the United States is disturbing (National Science Board 1999). While student performance in these subjects has increased inconsistently in the last three decades, most students still perform below levels considered proficient or advanced (National Science Board 2004). On the 2005 NAEP in science, only 18% of twelfth-grade students scored at or above the proficient level. Further, 2005 NAEP results for high school science decreased as compared to 1996 results (Grigg and others 2006). Results from the 1995 Third International Mathematics and Science Study (TIMSS), an international assessment of students in grades four, eight, and twelve, found children, ages 13-17, in the United States, trail other nations in science and mathematics achievement (Stevenson 1998).

It has been charged that the United States science and mathematics curricula contribute dramatically to these findings. In the United States, in contrast to other nations, curricula are fragmented and not sequential; lack coherence, depth, and continuity; and cover more topics and repeat across more grade levels (National Science Board 1999; Schmidt 1997; Stevenson 1998). Currently, no study has directly linked curricula to the overwhelming statistics mentioned above. However, studies have shown that high-quality curricula affect and energize learning (National Science Board 1999; Schmidt and others 2001).

Methods of science instruction conform to societal values, goals, and expectations. At various times, educators have focused instruction on observation and memorization, science and its applications in daily life, and rigorous preparation for studies in science and engineering (Atkin and Black 2003). Science education reform currently emphasizes inquiry-based instruction as a means to achieve science literacy for all.

Most young children are naturally curious and often ask the questions, “how” and “why” (National Research Council 2000). Inquiry-based instruction utilizes this natural curiosity and allows students to explore science by conducting experiments to test ideas and answer questions (National Science Board 2004). Thus, inquiry-based instruction emphasizes the process of science along with basic scientific facts and concepts. Research supports the effectiveness of inquiry-based instruction (Amaral and others 2002; Stoddart and others 2002; Stohr-Hunt 1996). Unlike traditional instruction, in which teachers provide students with facts and technical jargon, inquiry-based instruction has been shown to increase student achievement by promoting development of the problem solving, communication, and critical thinking skills overlooked by traditional instruction (Stohr-Hunt 1996).

Current reform in science education is based on recommendations from the American Association for the Advancement of Science and the National Research Council. For example, the American Association for the Advancement of Science report *Science for All Americans* recommends that schools not "be asked to teach more and more content, but rather to focus on what is essential to science literacy and to teach it more effectively" (Rutherford and Ahlgren 1990). Implementation of these recommendations will foster positive attitudes and values towards science within students during their early years, thus laying a foundation for their development as science literate adults (National Research Council 1996b).

Attitude Toward Science and Related Concepts

According to prevailing educational theory, learning occurs in three domains: cognitive, psychomotor, and affective (Simpson and others 1994). The cognitive domain involves knowledge and the development of intellectual skills, including problem solving and reasoning. The psychomotor domain involves the development of physical coordination and motor skills. The term "affective" is derived from Latin *affectus,* meaning "feelings." The affective domain includes the manner in which we deal with things emotionally—including values, beliefs, opinions, motivation, and attitudes (Simpson and others 1994).

Attitude, in addition to belief, opinion, and value, is one of the key concepts that comprise the affective domain (Koballa 1988). According to Simpson and others (1994), attitude can be "commonly defined as a predisposition to respond positively or negatively to things, people, places, events, ideas." Thus, attitude toward science is defined as a "general and enduring positive or negative feeling about science" (Koballa and Crawley 1985). According to Oliver and Simpson (1988), "attitude toward science is a reply to the question, to what extent does a student have interest in science?" More simply stated, attitude toward science is the degree to which a student likes science (Oliver and Simpson 1988).

In one of the largest studies of its kind, Simpson and Troost (1982) examined commitment to science—comprising attitude toward science, interest in science, future involvement in science, enrollment choices, and attentiveness to science—and science achievement among 4500 adolescent science students in a large, socially diverse school system in North Carolina. The goal of the study was to determine and understand the factors that lead to increased commitment to science. Simpson and Troost (1982) developed a five-response Likert-type scale to measure commitment to science across fifteen subscales (Table 2.1). The Likert-type, or agreement, scale (Simonson 1979) is the most commonly used form of summated rating scale (Gardner 1975), in which a subject responds according to a perceived "attitude intensity" to positive or negative statements (Simonson 1979). Responses to statements vary in amount of agreement, ranging from strongly disagree to strongly agree (Simonson 1979). In addition to the work of Simpson and Troost (1982), a number of studies have explored correlations between attitude and achievement, behavior, grade level, gender, peer influence, and science classroom variables.

While there are a number of motivations for attitude research in science education, the most obvious is the intuitive relationship between attitude and achievement, that is, the belief that improved attitude leads to greater achievement. Simpson and Oliver (1990) reported positive correlations between attitude toward science and achievement. Other studies question whether attitude is predictive of achievement or *vice versa* (Rennie and Punch 1991; Steinkamp and Maehr 1983). However, the belief remains that a positive attitude toward science should lead to greater motivation to learn science and therefore to higher achievement levels.

The second major motivation for attitude research is the evaluation of attitude, itself, as an educational outcome (Oliver 1989). Studies have identified various factors that influence students' attitudes toward science. Shrigley (1990) found attitude and behavior to be correlates. Attitude toward science was found to decline throughout the school year (Cannon and Simpson 1985; Simpson and Oliver 1985, 1990) and with increasing grade level (Simpson and Oliver 1985, 1990). Gardner (1975) and Simpson and Oliver (1985, 1990) found attitude to be affected by gender, with male students generally having a more positive attitude toward science than female students. Gender differences have also been observed in students' achievement motivation, with female students demonstrating greater motivation (Simpson and Oliver 1985, 1990). Students' attitudes toward science were found to be greatly affected by peer influences. This relationship was most evident in grade nine (Simpson and Oliver 1990). Classroom environment variables, including curriculum, climate, physical environment, teacher, other students, and friends, were found to have the highest correlation with attitude toward science, accounting for between 46 and 73% of the variance in attitude toward science (Talton and

Simpson 1986). Curriculum, the focus of the largest number of studies in attitude research (Simpson and others 1994), showed the strongest correlation with attitude toward science of all the classroom environment variables, explaining between 40 and 46% of the variation in attitude toward science (Talton and Simpson 1987). Finally, attitude toward science has been found to serve as a predictor of students' future involvement in science experiences (Simpson and Oliver 1990). While the motivations for attitude research in science education are diverse, Gardner (1975) concluded that, "The ultimate goal of all these endeavors is simply stated: to stimulate joy, wonder, satisfaction, and delight in children as a result of their encounters with science."

Integrated Thematic Instruction

Integrated Thematic Instruction, or thematic instruction, employs the exploration of a particular topic to integrate and link curriculum components (Loughran 2005; Yorks and Follo 1993). Educators continually seek innovative, real-world contexts from which to approach thematic instruction. Themes familiar to students allow them to build on prior experiences to construct their own knowledge, thereby gaining ownership of their learning (Francek 2004; Loughran 2005). With familiar themes, students are able to connect concepts to personal experiences, thus making learning more meaningful and increasing understanding (Loughran 2005; Yorks and Follo 1993). This approach also reinforces the curriculum and enhances learning by joining traditionally disjointed activities and lessons into a more cohesive unit (Loughran 2005; Yorks and Follo 1993). Yorks and Follo (1993) found that student engagement rates were higher during thematic instruction when compared with traditional instruction.

Food Science as a Theme in Integrated Instruction

Given teenagers' natural interest in food, food science is an obvious perspective from which to approach thematic instruction in high school science. Food science has been used in the classroom to integrate instruction within and across subjects. Duffrin and others (2005a) used food science-based instruction to teach K-12 science and mathematics concepts. Lindquist (2004) had students apply knowledge learned in mathematics, science, and language arts to the development of new foods for school lunch. Ward (2004) developed a high school food science course to integrate English, mathematics, and the sciences through the study of food production, processing, preservation, and packaging. Phillips and others (2004) developed a 14-week series of standards-based food science inquiry lessons for the elementary classroom. Each of the lessons simultaneously addressed mathematics and science concepts, integrating such topics as chemical and physical change, acids and bases, and fractions and percentages (Phillips and others 2004). Sarakatsannis used the science of fast food to explore chemistry concepts with 8th-grade physical science students (Davis and 2007).

To address the need for future food scientists, and to increase interest in science, the Institute of Food Technologists (IFT), a nonprofit scientific and professional society for food scientists and technologists, partnered with Discovery Education to design and produce educational and career guidance materials that introduce food science into high school science classrooms and increase visibility of the field of food science (McEntire and Rollins 2007). Food is encountered daily by students and therefore provides them with a frame of reference within which new ideas can be placed (Duffrin and others 2005b). Through the application of basic science concepts to the practical study of food, food science provides students with a real-world context from which to approach the basic sciences and reinforces the link between basic and applied sciences (McEntire and Rollins 2007; Miller 1993).

Undergraduate Food Science Instruction

In its education standards, IFT asserts that success in the food science industry requires skills in oral and written communication, critical thinking, computer applications, professionalism, ethics, lifelong learning, teamwork, information acquisition, and organization (Institute of Food Technologists 2005). Developing well-prepared food science graduates that have the skills needed to be successful requires food science programs to move away from traditional instructional techniques.

History of Undergraduate Instruction

Just as there have been important shifts in the nature of teaching and learning in secondary education, educational philosophies in higher education have shifted over time. The earliest American colleges focused their efforts on the moral, spiritual, and academic development of their students. Teachers at these early colleges acted as mentors in all aspects of students' lives. Later, the focus of colleges shifted to building the nation through practical pursuits in agriculture, manufacturing, and democracy. The goal of these colleges was to produce the "service-oriented patriot." By the early 1900s, the focus of American colleges was shifting from teaching and service to research and discovery of new knowledge. The role of the professor began to shift from teacher to researcher and publisher. Throughout each of these phases, one constant was the view of the student as a passive recipient of the teacher's knowledge. This view led to the beliefs that learning was individual and competitive and requires extrinsic motivation, that personal relationships among students and teachers were unnecessary or counterproductive, and that any expert in a content area was automatically qualified to teach. These views supported the time-honored tradition of instruction by lecture, in which knowledge is simply broadcast and the student holds the responsibility for absorbing and retaining that knowledge (Johnson and others 1991).

Active Learning in Undergraduate Instruction

Lecture is the oldest and most widely used method of instruction in higher education (McKeachie 1990; Terenzini and Pascarella 1994). However, compared to more active instructional techniques, lecture is less effective as measured by student retention of content. After 24 hours, students retain only 5% of lectured material, while retention for more active techniques, such as group discussion, practice by doing, and teaching others is 50%, 75%, and 90%, respectively (Sousa 1995). In lecture settings, students act as passive recipients of knowledge. This passive mode of learning produces little retention of knowledge and limited development of students' critical thinking abilities. These outcomes are directly contrary to the most crucial goal of post-secondary education, namely to prepare students for future professional endeavors by developing a deep understanding of discipline-specific knowledge, as well as critical thinking, problem solving, and interpersonal skills (Gardiner 1994).

Achieving the goals of post-secondary education requires a shift to a learner-centered pedagogy that encourages students to become actively involved in their own learning process. This active learning approach stems from the constructivist view that learners actively construct their own meaning through interactions with content, peers, and instructors, thereby promoting deeper understanding of content (Bruning and others 2004; Wiggins and McTighe 1998) and increases in student achievement (Reitmeier 2002; Terenzini and Pascarella 1994), engagement (Bonwell and Eison 1991), metacognitive abilities (Thompson and others 2003), and retention and retrieval (Sousa 1995; Thompson and others 2003). This approach requires students to plan and direct their own learning and to think explicitly about what they are learning and doing. The active learning classroom has students as its focus and requires students to analyze, synthesize, and evaluate knowledge as they engage in reading, writing, discussion, or problem solving (Bonwell and Eison 1991).

Active Learning in Undergraduate Food Science Instruction

The food industry faces an ongoing shortage of workers qualified to fill technical positions. Between 2005 and 2010, university programs will not meet the demand for graduates with food, agriculture, and natural resources degrees (Goecker and others 2005). Therefore, it is critical that food science graduates are well prepared for their professional responsibilities. The goal of university food science programs is to prepare students who have the professional knowledge and skills needed to succeed in the food industry. Developing well-prepared food science graduates that have the skills needed to be successful requires food science programs to move away from traditional instructional techniques. As a result of its applied nature, food science lends itself to active learning. During food science coursework, students build on their prior knowledge of the sciences to make new meaning as they apply that knowledge to authentic situations encountered in the food industry. This application of knowledge to authentic situations provides continual opportunities to incorporate active learning techniques into teaching and learning of food science.

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Table 2.1. Commitment to science subscales.

Subscale	**Sample Item**
Science affect (Attitude toward science)	I like science.
Science self-concept	I consider myself a good science student.
General self-esteem	I like myself.
Locus of control	Luck seems to be more important in life than hard work.
Achievement motivation	I try hard to do well in science.
Science anxiety	My mind goes blank when I am doing science.
Science class – emotional climate	I feel nervous in science class.
Science class – physical environment	Our science classroom contains a lot of interesting equipment.
Science class – other students	The students in this class aren't much fun.
Science teacher	My science teacher encourages me to learn more science.
Science curriculum	We learn about important things in science class.
Family – general	I am a member of a happy family.
Family – science	My parents encourage me to learn science.
Friends and best friend	My friends like science.
School	I feel like I'm in prison when I'm in school.

CHAPTER THREE

FACTORS INFLUENCING SELECTION OF AN UNDERGRADUATE MAJOR IN FOOD SCIENCE[1]

[1] Peacock, AR and Shewfelt, RL. To be submitted to the NACTA Journal.

Abstract

Agriculture is one of the nation's largest and most important industries, leading to a strong demand in the marketplace for college graduates with degrees in agricultural sciences. However, the supply of qualified candidates to fill positions in agricultural fields, including food science, is not keeping up with the demand. To meet the demand for highly qualified graduates in food science, university food science programs must revise their methods of student recruitment. The objectives of this study were (1) to determine awareness of food science among undergraduate students, (2) to determine the factors influencing the selection of an undergraduate major in food science, and (3) to compare these factors with factors influencing major selection of non-food science majors. Undergraduate students enrolled in introductory food science courses participated in a survey and focus group sessions to determine students' awareness of food science and to identify factors that influence the consideration and selection of an undergraduate major in food science. Awareness of food science and of the academic and career opportunities in the field was low. Personal interest, interest in science, previous experience, and job considerations were the most frequently identified factors affecting the consideration and selection of a food science major. To increase the number of students that choose food science upon entering college, university food science programs should initiate or support programs that integrate food science into the high school classroom, as well as continue to recruit students through introductory courses and other on-campus recruitment activities.

Introduction

Agriculture is one of the nation's largest and most important industries, leading to a strong demand in the marketplace for college graduates with degrees in agricultural sciences (Donnermeyer and Kreps 1994). A report from the United States Department of Agriculture estimated that there would be 52,000 annual job openings for graduates with food, agricultural, and natural resources degrees through the year 2010 (Goecker and others 2005). However, through the year 2010, university programs will not meet this demand for graduates with food, agriculture, and natural resources degrees (Goecker and others 2005) as a result of declining enrollment in these programs (Donnermeyer and Kreps 1994).

To meet the demand for highly qualified scientists, engineers, and technologists in the agricultural sciences, colleges of agriculture must revise their methods of student recruitment (National Research Council 1996). Effective student recruitment is based on knowledge of student populations and their decision-making process with regard to choosing a major (Wildman and Torres 2001). Research to identify factors influencing the selection of an agricultural major conducted at several colleges of agriculture identified prior experience in agriculture (Donnermeyer and Kreps 1994; Wildman and Torres 2001); influence of family, friends, and other role models (Donnermeyer and Kreps 1994; Jones 2003; Lindner and others 2004; Scofield 1994); and job considerations (Donnermeyer and Kreps 1994; Rawls 1995; Scofield 1994) as the primary factors influencing student selection of an agricultural major. Further, Tarpley and Miller (2004) found that students majoring in agricultural sciences were more likely to show interest in the natural sciences.

Researchers investigating factors influencing the selection of agricultural majors have proposed strategies to improve recruitment of students into agricultural majors. Prior experience with agriculture was the most significant factor in the choice of an agricultural major (Donnermeyer and Kreps 1994; Wildman and Torres 2001). Therefore, the most important recruitment strategy is to provide more students at the K-12 level, especially those students in urban settings, with some agricultural experience (National Research Council 1996; Rawls 1995). One way to provide this experience is to integrate agricultural sciences into K-12 science classrooms. This approach would expose students to the agricultural sciences while providing teachers with a means to connect science content to real-world applications (McEntire and Rollins 2007; National Research Council 1996). Colleges of agriculture should create and disseminate instructional materials that support this strategy (National Research Council 1996). Because the influence of family, friends, and role models—including teachers and counselors—is significant, another strategy is provide these individuals with accurate information regarding agricultural sciences, so that this information can be passed on to students as they select a college major (Cole and Fano 1999; Lindner and others 2004; Rawls 1995).

Like the agricultural industry as a whole, the food industry and university food science programs are facing a shortage of qualified graduates needed to fill the growing demand for food scientists (Goecker and others 2005). Although food science is a rapidly expanding and viable profession, it is often not discovered by students until their college years (Lang 2007). As a result, university food science programs, like colleges of agriculture, need to improve their methods of student recruitment. The first step in this process is to determine the factors influencing the selection of a major in food science.

The objectives of this study were (1) to determine awareness of food science among undergraduate students, (2) to determine the factors influencing the selection of an undergraduate major in food science, and (3) to compare these factors with factors influencing major selection of non-food science majors.

Materials and Methods

Awareness Survey

All students (n=149) enrolled in Food Issues and Choices and Freshmen Seminar – Chocolate Science during the 2005 fall semester were surveyed to assess undergraduate student awareness of food science. Of the participating students, 30% were male and 70% were female; while 2% were multiracial, 6% were African American, 6% were Asian or Pacific Islander, and the remaining 86% were white (non-Hispanic). Students ranged in age from 16 to 35, with a mean age of 20. Part one of the survey instrument was designed to collect basic demographic information. Part two of the instrument included three open-response items that were designed to sample students' awareness of food science and academic and career opportunities in the field (Table 3.1). The survey was given to students on the first day of class of the 2005 fall semester. Student responses were categorized according to the nature of response.

Focus Group Sessions

Undergraduate food science majors (n=20) from the Department of Food Science and Technology and undergraduate non-food science majors (n=20) enrolled in the fall 2006 section of Food Issues and Choices participated in focus group sessions in the first weeks of the semester, during which students were asked to discuss the major selection process. Focus group questions are presented in Table 3.2. Of the participating students, 25% were male and 75%

were female; while 5% were Asian, 7.5% were multiracial, and the remaining 87.5% were white (non-Hispanic). Students ranged in age from 17 to 31, with a mean age of 21. Of the 40 participating students, 5% were first-year, 15% were second-year, 42.5% were third year, 30% were fourth-year, and 7.5% were fifth-year. Forty-five percent of non-food science majors had majors in the college of agricultural and environmental sciences, while the remaining 55% had majors outside of the college.

Results and Discussion

Awareness of Food Science

Undergraduate student awareness of food science and academic and career opportunities in the field was low (Figure 3.1). Seventy-nine percent of students were unaware of food science. Of the 21% of students who reported they were aware of food science, 55% provided evidence that demonstrated they had an accurate understanding of food science. The remaining 45% provided inaccurate evidence, such as experience with nutrition, culinary arts, and food service. Further, of those students reporting accurate experiences in food science, only 16% experienced food science prior to entering college. This observation agrees with Lang's (2007) statement that students are not introduced to food science until the college years. Only 8% and 13% of the total students were able to demonstrate an understanding of the education and training required for and career opportunities in food science, respectively.

Consideration of Undergraduate Majors

Personal interest was the most frequently identified factor in the consideration of undergraduate majors for both food science and non-food science majors (Table 3.3). Presumably, activities undertaken by university food science programs are unlikely to replace students' existing personal interests and preferences; however, they may introduce new interests to students as a result of new exposures.

Following personal interest, another frequently identified factor for food science majors was the fact that a major led to a science-related career (Table 3.3). This factor was one of several job considerations considered by food science majors, including the future job market in the field and income. These findings agree with those of Donnermeyer and Kreps (1994), Rawls (1995), and Scofield (1994), who found that job considerations were important to students who select a major in agriculture. When asked during focus group sessions about other majors considered during the undergraduate major selection process, food science majors identified science majors 28 times, twice as often as did non-food science majors. The most popular undergraduate majors considered by food science majors were biology, chemistry, nutrition, and pre-pharmacy. The most popular undergraduate majors considered by non-food science majors were biology, pre-pharmacy, chemistry, and education. All food science majors expressed a strong interest in science, as would be expected based on the findings of Tarpley and Miller (2004). During their high school years, 65% of food science majors enrolled in honors science classes, 40% enrolled in Advanced Placement science classes, and 55% enrolled in elective science classes. In comparison, 85% of non-food science majors indicated an interest in science. Fifty percent of non-food science majors enrolled in high school honors science classes, 35% enrolled in Advanced Placement science classes, and only 15% enrolled in elective science classes. During their consideration of undergraduate majors, non-food science majors did not consider relation of a career to science, although future career plans was an important job consideration.

Both food science and non-food science majors identified the influence of family, friends, teachers, or mentors as a factor influencing the consideration of undergraduate majors (Table 3.3). These findings support those of Donnermeyer and Kreps (1994), Jones (2003), Lindner and others (2004), and Scofield (1994). Among the food science majors, 35% of students indicated that the influence of a high school science teacher was a factor in the consideration of undergraduate majors, while 5% cited the influence of a mentor. Among non-food science majors, 30% indicated the influence of a high school teacher, with 10% each citing a science teacher, an agricultural education teacher, or other teacher, respectively. Half of all non-food science majors indicated that the influence of family and friends was an important factor in the consideration of undergraduate majors. Only 15% of food science majors cited family and friends as a factor.

Experience in the field was another frequently identified factor for both food science and non-food science majors in the consideration of undergraduate majors (Table 3.3). These findings agree with those of Donnermeyer and Kreps (1994) and Wilman and Torres (2001), who found that prior experience in agriculture is an important factor in the selection of an agricultural major. Food science majors cited high school classes as the primary means of exposure; whereas, high school classes, work experience, and other experiences in the field were cited by non-food science majors. Food science majors were much more likely to have had experience in the field prior to or early in their college career. Among food science majors, 95% gained some experience with the field before or during their first two years of college. The majority (65%) of food science majors gained their first experience in the field through introductory courses or departmental recruitment activities. Others gained experience through work experience, high school exposure, or other experiences. In contrast, 75% of non-food science majors gained their first experience with the field of food science during the third or fourth year of college. The vast majority (85%) of non-food science majors gained their first experience with food science by enrolling in introductory food science courses. The timing of the first experience with food science had an important effect on whether food science was considered as a potential undergraduate major. Ninety-five percent of non-food science majors never considered food science as a major. Of those, 63% expressed that they would have considered food science as an undergraduate major had they become aware of it earlier in their educational career. Forty-two percent of those students who did not consider food science as a major indicated that they would have selected or changed their major to food science had they become aware of it earlier in their educational career.

Selection of an Undergraduate Major

Food science and non-food science majors most frequently identified personal interest as an influential factor in the selection of an undergraduate major (Table 3.3). Outside of personal interest, future career plans and influence of family and friends were the factors most frequently identified by non-food science majors as influential in the selection of an undergraduate major. For food science majors, job considerations and departmental factors, in addition to personal interest, were frequently identified as factors influencing the selection of an undergraduate major in food science. The most frequently identified job consideration was the applied nature of food science. Half of food science majors declared the major after switching from another science major. Of these students, 60% transferred to food science from a basic science—biology, microbiology, or chemistry. Thirty percent of food science majors entered college as a major (25%, 20%, and 25% declared the major as first-year, second-year, and third-year students, respectively), 15% selected food science from an undeclared status, and 5% switched to food science from a non-science major. Other job considerations frequently identified include the future job market in the field, the uniqueness of the job, and intended career plans of the student. Departmental factors that influenced students' selection of a major in food science were courses offered, size, recruitment activities, and faculty reputation. Courses offered by the department, specifically Freshmen Seminar – Chocolate Science, Food Issues and Choices, and Introduction to Food Science, was the most frequently identified departmental factor. Taken together, job considerations and departmental activities were important factors in students' selection of a food science major. This observation indicates that university food science programs should continue or expand any programs that provide prospective students with information on the applied nature of food science and on the career opportunities in the field.

Conclusions

The most important factor in a student's selection of a particular undergraduate major is the student's awareness of the field, and undergraduate students are largely unaware of the field of food science.   The most effective approach to improve recruitment of students into university food science programs is to reach students before entering college with a program that emphasizes the role of applied science in the field of food science. Incorporating food science into the high school science classroom, along with providing accurate information to high school teachers and counselors, has great potential to increase the number of students that choose food science as a major upon entering college. Once students arrive on the college campus, it is important that university food science programs continue to attract students through introductory classes that are well-publicized and interesting to students and through campus recruiting activities that target students with an interest in science, particularly students that may be undeclared or enrolled in basic sciences.

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Wildman, ML and Torres, RM. 2001. Factors influencing choice of major in agriculture. Journal of Agricultural Education 42(2): 46-55.

Table 3.1. Items comprising awareness survey.

Item	
1.	Are you familiar with the term "food science?" • If yes, provide a definition of the term. • If yes, what experience have you had with food science?
2.	Are you aware of the education and/or training required to become a food scientist? • If yes, what education and/or training is required? • Where would you receive this education and/or training?
3.	Are you familiar with jobs that a food scientist might hold? • If yes, please provide three examples

Note: Numbers preceding items indicate position of item in the instrument.

Table 3.2. Focus group questions.

Question
1. What year in school are you?
2. What is your major? • What other majors did you consider? • What factors influenced your consideration of these majors? • Why did you select the major that you did?
3. Describe your science background in terms of interest in science and the number and type of science courses taken in high school science.
4. How and when were you first introduced to the field of food science?
5. If your major is food science, at what point in your college career did you select food science as your major? • What specifically led to your selection of a food science major? • If you switched from a previous major, what was your previous major? • Why did you switch to a major in food science?
6. If you are not a food science major, did or would you consider a major in food science? • Why or why not?

Table 3.3. Factors identified by students (%) as influencing the consideration and selection of undergraduate majors.

Factor	**Majors Considered**		**Major Selected**	
	Food Science	**Non-Food Science**	**Food Science**	**Non-Food Science**
Personal Interests	85	60	55	45
Influence				
• Family & Friends	15	50	0	20
• High School Teacher or Mentor	40	30	5	5
Experience				
• High School Classes	35	10	0	0
• Work Experience	0	15	0	10
• Other	10	10	15	5
Departmental				
• Size	0	0	25	0
• Faculty Reputation	0	0	15	0
• Recruitment Activities	0	0	25	5
• Courses	0	0	45	0
Job Considerations				
• Future Job Market	25	10	40	10
• Income	15	5	5	5
• Uniqueness of Job	0	0	35	0
• Career Plans	0	25	30	25
• Agriculture-Based	10	5	15	5
• Science-Related	70	0	25	0
• Applied Science	5	0	50	0

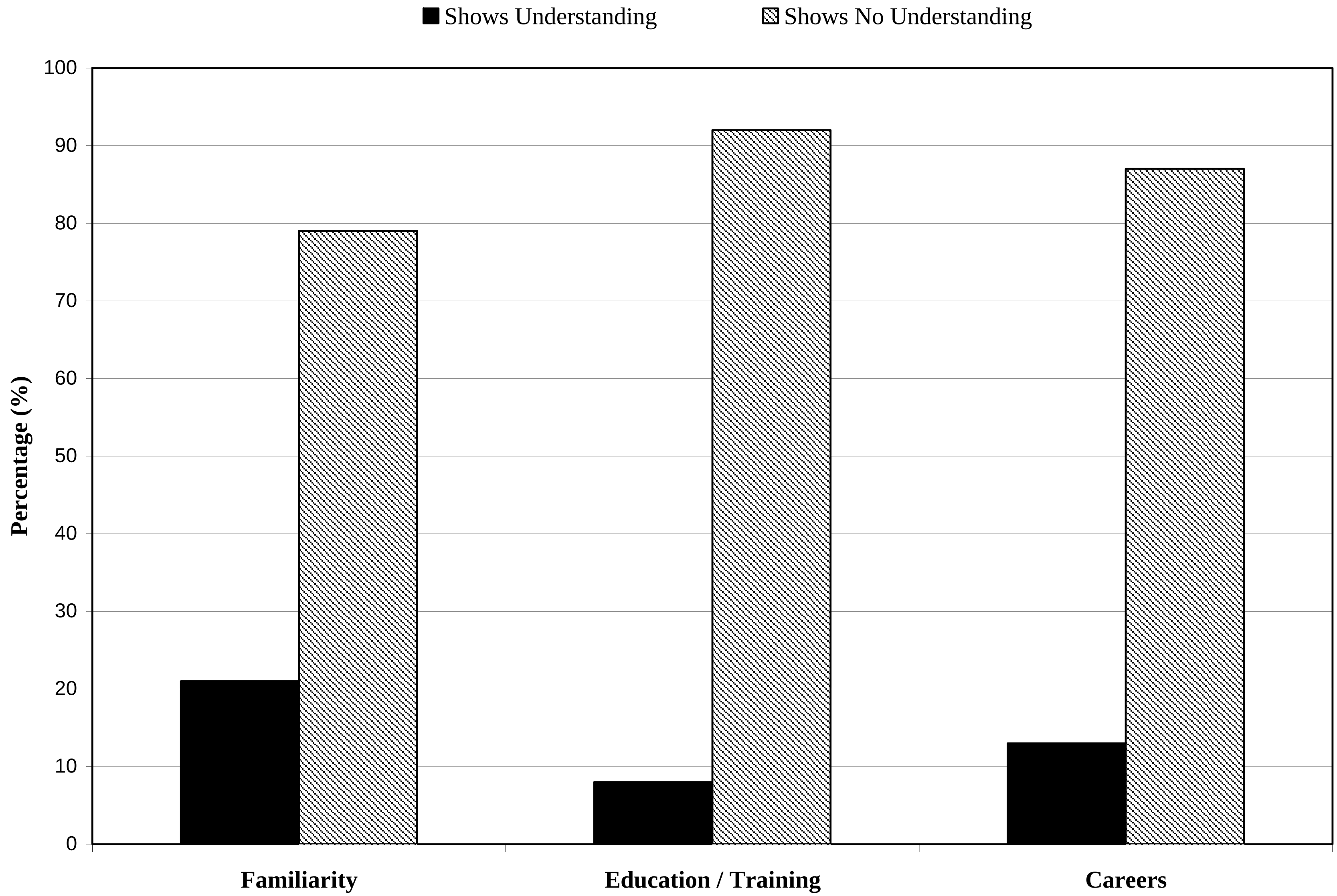

Figure 3.1. Undergraduate students' awareness of food science and academic and career opportunities in the field.

CHAPTER FOUR

EFFECT OF FOOD SCIENCE-BASED INSTRUCTION ON HIGH SCHOOL SCIENCE STUDENTS' ATTITUDES TOWARD SCIENCE AND AWARENESS OF FOOD SCIENCE AND ACADEMIC AND CAREER OPPORTUNITIES IN FOOD SCIENCE AND TEACHER PERCEPTIONS OF THE EFFECTIVENESS OF FOOD SCIENCE-BASED INSTRUCTION[2]

[2] Peacock, AR, Shewfelt, RL, Peacock, JS, and Oliver, JS. To be submitted to the Journal of Food Science Education.

Abstract

The food industry faces an ongoing shortage of qualified workers to fill the industry demand. University food science programs can potentially meet this demand. Recruitment programs must reach students earlier in their educational career by integrating food science into the high school science curriculum. Approaching high school science content from the real-world perspective of food science may be an effective means to improve students' science literacy and attitude toward science. The objectives of this study were (1) to determine the effects of food science-based instruction on high school students' attitudes toward science, motivation to achieve in science, attitude toward the science curriculum, and science self-concept, (2) to determine the effect of food science-based instruction on high schools students' awareness of food science and academic and career opportunities in the field, and (3) to determine teacher perceptions of implementation and effectiveness of food science-based instruction in the high school science classroom. Students participated in a series of activities that presented high school chemistry content from the perspective of food science. Objectives were assessed before and after instruction. Food science-based instruction had positive effects on students' attitudes towards science, which are expected to lead to improvements in science literacy and achievement. Students' awareness of food science and academic and career opportunities in the field was greatly improved. Teacher perceptions of food science-based instruction were positive and supported the idea of further incorporating food science into the high school science curriculum. To build upon recent efforts to reach high school students by incorporating food science into the high school classroom, university food science programs should develop curriculum materials, partner with high school science teachers, and work with

the food industry to seek funding to provide teachers with the professional development, equipment, and supplies needed to engage students in the active exploration of food science.

Introduction

The food industry faces an ongoing shortage of qualified workers to fill the industry demand. Through the year 2010, universities will not graduate enough students to fill the 52,000 annual positions available for college graduates with degrees in food, agriculture, and natural resources (Goecker and others 2005). University recruitment programs are one potential avenue to meet the demand. Currently, most students are not introduced to food science until the college years (Lang 2007), at a time when they have most likely chosen and begun coursework in their major. Researchers found prior experience to be the most significant factor in a student's selection of a major (Donnermeyer and Kreps 1994; Wildman and Torres 2001). Therefore, recruitment programs must reach students earlier in their educational career (McEntire and Rollins 2007; National Research Council 1996a; Rawls 1995). This goal can be accomplished by integrating food science into the high school science curriculum, thus providing the positive experiences with food science on which students can base a decision to major in the field (McEntire and Rollins 2007). However, before proposing any additions to today's standards-based high school science classrooms, one must be certain that the additions support the existing goals of science education.

The National Science Education Standards focus on developing science literacy (National Research Council 1996b), *i.e.* the ability to connect major scientific concepts and principles to everyday life (Rutherford and Ahlgren 1990). Americans live in a time when science and technology are critically important (Simpson and Anderson 1992), as economic growth and national security are driven by these endeavors (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine 2007; National Science Board 2003).

However, science literacy and an appreciation for science are not being cultivated during the high school years (National Research Council 2005).

Attitude toward science is closely linked to science literacy and can be defined as a "general and enduring positive or negative feeling about science" (Koballa and Crawley 1985). More simply stated, attitude toward science is the degree to which a student likes science (Oliver and Simpson 1988). Studies have identified various factors that influence students' attitudes toward science. Timing is one important factor, as attitude toward science was found to decline throughout the school year (Cannon and Simpson 1985; Simpson and Oliver 1985, 1990). Classroom environment variables; including curriculum, climate, physical environment, teacher, other students, and friends; were found to have the highest correlation with attitude toward science (Talton and Simpson 1986). Curriculum, the focus of the largest number of studies in attitude research (Simpson and others 1994), showed the strongest correlation with attitude toward science of all the classroom environment variables (Talton and Simpson 1987). Finally, attitude toward science has been found to serve as a predictor of students' future involvement in science experiences (Simpson and Oliver 1990).

Integrated thematic instruction may be an effective approach to improving science literacy and students' attitudes toward science. Thematic instruction employs the exploration of a particular topic to integrate and link curriculum components (Loughran 2005; Yorks and Follo 1993). Educators continually seek innovative, real-world contexts from which to approach thematic instruction, as themes familiar to students allow them to build on prior experiences to construct their own knowledge, thereby gaining ownership of their learning (Francek 2004; Loughran 2005).

Given teenagers' natural interest in food, food science is an obvious perspective from which to approach thematic instruction in high school science. Food science has been used in the classroom to integrate instruction within and across subjects (Davis and others 2007; Duffrin and others 2005a; Lindquist 2004; Phillips and others 2004; Ward 2004). The Institute of Food Technologists (IFT), a nonprofit scientific and professional society for food scientists and technologists, has taken steps toward integrating food science into high school science classrooms by developing educational and career guidance materials that were distributed to 18,000 U.S. high schools in January 2006. The goals of this project were to increase awareness of food science and related careers, reignite interest in science, and demonstrate applications of science to the real world (McEntire and Rollins 2007). Food is encountered daily by students and therefore provides them with a frame of reference within which new ideas can be placed (Duffrin and others 2005b). Through the application of basic science concepts to the practical study of food, food science provides students with a real-world context from which to approach the basic sciences and reinforces the link between basic and applied sciences (Miller 1993).

The objectives of this study were (1) to determine the effects of food science-based instruction on high school students' attitudes toward science, motivation to achieve in science, attitude toward the science curriculum, and science self-concept, (2) to determine the effect of food science-based instruction on high schools students' awareness of food science and academic and career opportunities in the field, and (3) to determine teacher perceptions of implementation and effectiveness of food science-based instruction in the high school science classroom.

Materials and Methods

Participants

Teachers (n=2) and students (n=115) from an urban high school with an enrollment of approximately 1400 students located in the Atlanta, Georgia metropolitan area served as the subjects for this study. Ninety-eight percent of the high school's student population is African-American, and 59% of students are eligible for free or reduced-price lunch. In 2005, 41% of the school's eleventh grade students passed the science portion of the Georgia High School Graduation Test, compared to the state average of 71%. An increase was seen in 2006 with 63% of students passing the science portion, compared to the state average of 76%. Students were enrolled in one of six chemistry 4X4 block classes taught during the 2006 spring semester. Of the participating students, 30% were male and 70% were female, while 43% were in the tenth grade and 57% were in the eleventh or twelfth grade. All students had previously taken high school biology, and 63% of students had previously taken high school physical science. The school was in the third year of participation in a National Science Foundation GK-12 program, *The Science Behind Our Food*, that introduced graduate students from the The University of Georgia's College of Agricultural and Environmental Sciences to various science classrooms on a weekly basis. Graduate students translated current agricultural research into innovative, inquiry-based science lessons centered on the theme of the science of food.

Food Science-Based Instruction

Students participated in a series of classroom, laboratory, and project-based activities that presented chemistry content from the perspective of food science (Table 4.1). All activities were aligned to Georgia's state curriculum standards for high school chemistry. Lessons were implemented on a weekly basis throughout the entire semester.

Data Collection

A three-part instrument was used in this study. Part one of the instrument was designed to collect basic demographic information from the students. Part two of the instrument was a modified version of an instrument created by Simpson and Troost (1982) and included seventeen items, comprising four subscales, designed to sample students' attitudes toward science, motivation to achieve in science, attitude toward the science curriculum, and science self-concept (Table 4.2). Student responses to these items were recorded using a five-response Likert-type scale. A response of five indicated strong agreement, and a response of one indicated strong disagreement. Part three of the instrument included six open-response items (Table 4.3). Of the six questions, four were designed to sample students' awareness of food science and academic and career opportunities in the field, one was designed to sample students' intended career choices, and one was designed to probe students' interest in pursuing food science careers. During the first and last weeks of the semester, the instrument was given to participating students from whom consent was obtained. The instrument was distributed and collected by the participating teachers. Additionally, during the last week of the semester, participating teachers met with the researcher to participate in a hour-long interview session. During the session teachers were probed on implementation and effectiveness of food science-based instruction in the high school science classroom. Interview questions are presented in Table 4.4.

Data Analysis

Subscale data were analyzed using SAS 9.1 software (2005, SAS Institute, Inc. Cary, North Carolina). Only data collected from students who fully completed instruments during the pre- and post-evaluations were analyzed. Means and standard deviations were calculated for each subscale and individual item for pre- and post-evaluations. A statistical model grouping for gender, teacher, class, grade level, and previous science courses was developed to compare mean subscale scores from pre- and post-evaluations. Comparisons were made using t-tests and analysis of variance (ANOVA). Cronbach's alpha was calculated for each subscale to assess reliability. Pearson correlation coefficients were calculated to compare between subscales.

Student responses to open response items were categorized according to the nature of response and level of understanding and grouped into one of the following categories: unaware - no understanding, aware-basic understanding, and aware-advanced understanding. The percentage of each response type was compared graphically between pre- and post-evaluations. Student career choices were categorized according to career field. Frequency of career field selection was compared between pre- and post-evaluations using percent difference. The percentage of students expressing interest in food science careers was compared between pre- and post-evaluations. Responses from the teacher interview sessions were summarized.

Results and Discussion

Acceptable alpha reliability (> 0.70) was found for all but one subscale (Table 4.5). Attitude toward science, the subscale consisting of the larget number of items, had the highest reliability (0.861). The motivation to achieve in science and attitude toward the science curriculum subscales both consisted of four items and had alpha reliabilities of 0.739 and 0.718, respectively . Science self-concept, consisting of only two items, had the lowest alpha reliability (0.550).

The strongest correlations were found between science self-concept and attitude toward the science curriculum (0.854) and between science self-concept and motivation to achieve in science (0.807; Table 4.6). The lowest correlations were found between motivation to achieve in science and attitude toward the science curriculum (0.382) and between motivation to achieve in science and attitude toward science (0.415). Pearson correlation coefficients were significant ($p < 0.001$) for all subscale relationships.

No significant effect was found when pre- and post-evaluation subscale data was grouped by gender, grade, teacher, class, or previous science courses. Further, no significant differences were found between pre- and post-evaluations of attitude toward science, motivation to achieve in science, attitude toward the science curriculum, or science self-concept (Table 4.7). Motivation to achieve in science exhibited the highest mean scores on pre-and post-evaluations. Individual item and subscale mean scores generally remained the same or increased slightly from pre- to post-evaluations. Mean scores for the attitude toward the science curriculum and attitude toward science subscales increased by 0.19 and 0.18, respectively. Within the attitude toward the science curriculum subscale, the items with the largest increases were “We cover interesting topics in science class” and “We do a lot of fun activities in science class.” Within the attitude toward science subscale, the items with the largest increases were “Science is fun,” “I would enjoy being a scientist,” and “I really like science.” Previous researchers (Cannon and Simpson 1985; Simpson and Oliver 1985, 1990) found that attitude toward science decreases throughout the school year. Therefore, the fact that mean scores on attitude subscales remained steady following instruction is interpreted as evidence of a positive effect of instruction.

Large differences were observed between the pre- and post-evaluations in the levels of awareness of food science and academic and career opportunities in the field (Figure 4.1). Prior to instruction, most students were unaware of the field of food science and the academic and career opportunities in the field. Those students that were aware primarily demonstrated only a basic understanding of the field. Following instruction, there were large increases in the percentage of students demonstrating awareness and understanding of the field. The percentage of students that demonstrated awareness of the field increased by at least 58% for all awareness items. The percentage of students that demonstrated an advanced understanding increased by at least 23% for all awareness items.

Prior to instruction, students most frequently identified intended careers within the field of medicine and healthcare (Table 4.8). Other frequent selections were business and financial management, law and public policy, performance and entertainment, and science and engineering . Twenty-three percent of students indicated that they would consider a career in food science. However, only three students listed food science as an intended career. Following instruction, students again most frequently identified intended careers within the field of medicine and healthcare. Business and financial management, performance and entertainment, and science and engineering remained steady, while law and public policy declined by 25% and education increased by 50% . After instruction, 45% of students indicated that they would consider a career in food science. Nine students identified food science as an intended career, resulting in a 200% increase. This increase is at least two times greater than increases seen in any other field.

Teachers indicated that food science-based instruction was effective in improving students' attitudes toward science. As evidence, teachers cited increases in students' excitement about class activities, outside preparation for class, personal investment in assignments, and willingness to work collaboratively. Teachers also believed that food science-based instruction was effective in increasing students' awareness of food science and academic and career opportunities in the field. Prior to instruction, students had little or no knowledge of the field of food science. As a result, teachers believed that students who participated in food science-based instruction are more likely to consider further study or careers in food science.

Regarding their own experiences, teachers indicated that use of food-science based instruction allowed them to better relate real-world science content to students' everyday lives, provided a non-traditional means of addressing educational standards, and allowed them to incorporate more hands-on activities into the curriculum. Further, teachers' attitudes toward teaching were improved. Teachers reported that teaching was more enjoyable, and that the addition of interesting activities and examples, as well as the opportunity to increase their own content knowledge, increased their motivation and enthusiasm for teaching and their content area.

Teachers identified several advantages offered by food science-based instruction over traditional instruction. Food science-based instruction provides exposure to career opportunities, uses students' prior knowledge of food to build their knowledge of science content, assists teachers in varying their instructional approach, addresses various learning styles, and encourages higher-order thinking skills (*e.g.* synthesis, analysis, and evaluation).

Overall, teachers believed food science-based instruction to be an effective instructional tool in the high school science classroom. Teachers indicated that the approach spans different subject areas and curricula, facilitates collaboration across subjects, and is ideal for schools that emphasize career preparation.

Teachers invovled in the study reported that they would continue to use food science-based instruction in their classrooms. Resources that would facilitate continued implementation included additional background literature, student reading resources, laboratory guides for student use, additional food science-based activities, and additional equipement that would allow for more authentic laboratory procedures and investigations.

Conclusions

The use of food science as a context for high school science instruction has showed the potential to improve students' general attitudes toward science, thereby improving science literacy and achievement. Further, students' increased awareness of food science and academic and career opportunities in food science stands to benefit university food science programs and the food industry by increasing the supply of interested and qualified individuals to fulfill the increasing demand for technical positions in food science. Finally, food science-based instruction supports the goals and standards of high school science education and is enthusiatically supported by teachers when they are provided with the proper resources to implement such instruction. To build upon recent efforts to reach high school students by incorporating food science into the high school classroom, university food science programs should develop curriculum materials, partner with high school science teachers, and work with the food industry to seek funding to provide teachers with the professional development, equipment, and supplies needed to engage students the active exploration of food science.

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Table 4.1. Food science-based instructional activities used in the classroom.

Activity	Description
I'm Eating What?!?	Classroom – Students were introduced to the field of food science, as they matched raw ingredients with finished food products.
What's Happening To My Food?	Laboratory – Students observed and classified physical and chemical changes that commonly occur in foods.
Vending Machine Product Development	Classroom – Students were introduced to product development as they created an original food item using the contents of the school vending machine.
Edible Elements	Classroom – Students discovered, through the construction of a periodic table, the many roles of chemicals in the growth, harvest, processing, preparation, preservation, and contamination of foods.
Bag O' Isotopes	Classroom – Students calculated average atomic mass of the fictional element legumium.
How Sweet It Is!	Laboratory – Students explored the relationship between chemical structure and the functional properties of food ingredients as they compared natural and artificial sweeteners.
The Chemist's Cookbook	Laboratory –Students explored product formulation and quality control, performed metric conversions, and evaluated accuracy and precision as they followed a scientific protocol to prepare cookies.
One of These Things is Not Like the Other	Classroom – Students explored the principles of sensory evaluation as they conducted and analyzed a cola triangle test—a test used to determine whether there is a sensory difference between two products.
The Tomato… Flavorful or Flavorless?	Classroom – Students explored the principles of sensory evaluation as they conducted and analyzed an intent to purchase evaluation—a type of consumer acceptability test that is used to determine the likelihood that consumers would purchase a particular product.
The Perfect Package	Classroom – Students acted as food packaging engineers as they evaluated an existing food package and proposed improvements needed to make it the "perfect" package.
Can You Believe Everything You See?	Laboratory – Students explored the allure of marketing as they used the scientific method to evaluate a popular food-related, science-based television, radio, or print marketing claim.
FOOD FIGHT! Product Development Project	Project – Students became food scientists as they applied chemistry and other science concepts to the development of an original food product and complete product proposal.

Table 4.2. Items comprising attitude subscales in part two of the instrument.

Subscale	Item	
Attitude Toward Science	1.	Science is fun.
	6.	Everyone should learn about science.
	7.	I would enjoy being a scientist.
	10.	I have good feelings toward science.
	11.	I think scientists are neat people.
	14.	I really like science.
	19.	I enjoy science courses.
Motivation to Achieve in Science	2.	I always try to do my best in school.
	8.	I always try hard, no matter how difficult the work.
	13.	When I fail, that makes me try that much harder.
	18.	I try hard to do well in science.
Attitude Toward the Science Curriculum	3.	We cover interesting topics in science class.
	4.	I like our science textbook.
	9.	We learn about important things in science class.
	16.	We do a lot of fun activities in science class.
Science Self-Concept	12.	I consider myself a good science student.
	20.	I think I am capable of becoming an engineer, scientist, or doctor.

Note: Numbers preceding items indicate position of item in the instrument; adapted from Simpson and Troost (1982).

Table 4.3. Open response items in part three of the instrument.

Section	Item	
Awareness	1.	Are you familiar with the term "food science?" • If yes, provide a definition of the term "food science."
	2.	Are you aware of the academic background required for a career in food science? • If yes, please list three high school courses that would be important in pursuing a career in food science.
	3.	Are you aware of the education and/or training required after high school to become a food scientist? • If yes, what education and/or training is required? • Where would you receive this education and/or training?
	4.	Are you familiar with jobs that a food scientist might hold? • If yes, please provide three examples.
Intended Career Choices	5.	I intend to pursue the following career 1. __________. 2. __________. 3. __________.
Interest in Food Science	6.	Would you consider a career in food science?

Note: Numbers preceding items indicate position of item in the instrument.

Table 4.4. Teacher interview questions.

Question	
1.	Do you believe that food science-based instruction was effective in improving students' attitudes toward science?
2.	Do you believe that food science-based instruction was effective in increasing students' awareness of food science and academic and career opportunities in the field?
3.	Do you believe that students who participate in food science-based instruction are more likely to pursue careers in food science?
4.	What effect, if any, did your experience with food science-based instruction have on your teaching practice?
5.	What effect, if any, did your experience with food science-based instruction have on your attitude toward teaching?
6.	How did your experience with this project affect your awareness of food science and academic and career opportunities in the field?
7.	Based on your experience, what advantages does food science-based instruction offer to teachers and students over traditional instruction?
8.	Based on your experience, what disadvantages does food science-based instruction present to teachers and students compared traditional instruction?
9.	Do you believe that food science-based instruction can be an effective instructional tool in the high school science classroom?
10.	Would you use food science-based instruction in your classroom in the future? • If so, what would you do differently?
11.	What resources would you need to make your efforts in food science-based instruction more effective?
12.	Other than its stated goals, what effect, if any, did the project have on your students?

Table 4.5. Reliability of instrument subscales.

	Number of Items in Subscale	Reliability
Attitude Toward Science	7	0.861
Motivation to Achieve in Science	4	0.739
Attitude Toward the Science Curriculum	4	0.718
Science Self-Concept	2	0.550

Table 4.6. Pearson correlation coefficients for instrument subscales.

	Motivation to Achieve in Science	Attitude Toward the Science Curriculum	Science Self-Concept
Attitude Toward Science	0.415	0.602	0.619
Motivation to Achieve in Science	-	0.382	0.807
Attitude Toward the Science Curriculum	-	-	0.854

Note: All values are significant at $p < 0.0001$.

Table 4.7. Pre- and post-evaluation mean scores (standard deviation) for instrument individual items and subscales.

		Pre-Evaluation	Post-Evaluation
Attitude Toward Science			
1.	Science is fun.	3.66 (0.92)	3.96 (0.85)
6.	Everyone should learn about science.	4.12 (0.91)	4.31 (0.85)
7.	I would enjoy being a scientist.	2.88 (1.29)	3.08 (1.27)
10.	I have good feelings toward science.	3.77 (0.95)	3.90 (0.93)
11.	I think scientists are neat people.	3.90 (0.80)	3.99 (0.80)
14.	I really like science.	3.48 (1.14)	3.72 (1.05)
19.	I enjoy science courses.	3.60 (1.07)	3.70 (1.08)
Subscale Mean		**3.63 (1.08)**	**3.81 (1.05)**
Motivation to Achieve in Science			
2.	I always try to do my best in school.	4.46 (0.67)	4.57 (0.68)
8.	I always try hard, no matter how difficult the work.	4.35 (0.70)	4.39 (0.72)
13.	When I fail, that makes me try that much harder.	4.42 (0.76)	4.36 (0.69)
18.	I try hard to do well in science.	4.40 (0.63)	4.38 (0.66)
Subscale Mean		**4.41 (0.69)**	**4.42 (0.69)**
Attitude Toward the Science Curriculum			
3.	We cover interesting topics in science class.	3.79 (0.80)	4.00 (0.81)
4.	I like our science textbook.	3.26 (0.83)	3.36 (0.82)
9.	We learn about important things in science class.	4.23 (0.69)	4.37 (0.60)
16.	We do a lot of fun activities in science class.	3.75 (0.84)	4.09 (0.73)
Subscale Mean		**3.76 (0.86)**	**3.95 (0.83)**
Science Self-Concept			
12.	I consider myself a good science student.	3.75 (1.01)	3.82 (0.94)
20.	I think I am capable of becoming an engineer, scientist, or doctor.	4.10 (1.05)	4.09 (1.12)
Subscale Mean		**3.92 (1.04)**	**3.95 (1.04)**

Table 4.8. Frequency and percent difference of high school students' intended career fields identified in pre- and post-evaluations.

	Pre-Evaluation	Post-Evaluation	% Difference
Administrative	1	1	0
Armed Forces	1	0	-100
Business and Financial Management	31	33	6
Construction	1	2	100
Installation	3	2	-33
Professional			
a. Computer and Mathematical	11	11	0
b. Architecture and Planning	4	2	-50
c. Science and Engineering	29	30	3
d. Food Science	**3**	**9**	**200**
e. Social Science and Social Services	17	16	-6
f. Law and Public Policy	28	21	-25
g. Education	14	21	50
h. Art and Design	14	17	21
i. Performance and Entertainment	33	35	6
j. Media and Communications	21	18	-14
k. Medicine and Healthcare	84	82	-2
Sales	4	5	25
Service	15	14	-7
Transportation	6	7	17
Undecided	25	17	-32

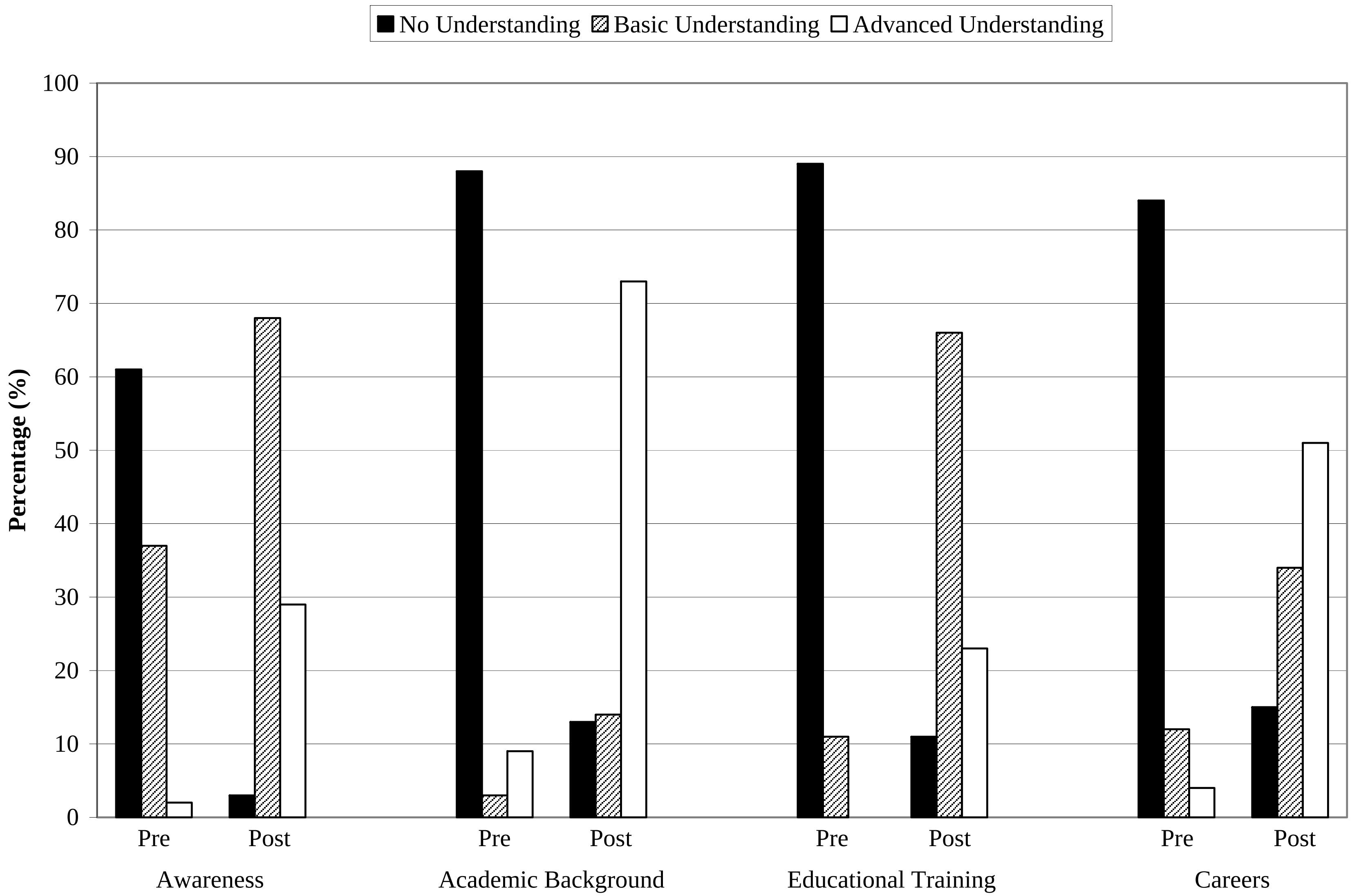

Figure 4.1. High school students' pre- and post-instruction awareness of food science and academic and career opportunities in the field.

CHAPTER FIVE

INTEGRATING ACTIVE LEARNING INTO FOOD CHEMISTRY[3]

[3] Peacock, AR and Shewfelt, RL. To be submitted to the NACTA Journal.

Abstract

University food science programs are not producing enough qualified graduates to fulfill the food industry's growing demand for food scientists. Developing well-prepared food science graduates that have the skills needed to succeed requires university food science programs to move away from traditional instructional techniques toward a learner-centered approach that actively involves students in their own learning. As a result of its applied nature, food science readily lends itself to active learning techniques in which students build on their prior knowledge of the sciences to make new meaning as they apply that knowledge to authentic situations encountered in the food industry. The objectives of this study were (1) to enhance student learning by incorporating active learning strategies into an undergraduate food chemistry course, (2) to assess students' attitudes toward active learning, and (3) to evaluate the effects of active learning techniques on student achievement of course learning outcomes. In-class lectures were replaced by a combination of in-class active learning exercises and out-of-class automated, web-based lectures. Students enjoyed active learning exercises but showed resistance to change from more traditional instruction. Students had difficulty in connecting exercises to course learning outcomes. Students' course evaluation scores generally improved following changes made to the course. Assessment scores did not show improvement following the use of active learning exercises. To fully realize the expected benefits of active learning, instructors must overcome student resistance to non-traditional teaching methods by making the link between these techniques and learning outcomes more explicit to students.

Introduction

University food science programs are not producing enough qualified graduates to fulfill the food industry's growing demand for food scientists. Annually, 52,000 positions will be available for college graduates with food, agriculture, and natural resources degrees through the year 2010 (Goecker and others 2005). Following current trends, university programs, food science programs included, will not meet this demand. Therefore, it is critical that food science graduates be well prepared to meet the challenges of the food industry. With this in mind, the goal of university food science programs is to prepare students who have the professional knowledge and skills needed to succeed in the food industry. In its education standards, the Institute of Food Technologists (IFT), a nonprofit scientific and professional society for food scientists and technologists, asserts that success in the food science industry requires skills in oral and written communication, critical thinking, computer applications, professionalism, ethics, lifelong learning, teamwork, information acquisition, and organization (Institute of Food Technologists 2005).

Developing well-prepared food science graduates that have the skills needed to be successful requires food science programs to move away from traditional instructional techniques. Lecture is the oldest and most widely used method of instruction in higher education (McKeachie 2002; Terenzini and Pascarella 1994). However, compared to more active instructional techniques, lecture is less effective as measured by student retention of content. After 24 hours, students retain only 5% of lectured material, while retention for more active techniques, such as group discussion, practice by doing, and teaching others is 50%, 75%, and 90%, respectively (Sousa 1995). In lecture settings, students act as passive recipients of knowledge. This passive mode of learning produces little retention of knowledge and limited development of students' critical thinking abilities. These outcomes are directly contrary to the desired outcomes for preparing food science graduates.

Achieving the goal of adequately prepared food science graduates requires a shift to a learner-centered pedagogy that encourages students to become actively involved in their own learning process. This active learning approach stems from the constructivist view that learners actively construct their own meaning through interactions with content, peers, and instructors, thereby promoting deeper understanding of content (Bruning and others 2004; Wiggins and McTighe 1998) and increases in student achievement (Reitmeier 2002; Terenzini and Pascarella 1994), engagement (Bonwell and Eison 1991), metacognitive abilities (Thompson and others 2003), and retention and retrieval (Sousa 1995; Thompson and others 2003). This approach requires students to plan and direct their own learning and to think explicitly about what they are learning and doing. The active learning classroom has students as its focus and requires students to analyze, synthesize, and evaluate knowledge as they engage in reading, writing, discussion, or problem solving (Bonwell and Eison 1991).

As a result of its applied nature, food science lends itself to active learning. During food science coursework, students build on their prior knowledge of the sciences to make new meaning as they apply that knowledge to authentic situations encountered in the food industry. This application of knowledge to authentic situations provides continual opportunities to incorporate active learning techniques into teaching and learning of food science.

The objectives of this study were (1) to enhance student learning by incorporating active learning strategies into an undergraduate food chemistry course, (2) to assess students' attitudes toward active learning, and (3) to evaluate the effects of active learning techniques on student achievement of course learning outcomes.

Materials and Methods

Course Structure

Food science majors (n=17 in fall semester 2004 and n=14 in fall semester 2005) were enrolled in Food Chemistry, a three credit, upper-level, core undergraduate food science lecture and laboratory course that is offered fall semester each year. The course examines chemical, physical, and functional properties of food constituents and ingredients. The course textbook was *Food chemistry: Principles and applications* (Christen and Smith 2000). Previously, the 30 semiweekly lecture sessions consisted of 3 periods: a 20-minute in-class discussion of assigned reading, a 10-minute student presentation of the molecule of the day, and a 20-minute lecture introducing material to be discussed in the following class session. In this study, the 30 course lectures were grouped into five six-lecture segments. Each segment was organized around a key course topic and designed to emphasize one of five course learning outcomes (Table 5.1). For course segments two through five, in-class lecture periods were replaced by a combination of in-class active learning exercises and out-of-class automated, web-based lectures.

Active Learning Exercises

Active learning exercises replaced the 20-minute in-class lecture period in course segments two through five. Multiple exercises were used in each segment to emphasize the specific course learning outcome designated in each course segment. Exercises were adapted from Angelo and Cross (1993) and Silberman (1996). One example was the use of applications cards, which asked students to identify real-world applications of newly learned concepts or principles (Angelo and Cross 1993). These applications tied new learning to students' prior knowledge. In a specific example, students were asked to describe applications of the concept, "Starches are chemically modified to improve ingredient functionality." This activity served as both a learning exercise and an informal assessment of student understanding.

Automated, Web-based Lectures

Automated, web-based lectures were produced to replace in-class lectures for course segments two through five. Lectures were captured using Camtasia® software and made available through WebCT® online course management software. Each automated, web-based lecture could be played in its entirety by selecting a single web-page link from within the WebCT® interface. These lectures were designed for delivery over both high- and low-bandwidth connections. Each automated, web-based lecture contained instructions to pause, stop, and restart the lecture; a brief introduction from the instructor; a narrated PowerPoint® presentation; and a brief summary from the instructor. Students were expected to watch the lectures on WebCT® outside of the scheduled class time.

Data Collection and Analysis

Written assessments were given to all students in the course at the end of each course segment. Each assessment was composed of five sections corresponding to each of the five learning outcomes, respectively (Table 5.2). Assessments were evaluated by the instructor and by the graduate teaching assistant. For each assessment, the assessment section corresponding to the course outcome emphasized during the preceding lecture segment was compared to the section mean across all exams to determine whether targeted active learning exercises affected students' performance. Student responses to the course format were assessed during small focus group sessions. Focus group questions are presented in Table 5.3. Student evaluations of the course and instructor were compared to evaluations collected in fall 2003 before course changes were implemented. Student responses to evaluation items were recorded using a five-response Likert-type scale. A response of one indicated strong agreement, and a response of five indicated strong disagreement.

Year Two Modifications

The study was repeated for a second year with modifications. The first and last classroom exercise period of each course segment was replaced with a 20-minute in-class lecture that previewed and reviewed the key concepts of the segment. Active learning exercises and automated, web-based lectures were implemented for lecture segment one. Active learning exercises were modified and limited to one exercise per lecture segment. All active learning exercises were adapted from Angelo and Cross (1993). Each student was required to develop a concept map for key terms in each lecture segment. Performance in classroom exercises and homework was counted as 15% and 10% of the final course grade, respectively.

Results and Discussion

Focus group discussions in year one of this study indicated that a majority of students preferred traditional class instruction to the modified format of Food Chemistry. Web-based lectures were generally clear and understandable, but most students preferred direct, in-class instruction. In-class exercises were generally found to be more fun than lectures, but students commented that the activities were unrelated to other course materials and did not correlate well to course assessments. Student suggestions included increasing accountability for classroom exercises and class participation. Year one sample student responses to focus group questions are presented in Table 5.4.

Modifications in the second year of the study appeared to improve student responses to the in-class exercises, but there was still a preferrence for traditional lecture. Students found the web-based lectures to be an important resource, but they noted a lack of interaction with the instructor. In addition, students indicated that their motivation to watch the web-based lectures was low. In general, students enjoyed the in-class exercises, claiming they made class more fun and created a community within the classroom, but many students felt that the in-class activities did not promote learning. Year two sample student responses to focus group questions are presented in Table 5.5.

Students' course evaluation scores generally improved (that is, lower digits indicate higher satisfaction) following the changes made to the course (Table 5.6). Although scores in several categories increased in the first year of the study when compared to the control year, scores generally decreased in the second year of the study when compared to the control year. A decrease was seen in estimated study time from the control year to the first and second years.

The instructor observed that the in-class exercises forced students to use the textbook and other materials to solve problems. Observations from in-class exercises and discussions indicated that students were much better able to see the practical applications of course material. However, assessments scores for segments linked to specific learning outcomes did not show improvement following the course segment emphasizing the outcome. For year one assessments, the section scores corresponding to emphasized learning outcomes were generally below the respective section means (Table 5.7). The exceptions were the discussion section on assessment 3 and the problems section on assessment 5, which were approximately equal to the respective section mean. In year two, emphasized sections for assessments one through three were below the respective section means, while emphasized sections on assessments four and five were above the repesective section means (Table 5.8).

Conclusions

Active learning does support the goals of food science education, namely to provide highly-qualified, well-prepared graduates to fill the growing number of positions in the field. Although active learning is expected to improve student achievement (Reitmeier 2002; Terenzini and Pascarella 1994), gains were not observed in this study. Instead, students displayed resistance to change from traditional lecture to active learning techniques. Students also failed to make a clear connection between active learning exercises and course objectives. Although there are numerous benefits associated with active learning, it is not yet highly prevalent in higher education. Therefore, students have not become familiar and comfortable with active learning techniques and have difficulty in understanding the value of such strategies. The lack of understanding of the connections between active learning exercises and course objectives on the part of the students may have contributed to the lack of improvements in student achievement. To fully realize the benefits of active learning, instructors must overcome student resistance to non-traditional teaching methods by making the link between these techniques and learning outcomes more explicit to students.

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Table 5.1. Course segments and emphasized learning outcomes.

Segment	Content	Learning Outcome
1	Animal and Plant Products	Define key terms used in food chemistry
2	Contaminants and Food Additives	Recognize the role of chemicals in foods, including both beneficial and detrimental aspects
3	Enzymes and Proteins	Identify the structural and functional relationships of food chemicals in the roles of ingredients
4	Lipids and Carbohydrates	Distinguish the specific attributes of a specific food product based on general principles taught in class lectures
5	Dispersed Systems, Water, and Summary	Solve specific problems in food chemistry for a wide variety of important topics

Table 5.2. Assessment sections and designated course learning outcomes.

Assessment Section	Learning Outcome
I. Definitions & Molecules	Define key terms used in food chemistry
II. Principles	Recognize the role of chemicals in foods, including both beneficial and detrimental aspects
III. Discussion	Identify the structural and functional relationships of food chemicals in the roles of ingredients
IV. Applications	Distinguish the specific attributes of a specific food product based on general principles taught in class lectures
V. Problems	Solve specific problems in food chemistry for a wide variety of important topics

Table 5.3. Student focus group questions.

Question
1. Did you like the format of the class?
2. What did you like most about the class? • What did you like least?
3. Were the lectures on WebCT® understandable? • Were they better or worse than having them in class? • Why or why not?
4. What was the best in-class exercise? • What are other in-class exercises that were good?
5. What was the worst in-class exercise? • What are other in-class exercises that were not so good?
6. Did the in-class exercises make the learning more fun? • If so, how? If not, why not?
7. Did the in-class exercises help you learn the material better? • If so, how? If not, why not?
8. What changes should the professor make in the course structure for next year?
9. Do you have any other ideas that could make the WebCT® lectures or the in-class exercises more effective?

Table 5.4. Year one sample student comments about course.

Sample Student Comments
"Class was fun. I enjoyed the interaction with my fellow students."
"I did not take away from class and exercises as much as I thought I should have."
"I prefer in-class lecture, because the professor is not available immediately to answer questions during online lectures."
"It was too easy to slack off and not watch the lectures."
"The exercises and interaction with students were fun but did not contribute to learning."
"The exercises were not related to the lecture or covered on the tests, so I felt like it was okay to miss class."
"Next year, continue with the exercises but add in-class lecture."
"I never knew the objective of the exercise. Next year, set clear goals for activities."
"Assess exercises on tests next year. This will encourage class attendance on activity days."
"Put more emphasis on class participation, so students will come to class."

Table 5.5. Year two sample student comments about course.

Sample Student Comments
"I enjoyed the exercises because we were able to interact with students and pool ideas. Exercises were more interesting than lectures."
"I enjoyed the activities that used real food science applications."
"Lecture is better in person, because you can interact with the professor and ask questions. Although I liked the online lectures, because I could refer back to them to study for the tests."
"My motivation to watch the online lectures was very low."
"I need the interaction with a professor to motivate me. My motivation for the online lectures was not there."
"The exercises made class more enjoyable, but I did not learn from them."
"Maybe something is needed to force us to watch the online lectures."
"The thing I liked most about the class was the interaction with other students."
"Activities should be more connected to the rest of the course."
"I did not get anything from the activities."

Table 5.6. Student course and instructor evaluation summary scores.

Evaluation Item	Evaluation Year		
	2003	2004	2005
1. The instructor increased your interest in the subject.	1.95	2.27	1.53
2. The instructor was enthusiastic about the subject.	1.55	1.64	1.13
3. The instructor was willing to give individual assistance outside of class.	1.40	1.27	1.27
4. The instructor encouraged students to think for themselves.	1.55	1.45	1.27
5. The instructor was clear about the basic principles, presented them in a logical manner and tried to explain materials that were confusing to students.	2.10	2.00	1.53
6. The instructor was receptive to questions and/or discussion during class.	1.53	1.73	1.33
7. The instructor recognized student difficulties in understanding new material.	1.84	1.91	1.60
8. The instructor gave tests on materials covered.	2.00	1.80	1.20
9. The instructor was prompt in returning graded materials.	1.40	1.09	1.07
10. The instructor clearly described the grading procedures.	1.30	1.55	1.67
11. Compared with other instructors you have had at this university, how would you rate the teaching ability of this instructor?	2.00	1.45	1.20
12. Compared with other courses you have had at this university, how would you rate this course?	1.84	1.91	1.57
13. How many hours per week did you devote to this course outside of class?	4.40	3.73	3.28

(2003 – Control Year, 2004 – Year One, 2005 – Year Two; For items 1-12: 1 – Strongly Agree, 5 – Strongly Disagree)

Table 5.7. Year one average assessment section scores (%).

Section	Definitions & Molecules	Principles	Discussion	Applications	Problems
Assessment 1	**63**	74	71	76	69
Assessment 2	70	**67**	83	76	81
Assessment 3	75	76	**77**	71	72
Assessment 4	69	68	73	**67**	80
Assessment 5	73	76	77	72	**76**
Section Mean	**70.0**	**72.2**	**76.2**	**72.4**	**75.6**

(Value in bold indicates learning outcome emphasized prior to assessment.)

Table 5.8. Year two average assessment section scores (%).

Section	**Definitions & Molecules**	**Principles**	**Discussion**	**Applications**	**Problems**
Assessment 1	**60**	60	87	59	81
Assessment 2	77	**71**	76	73	69
Assessment 3	84	83	**76**	77	75
Assessment 4	73	74	76	**74**	69
Assessment 5	71	73	80	63	**80**
Section Mean	**73.0**	**72.2**	**79.0**	**69.2**	**74.8**

(Value in bold indicates learning outcome emphasized prior to assessment.)

CHAPTER SIX

CONCLUSIONS

The greatest challenge to increasing student enrollment in university food science programs is the lack of high school and undergraduate student awareness of the field. The most effective approach to improve student awareness of food science is to reach students before entering college with a program that emphasizes the role of applied science in the field of food science. Students' increased awareness of food science and academic and career opportunities in food science stands to benefit university food science programs and the food industry by increasing the supply of interested and qualified individuals to fulfill the increasing demand for technical positions in food science. Incorporating food science into the high school science classroom, along with providing accurate information to high school teachers and counselors, has great potential to increase the number of students that choose food science as a major upon entering college. The use of food science as a context for high school science instruction also has showed the potential to improve students' general attitudes toward science, thereby improving science literacy and achievement. Further, food science-based instruction provides a link between the science curriculum and the real world. To build upon recent efforts to reach high school students by incorporating food science into the high school classroom, university food science programs should develop curriculum materials, partner with high school science teachers, and work with the food industry to seek funding to provide teachers with the professional development and resources needed to engage students in the active exploration of food science. Once students arrive on the college campus, it is important that university food science programs continue to attract students through introductory classes that are well-publicized and interesting to students and through campus recruiting activities that target students with an interest in science, particularly students that may be undeclared or enrolled in basic sciences. Beyond recruiting, undergraduate food science educators should further explore maximizing the talents of future graduates by replacing traditional instructional methods with more active, student-centered approaches that develop within students the skills needed to succeed in the food industry.