

ABSTRACT

FORRESTER, JENNIFER HARRIS. Competitive Science Events: Gender, Interest, Science Self-Efficacy, and Academic Major Choice. (Under the direction of Dr. M. Gail Jones).

Understanding present barriers to choosing a STEM major is important for science educators so that we may better prepare and inspire future generations of scientists and engineers. This study examined the relationships between participation in competitive science events, gender, race, science self-efficacy, interest in science, and choosing a STEM discipline as a college major. The participants included 1,488 freshman students at a large southeastern public university. Students completed a survey of pre-college experiences with science events, science interests, and college major, as well as, an assessment of science self-efficacy. A subsample of sixty students (30 STEM; 30 non-STEM majors) were interviewed about their participation and academic major choice. Results showed that science, engineering, and non-STEM disciplines were the most frequently reported academic majors. Significant gender differences were found for science self-efficacy and academic major choice. There were significant race differences for participation in specific types of science competitions. Study participants also reported being motivated to participate in a competitive science event as a result of their teacher or parents' encouragement.

Competitive Science Events: Gender, Interest, Science Self-Efficacy, and Academic Major
Choice

by
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DEDICATION

This dissertation is dedicated to my family: my husband David, my son JD, my father Frank, and my mother Joyce.

To my wonderful husband, David: Thank you for always believing I could do it. Thank you for never letting me quit, no matter how badly I wanted to. Thank you for knowing when to push me and when to leave me alone with my thoughts. Thank you for being there. You are my best friend and soul mate. I love you.

To my sweet son, JD: I hope that you love learning as much as I do and will always follow your dreams. Don't ever let anyone tell you that you can't do something. Believing in yourself is one of the most important life lessons I hope I will be able to teach you. Mommy loves you very much!

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you one of the most amazing teachers I have ever had the pleasure of knowing. Watching you in front of a class is like watching a masterpiece unfold before my very eyes. I hope that I am able to touch the lives of my students, as you have touched the lives of yours. I love you.

BIOGRAPHY

Jennifer Harris Forrester was born Jennifer Michelle Harris on November 18, 1979 in Charlotte, North Carolina. She attended Western Carolina University for her undergraduate studies where she received her Bachelors of Science in Biology on May 5, 2002. Not knowing what to do with her professional life, she began teaching sixth grade science at Sun Valley Middle School in Indian Trail, North Carolina during the fall of 2002. After falling in love with teaching, she chose to pursue her Masters of Arts in Teaching at the University of North Carolina at Charlotte in Middle and Secondary Science Education. It was during her studies at UNCC, that she began to realize her passion in life was not only for teaching science, but was also for conducting research in science education. After graduating with her MAT in the summer of 2006, she began one of the greatest and most challenging adventures of her academic career in pursuing her PhD in Science Education at NC State University.

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TABLE OF CONTENTS

LIST OF TABLES.....	ix
COMPETITIVE SCIENCE EVENTS: GENDER, INTEREST, SCIENCE SELF-EFFICACY, AND ACADEMIC MAJOR CHOICE.....	1
Introduction.....	1
Purpose and Significance of Study.....	1
A Theoretical Framework: The Social Cognitive Career Theory.....	2
Research Questions.....	4
Review of the Literature.....	5
Factors Effecting Academic Major Choice and Career Choice Decisions.....	5
<i>Gender</i>	6
<i>Race</i>	8
<i>Mentoring Relationships</i>	10
<i>Socioeconomic Status</i>	11
<i>Self-Efficacy</i>	11
Defining a Competitive Science Event.....	14
Research Studies on Competitive Science Events.....	15
The Social Cognitive Career Theory.....	19
Methodology.....	23
Research Design.....	23
Study Site and Participants.....	23
Assessment Development.....	25
Limitations.....	27
Analysis.....	28
Qualitative Analysis.....	29
Results.....	30
Demographic Differences.....	30
<i>Total Student Population versus Study Population</i>	30
<i>Demographic Differences by Participation</i>	32
<i>Demographic Differences by Type of Event</i>	34
Competitive Science Experience Survey.....	37
Factors Influencing the Decision to Participate.....	40
<i>Science Self-Efficacy</i>	42
<i>Interest in Science</i>	44
<i>Participation Differences and Academic Major Choice</i>	44
Motivation.....	45
<i>Academic Major Choice: Semi-Structured Interview Responses</i>	45
<i>STEM Academic Major Choice</i>	45
<i>Non-STEM Academic Major Choice</i>	47
Participation in a Competitive Science Event.....	48

<i>Motivation to Participate in a Competitive Science Event:</i>	
<i>Semi-Structured Interview Responses</i>	49
Competition Outcomes: Winning or Losing a Competitive Science Event.....	51
<i>STEM Majors</i>	51
<i>Non-STEM Majors</i>	52
Conclusion.....	53
Discussion.....	54
Participants in Competitive Science Events.....	55
<i>Gender and Race Differences of Participants by Event Type</i>	55
<i>Science Self-Efficacy Difference by Participation</i>	57
<i>Competition Outcomes and Science Self-Efficacy</i>	58
<i>Gender Differences in Science Self-Efficacy</i>	60
<i>Participation Differences in Interest in Science Outside of School</i>	61
<i>Valuing the Competitive Science Experience</i>	63
Motivation to Participate in a Competitive Science Event.....	63
Academic Major Choice.....	64
<i>Gender Differences in Academic Major Choice</i>	64
<i>Science Self-Efficacy Differences Between Academic Majors</i>	65
<i>Differences in Academic Major Choice by Event Type</i>	66
<i>Other Motivational Factors Influencing Academic Major Choice</i>	67
<i>Non-STEM Majors</i>	67
<i>STEM Majors</i>	67
Interest in Science.....	67
Implications for K-16 Education.....	69
Future Research.....	70
Conclusion.....	71
References.....	72
APPENDICES.....	84
Appendix A. Competitive Science Experience Survey.....	85
Appendix B. Semi-Structured Interview Questions.....	88

LIST OF TABLES

Table 1	Demographics of Study Participants.....	24
Table 2	Types of Competitive Science Experiences.....	26
Table 3	Demographics of Types of Majors (STEM vs. Non-STEM).....	31
Table 3.1	Demographics of Individuals Who Competed or Not in a Competitive Science Event.....	33
Table 3.2	Demographics of Individuals by Competitive Science Event Type.....	35
Table 3.3	Summary of Differences Between Types of Competitive Events by Gender, Race, and Academic Major Choice.....	36
Table 4	Differences in Survey Results.....	38
Table 5	Overall Model Fit for the Proposed Logistic Regression Model.....	40
Table 6	Summary of Predictor Variables for Participating in a Competitive Science Event.....	41
Table 7	Science Self-Efficacy Means, Standard Deviation, and P-Values.....	44
Table 8	Motivation to Participate in a Pre-College Competitive Science Event.....	50
Table 9	Comparing Formal, Non-Formal, and Informal Learning Environments and Science Teaching.....	62

Introduction

Purpose and Significance of the Study

One goal of science education, according to educators and political leaders alike, is to inspire and cultivate the next generation of scientists and engineers. Recently, this education goal has received attention as current research has highlighted the decline in U.S. students majoring in science, technology, engineering, and mathematics (STEM) (Panteli, Stack, & Ramsay, 2001). This decline has paralleled the decrease in qualified graduates in this country to enter into STEM careers. According to the National Science Foundation (2004), since 1966 there has been a 2.9% decrease in bachelor degrees, a 7.9% decrease in master's degrees, and a 2.2% decrease in doctorates awarded in science and engineering fields in the U.S. Out of those students receiving degrees in STEM fields, only 44% work in a science and engineering or related occupation, leaving 56% of science and engineering graduates not employed in a STEM field at all (National Science Foundation, 2003). Declining enrollment in STEM classes on U.S. university campuses hinders our ability to compete in a science and technology-based global economy, as well as affects citizens' ability to participate effectively in science policy decisions (Betz, 1992; Fox & Richmond, 1979).

Many possible barriers exist to selecting a STEM major and may lead to a subsequent decline in the pursuit of STEM careers. Such barriers include: a decrease of interest in science; a decline in science self-efficacy; perceived gender and race barriers; and a decrease or lack of practical hands-on science experiences (Luzzo, Hasper, Albert, Bibby, & Martinelli, 1999; Lent & Brown, 2001). The nature and context of students' experiences with science could also impact the strength and presence of these barriers. For example,

some researchers have discussed the disconnect students feel between the science they learn in school and the science they learn outside of school (Aikenhead, 2005; Osborne, Simon, & Collins, 2003). However, research shows that when science is presented in a context of its “real world” application it is valued and remembered (Lave, 1988).

Studies have shown that participating in out-of-school academic activities may influence self-efficacy and emerging cognitive abilities (Eccles, Wigfield, & Schiefele, 1998; Gauvain, 1999; Guberman, 1999). Specifically, math and science out-of-school activities have been positively associated with student interest in science and these activities have a positive influence on self-efficacy (Dickhauser & Steinsmeir-Pelster, 2003; Jacobs, Finken, Griffen, & Wright, 1998). Self-efficacy is one’s perception of their capabilities for learning or performing an action (Bandura, 1997). Researchers have documented that students between the ages of five and sixteen only spend 14-18% of their waking hours in school (Bransford, 2006; National Research Council, 2001), leaving more than 80% of their time out-of-school. Despite these documented statistics, the influence of extracurricular science activities and out-of-school science experiences on students’ academic major choice and career goals has not been clearly delineated. The goal of this research was to examine the relationships between participation in competitive science events, gender, race, science self-efficacy, interest in science, and choosing a STEM discipline as a college major.

A Theoretical Framework: The Social Cognitive Career Theory

Few studies have been conducted (or exist) that examine learning experiences and their relationships to academic major choice. The social cognitive career theory (SCCT) has been used to explore career choice variables in formal education settings (Lent, Brown, &

Hackett, 1994, 1996) but not in out-of-school contexts. The SCCT was developed in an attempt to explain the processes and mechanisms through which, “(a) career and academic interests develop, (b) career-relevant choices are forged and enacted, and (c) performance outcomes are achieved” (Lent et al., p. 80, 1994). Because it has been established that models of academic choice use similar causal mechanisms as those used in models of career development, the SCCT can be applied to investigations of both academic major and career choice behaviors (Lent et al., 1994) and was used as a framework for this study. Major factors in the SCCT model include: self-efficacy, interests, learning experiences, background contextual affordances, and establishing goals (Lent et al., 1994, 2000, 2002).

Research Questions

The overall aim of this study was to explore the relationship between pre-college participation in a competitive science and students' academic major choice. This study also examined and documented how competitive science events could influence interest in science, science self-efficacy, and gender and race barriers in science. The specific research questions of this study were:

1. What are the characteristics (gender, race, and academic major) of an individual who chooses to major in a STEM discipline?
2. Are there differences in general science self-efficacy and interest in science between students who participate in a pre-college competitive science event and those who do not?
3. What factors do students recall as motivating them to participate in a pre-college competitive science event?
4. Is there a relationship between pre-college participation in a competitive science event and academic major choice?

In the chapters that follow: factors effecting academic majors and career decision choices, defining a competitive science experience, current and pass research studies on science competitions, and the social cognitive career theory are discussed.

A Review of the Literature

Factors Effecting Academic Major and Career Choice Decisions

A number of factors play a role in choosing a career. Research has investigated many of these factors including: self-efficacy, gender, race, socioeconomic status, ethnicity, motivation, expectation outcome, mentoring relationships, and personality traits (Smith & Calasanti, 2005; Dick & Rallis, 1991; Thompson & Subich, 2006). Identifying the relationships between these factors and career choices has enabled researchers to offer explanations of people's career decisions and career-decision-making processes. These relationships also offer educators the opportunity to identify and strengthen factors that may influence academic major choice and career decision. For example, Dick and Rallis (1991) found males and females who choose a science and engineering career have similar career profiles compared to those who do not choose a science and engineering career. The most significant variable reported by participants as mediating their choice of a science or engineering career was the relationship with and mentorship of their teachers. This finding suggests that teachers and other adult role models may be a powerful predictor and influence on academic major choice and career goals.

Career choice decisions and career-related decisions such as applying for a promotion, or starting a completely new career trajectory have been found to be effected by ones gender, race, and ethnicity (Betz, 1990; Hackett, 1985; Hilton & Lee, 1988). Previous research has highlighted the disproportionate representation observed in science, technology, engineering, and mathematics (STEM) majors and careers between the number of men and women as well as Caucasian and minority groups (National Science Foundation, 2003,

2004). Smith and Calasanti (2005) investigated career decisions of tenure track faculty by examining how social isolation within academic institutions differs by race, gender, and ethnicity and if these patterns of isolation are related to participants' decisions or intentions to deviate from their career paths. Findings indicated that Asian Americans felt more institutionally isolated than whites. However there was no difference between African Americans and whites in terms of institutional isolation. Results also showed a significant difference between males and females, with females reporting more feelings of social isolation. These feelings of isolation by certain minority groups and by women may explain the career decision patterns observed in certain academic domains such as science, technology, engineering, and mathematics.

Gender

Understanding how gender affects the career choice process (especially academic major choice) is essential to reversing the pattern of women not choosing careers in the sciences, specifically physics, engineering, and earth science. There have been a number of studies that examined reasons for an unequal representation of women in the sciences (Betz, 1990; Hackett, 1985; Hilton & Lee, 1988; Fernandez, Castro, Otero, Foltz, & Lorenzo, 2006; Maple & Stage 1991).

Ambition and motivation have been researched in an attempt to identify which factors have the most influence in the academic major and career decision-making process for females. Francis (2002) found that females in high school are more ambitious about their future occupations than females in high school were 20 years ago. Findings also indicated that female participants show interest in an array of jobs, which is a significant change from

previous studies conducted in the 1980's (Francis, 1996). The majority of the female participants (n=100; 50 females and 50 males) viewed their chosen career trajectory as reflecting their identities. Despite the positive patterns of change in female career choice highlighted in this study, few of the female participants opted for technical, business, or scientific jobs (Francis, 2002). The positive shift observed in anticipated career trajectory for high school females is not paralleled in their choice of academic major selection. Studying females during the time between high school and graduating from college may bring to light reasons why the rift in career selection of science and engineering continue today. The current study examined factors influencing academic major choice in an attempt to highlight those reasons.

Farmer, Wardrop, and Rotella (1999) attempted to identify which factors differentiated women in a science career from women in other career fields. The authors discovered that African American and Hispanic women had substantially higher career aspirations than European American women. These career aspirations had a direct effect on choosing a career path in science. In fact, longitudinal data suggests that if female students possessed these high career aspirations in high school, they were more likely to make career-decisions along a path to a science career as young adults (Farmer et al., 1999). Examples of such factors effecting career-decisions may include taking more science and advanced science courses, or participating in an extracurricular science experience such as a science club or competition. The strongest predictor for women pursuing a career in science or engineering was whether or not they valued the science content to which they had been exposed (Farmer et al., 1999). This piece of evidence may indicate the importance of

demonstrating the relevance of what students are learning in the K-12 classroom with their everyday lives. Participation in competitive science events may be the vehicle needed to make those connections.

Fernandez, Castro, Otero, Foltz, and Lorenzo (2006) identified connections between college major, motivation (intrinsic and extrinsic), career goals, sexist attitudes towards women, and gender reported by 448 undergraduates attending a large university in Spain. Analyses indicated that both males and females participants pursuing a career in the technical fields (physical science, engineering, and applied mathematics) reported more sexist attitudes than do participants who indicated career goals in a non-technical (social sciences and humanities) major. Findings also suggest that women in technical majors tend to identify with men and their stereotypes and attitudes (Fernandez et al., 2006). The authors suggested that females engaged in science and engineering majors and career paths may adopt the sexist attitudes of their male peers in an attempt to successfully integrate themselves into the male dominated culture of science (Fernandez et al., 2006).

Race

The inequalities in career outcomes in science, technology, engineering, and mathematics (STEM) are not only byproducts of differences in gender but also in race and ethnicity. There are many different aspects of race that have been examined in relation to career choices. Social capital (the access to social networks to advance one's station in life) is one such a variable. Access to certain social networks may provide students with the opportunity to learn the "unwritten" rules and procedures of the culture of science and engineering. Many universities offer paid internship opportunities for their students to gain

social capital in preparation for their chosen careers. Parks-Yancy (2006) analyzed which racial groups (blacks and whites specifically) and gender have more or less access to social capital resources and the subsequent effect this had on their careers. Findings indicated that white men have better career outcomes than black women in terms of promotion and gross earnings. Black men had advantages over black women in regards to earnings but not promotion and white women were more advantaged in both areas than either black men or women. In this study, gender and race had the greatest effects on earnings, but social capital resources were shown to have an impact as well. As shown, social capital resources are not equally available to minority groups. This inequality may influence career selection in the STEM areas and may explain the current racial gap observed between whites and minority groups in science, technology, engineering, and mathematics careers.

Research has indicated that there are some career choice factors that are not affected by race or gender. Osborn, Howard, and Leiter (2007) reported that for 158 freshman students who participated in a career development course aimed at changing dysfunctional career thoughts, gender and race were not related to the observed changes. Other research, however, has shown race differences in regards to career role models and mentors. For example, Karunanayake and Nauta (2004) examined college students' (n=220) career role models and found that most students (all but two) identified some type of role model that they admired and would like to imitate. A large majority of these role models were of the same race/ethnicity as the participant, even if they were not a family member. Researchers have suggested that minorities may intentionally identify with a role model of similar race/ethnicity in hopes of learning how to successfully maneuver their chosen career field

(Assibey-Mensah, 1997; Greene, 1990; Hackett & Byars, 1996). Mentoring relationships are a common theme found in the career and academic major choice literature when examining race, gender, and ethnicity. It is imperative that such relationships are researched in depth in different social and learning environments so that female and minority students will be a part of the next generation of scientists and engineers.

Mentoring Relationships

Positive relationships with adults as role models and mentors have a profound effect on an individual's career choices. For instance, the nature and role of families in children's development of achievement, intelligence, and social skills has been well documented in the literature (Dierking & Falk, 1994; Epstein, 1987; Fehrmann, Keith, & Reimers, 1987; Parsons, Adler, & Kaizala, 1982; Renihan & Renihan, 1995). The development of these skills is important for future career development, such as academic major choice, and assimilation into specific cultures of practice (like the culture of science). The family has been shown to be an especially important factor in career choice and development for minority students. Parental expectations, measured by encouraging their child to take advanced science and mathematics courses, have been found to be a strong indicator in academic performance (standardized test scores) (Smith & Hausafus, 1997).

Fadigan and Hamrich (2004) conducted a study exploring the career trajectories of minority women who had participated in an informal science education enrichment program at a museum while in high school. The researchers showed that participation resulted in increased enrollment in advanced placement or honors-level STEM courses during high school. A large majority of participants indicated the relationships with staff members and

the friendships forged during this informal education experience steered their career trajectories in the direction of a STEM or STEM related career.

Socioeconomic Status

Unlike mentoring relationships, factors such as gender, race, and ethnicity are unchanging throughout a persons' life. Social status may also be a difficult factor to alter. Social status is a product of several components such as socioeconomic status, parental occupation, and household gross incomes (Thompson & Subich, 2006). Thompson and Subich (2006) conducted a study exploring the relationships between social status, career decision self-efficacy and the career decision-making process. Participants (74 males and 147 females) who reported greater economic resources, social power, and social prestige also reported greater confidence in their abilities to complete career decision-making tasks (Thompson & Subich, 2006). According to the study analysis, the correlation observed between social status and career choice was accounted for by participants' career decision self-efficacy. This suggests that any effect social status has on career decisions occurs through the mechanisms of self-efficacy. Thompson and Subich (2006) did not report correlating gender or race to the variables career decision self-efficacy, economic resources, social power and prestige.

Self-Efficacy

Self-efficacy can have an effect on one's school performance, peer and family relationships, and academic major and career choices (Schunk & Meece, 2006). The construct of self-efficacy is grounded within the social cognitive theory, which claims that people self-regulate their thoughts, motivations, and actions through cognitive processes

(Bandura, 1986, 1997; Pajares, 1997). This control extends to perceptions, allowing “beliefs in one’s capability to organize and execute the course of action required to manage prospective situations” (Bandura, 1997, p. 2). Self-efficacy is task and situation specific because it deals directly with one’s perception of his or her capabilities to achieve a certain goal (Pajares, 1997).

Self-efficacy information comes from four sources: mastery experiences (also known as actual performances or performance attainments), vicarious experiences (watching others), forms of persuasion (verbal or non-verbal), and physiological reactions (Bandura, 1997; Pajares, 1997). According to Bandura (1986) mastery experiences are the most significant sources of self-efficacy information because success or failure on past attempts of achieving a goal has the strongest impact on if one will try for the same or similar goal in the future. For example, if a student is successful in his or her science class he or she will more than likely sign up for another one.

Vicarious experiences are a second source of self-efficacy information. Although weaker than mastery experiences because people do not rely on experiences they themselves do not participate in as much as ones they do, watching others perform a task or action successfully can increase one’s self-percepts of efficacy, convincing the observer that they too possess the skills necessary to negotiate similar activities (Bandura, Adams, Hardy, & Howells, 1980; Kazdin, 1979). Relationships with peers serve as another avenue for acquiring self-efficacy information (Schunk & Meece, 2006) through social comparisons and role modeling (Pajares, 1997). Self-efficacy can also develop via verbal persuasion received from family members, peers, and teachers (Pajares, 1997). Lastly one’s physiological states can act as a

method of self-efficacy information transfer. Stress, anxiety, fear, and other emotional moods can alter self-efficacy beliefs (Pajares, 1997).

Self-efficacy research has included studies on group differences, mainly focusing on gender. Researchers are unable to come to a consensus with regards to gender differences because of the number of mixed findings. Some studies on gender and self-efficacy have indicated that male students have greater self-efficacy beliefs (Anderman & Young, 1994; Meece & Jones, 1996; Pintrich & De Groot, 1990; Zimmerman & Martinez-Pons, 1990) while others indicate that girls have greater self-efficacy (Britner & Pajares, 2001). Zeldin, Britner, and Pajares (2006) conducted a comparative study of men and women's self-efficacy beliefs whom were currently in a mathematics, science, or technology career. Zeldin et al., (2006) documented the narratives of men (n=10) in a STEM career to understand the influence of their self-efficacy beliefs on their academic and career choices (Zeldin et al., 2006). Participants recalled that mastery experiences were the most influential source of self-efficacy belief information in developing their academic major and career trajectories. They also reported vicarious experiences and verbal persuasions as playing a key role in their self-efficacy development. These findings were compared to a previous study of women in STEM careers and the influence of their self-efficacy beliefs on career choice (Zeldin & Pajares, 2000). The major difference between the two genders was that women felt relationships with their family members, teachers, and peers were the most important source of self-efficacy information. This observed difference may serve as further justification for creating strong mentoring programs for girls interested in the STEM career areas.

Lent, Lopez, and Bieschke (1991) reported findings of a similar study that explored relationships between students' mathematic self-efficacy beliefs, gender and science-based occupational choices. Male participants reported higher mathematics self-efficacy beliefs than women. Researchers discovered that these gender differences decreased when male and female participants had similar coursework during middle and high school (Lent et al., 1991; Lent, Brown, & Larkin, 1984, 1986). Ultimately, mathematics self-efficacy had an indirect statistical relationship with choosing a science-based career. Further research is needed to tease apart the different types of self-efficacy most influential in choosing a STEM related academic major or career.

Defining a Competitive Science Experience

Formal competitive science experiences have been around since at least 1828 when the first Science and Technology Exposition was held in New York City (Silverman, 1986). The number of competitive science experiences has grown exponentially over the last 200 years to include Science Olympiads, Environthons, Odyssey of the Mind, and Science Decathlons to name a few. Competitive science experiences typically include the following components: (1) an extracurricular environment, (2) working with science content, (3) competition, and (4) elements of student choice. Not all competitive science experiences exhibit all of these components, but science content and competition are common to all. Science fairs, for instance, are usually done individually (some exceptions are made at the elementary level). On the other hand, Science Olympiad has both competitive and cooperative characteristics, is usually student directed, may involve team competitions, and event preparation and competition takes place outside of school.

Research Studies on Science Competitions

There is a dearth of research on science competitions. Studies that have been conducted in this area have not examined the influence of participating in a science competition on students' science self-efficacy, academic major choice, or career goals. However studies have investigated the gender difference in participation, students' attitudes and motivations for participating, perceived rewards for participating, and the influence of creating events for science competitions on pre-service and in-service teachers attitudes towards teaching (Czerniak & Lumpe, 1996; Breyfogle, 2003; Mettas & Constantinou, 2007; Greenfield, 1995; Jones, 1991; and Hounsell, 2000).

Adamson, Foster, Roark, and Reed (1998) examined 268 science fair projects from 322 elementary school students (grades 1-6) over a two-year period. The researchers were interested in determining if male and female students tended to display different levels and forms of engagement with the scientific process during creation of a science fair project. Findings indicated that female students were more likely to work within the areas of social and biological sciences than male students. Despite the differences observed in the area of science being investigated by the student, both male and female students were equal in their level of engagement with the scientific process as well as their achievement during the competition.

Jones (1991) conducted a similar study with middle and high school students (1113 males and 972 females) to determine if gender differences existed in student involvement in science competitions (specifically science fairs, Science Olympiad, Junior Science and Humanities Symposia, the NC Student Academy of Science, and the Westinghouse Science

Talent Search) and the science domains selected for students' projects. Jones (1991) found that more males competed in each type of competition with the exception of the senior level regional science fair and the junior level state science fair. Male students also reported having a higher level of interest and participation in the physical sciences, while female students indicated higher interest and participation levels in the biological sciences.

It is interesting to note that unlike Jones (1991), Adamson et al. (1998) found no discrepancies between the levels of participation by gender for elementary students. Because of the trends seen in previous gender studies on science competition participation, investigating the role of gender, and other demographic variables (race and age) is an important next step for researchers. Understanding these variables influences on academic major choice and career selection may assist science teachers at all levels in developing the next generation of scientists and engineers.

In another study of science fairs, Czernaik and Lumpe (1996) utilized Ajzen and Madden's (1986) theory of planned behavior (TPB) as a theoretical lens to examine what factors predicted student attitudes toward entering a district science fair, students' perceptions of approval or not of their participation, and autonomy in choosing to participate. The TPB consists of three components: attitude toward behavior, subjective norm, and perceived behavioral control. These components interact with belief-based factors, which contribute a partial influence on people's intentions and behaviors (Ajzen & Madden, 1986). A questionnaire was used to document the components of TPB, grade level, type of school (public vs. private), gender, GPA, requirements to complete the science fair, participation in gifted classes, participation in research courses, and levels of anxiety. Results indicated that

54% of participants reported learning something to be the most important reason for competing in a science fair. Twenty-eight percent reported receiving extra credit, 23% receiving money and prizes, 14% impacting their academic record, and 10% meeting new people as subsequent reasons for science fair participation. The strongest predictors of behavioral control were school type (public or private), parents' level of education and research programs provided at participants' schools.

Breyfogle (2003) investigated the effect of pre-service teacher involvement with the preparation and supervision of chemistry-related events for a regional Science Olympiad tournament. During a secondary science methods course, pre-service teachers were required to design and run selected chemistry events for a class project. Findings from this study implied that pre-service teachers were able to experience first hand, the logistics of being a classroom teacher, such as preparing lab equipment and materials, live trouble-shooting, and clean up for a large number of students. Participants reported increased confidence in their classroom management abilities from this practical experience. They also indicated they would be more likely to encourage their future students to participate in Science Olympiad. In fact, three of the participants are now Science Olympiad coaches at the high schools were they teach. These pre-service teachers were able to gain an appreciation of: (a) preparing chemistry lab experiences, (b) be exposed to a variation of student responses to the activity or experiment, (c) acquired experience with answering spontaneous student derived questions, and (d) encountered authentic experience working in a laboratory setting.

In a similar study, Mettas and Constantinou (2007) examined how 52 pre-service teachers' participation in a Technology Fair influenced their involvement and interest in

technology as well as the level of understanding and different strategies used. Mettas and Constantinou (2007) collected data using pre, mid, and post-tests, reflective writings in participants' diaries. In addition they documented participants' difficulty with problems and how they solved them. Twelve participants were selected and interviewed at the conclusion of the intervention. The intervention included six tasks. Each pre-service teacher collaborated with one student (ages 10-12) to complete the tasks. The results of this study indicated that 94% of the pre-service teachers characterized the opportunity to participate in a technology fair as an important experience for their future teaching practices. A significant number of pre-service teacher participants considered themselves to be more effective at identifying technology related problems and in a better position to overcome unforeseen obstacles they may encounter while teaching technology problem solving skills. Eighty-six percent of participants noted that primary school children worked on the design parts of their projects with enthusiasm and positive attitudes. This reaction from the students inspired and motivated the pre-service teachers to develop well thought-out lessons and design problems. Seventy-four percent of participants also recognized a shift in the structure and development of their teaching approaches; their approach changed from a structured and rigid model to a more flexible teaching strategy generally more consistent with a constructivist model.

Both Breyfogle (2003) and Mettas and Constantinou (2007) illustrate the importance of teacher involvement in extracurricular competitive science experiences, at the pre-service and in-service levels. These experiences allowed teachers to expand and shift their teaching styles, prepare for "real life" situations in a classroom, and work closely with students before beginning their student teaching. As a result, teachers reported increased feelings of

confidence, self-efficacy, and becoming more comfortable with the science content they would be teaching.

Baird (1989) investigated the correlation between students' performance in Science Olympiad events and their scores on the Test of Integrated Process Skills (TIPS) (Baird, 1989). The results from 462 students participating in a regional Science Olympiad tournament (grades 9-12) TIPS exams and demographic profile sheets were analyzed. From these data sources Baird (1989) determined that there were significant correlations between students' TIPS scores and the following events: Bio-Process Lab, Designer Genes, Measurement Lab, Periodic Table Quiz, Science Bowl, A is for Anatomy, and Pentathlon Topographic Map Reading. The type of school (rural vs. urban), number of previous tournaments attended, the number of microcomputers available in school, and the number of science courses completed were also significantly correlated with students' performance in the Science Olympiad. Baird (1989) believes that based on the results of this study, it could be inferred that cognitive skills are necessary for success in Science Olympiad and possibly other competitive science events.

How can demographic variables (race and gender) and cognition influence one's choice in majoring or creating a career goal in a STEM area? The following section explains Lent, Brown, and Hackett's (1994) social cognitive career theory detailing the factors associated with their theory.

The Social Cognitive Career Theory

A number of studies have been conducted utilizing the social cognitive career theory model factors (c.f., Fouad & Smith, 1996; Hackett & Lent, 1992; Lapan, Shaughnessy &

Boggs, 1996; Lent, Brown, & Hackett, 1994, 1996; Lopez, Lent, Brown, & Gore, 1997) and those factors have been shown to influence academic major choice. The social cognitive career theory (SCCT) links existing career models with learning and cognition (Lent, Brown, & Hackett, 1994). It is based on Bandura's (1986) social cognitive theory, bridging the components of that theory (self-efficacy beliefs, outcome expectations, and goal representation) with a career development model. Bandura (1993) argues that we control the impact of our environment on our motivation, emotions, and actions through cognitive processes. Therefore our actions and motivations become self-regulated. The most important factor in self-regulation is efficacy or the belief that we have the capability to exhibit varying levels of control over our abilities during specific events (Bandura, 1993). The SCCT model divides academic major choice and career selection choice into a multi-component process: "(a) the expression of a primary choice goal from among one's major career interests, (b) actions designed to implement the choice (e.g. enrollment in a particular training program or academic major), and (c) subsequent performance attainments (e.g., academic failures, admission acceptances) that create a feedback loop, affecting future career behaviors" (Lent, Brown, & Hackett, p. 94, 1994). Lent et al. (1994) suggested that these multiple processes are mediated by self-efficacy, interest, and outcome expectation and that these factors regulate one's academic major choice or career selection from the goal stage (I want to become an engineer) into the action stage (majoring in engineering). Gender, race and socioeconomic factors are also included the SCCT model.

A number of studies have been conducted to examine the influence of self-efficacy on academic major choice and career selection in science. Luzzo, Hasper, Albert, Bibby, and

Martinelli (1999) investigated the relationship between performance accomplishment and vicarious learning experiences on the math and science self-efficacy and math and science related career interests of undeclared college freshman. Participants included 55 females and 39 males, who were divided into two groups. One group received a performance accomplishment intervention and the other group received a vicarious experience intervention. All participants completed math and science ability measures, math and science course self-efficacy measures, and math and science self-efficacy measures. The results indicated a significant statistical relationship between math/science self-efficacy and career choice interests and actions. For example, those participants with high math/science self-efficacy scores were more likely to indicate an interest in a math or science related career and indicated their intent to major in a math or science field. These findings support the claim that science self-efficacy influences science interest and decision to choose a science related major and career.

Lent et al. (1994) built on Holland's (1985) career selection hypothesis (people tend to select careers that are compatible with their interests) to support the theory that learning experiences can influence one's academic major choice and career selection. For example, if someone has an interest in cars and takes a mechanics course, the combination of their initial interest with their learning experiences in class may influence their choices of an academic major and career. In the SCCT, self-efficacy and interests mediate this progression from goals to actions, but in this context they too are moderated by social, cultural, and physical experiences within the learning environment (Lent et al., 1994). Therefore, there may be a bidirectional influence between self-efficacy, interests, learning experiences, and choosing an

academic major and career. This is echoed in the SCCT's hypotheses that state learning experiences are positively related to corresponding self-efficacy beliefs and outcome expectations (Lent et al., 1994; Schaub & Tokar, 2005). Lent et al. (1994) have acknowledged that their claim that career-related learning experiences shape self-efficacy and outcome expectations merits further inquiry. Schaub & Tokar (2005) conducted a study with 327 undergraduate students (209 females and 118 males) to test Lent et al.'s (1994) claim that learning experiences may influence career interests and development and produce an effect on self-efficacy beliefs and outcome expectations. Participants in the study represented 55 academic majors (business, marketing, cultural studies, economics, English, history, government, linguistics, policy, math, science, social sciences, and undecided). Surveys were used to collect the relevant self-efficacy, career interests, and outcome expectations data. Findings indicated that learning experiences were positively correlated with self-efficacy beliefs and outcome expectations.

The current study examined the relationships among competitive science experiences, science self-efficacy, science interest, and academic major choice. The following methodology details the research design, participant site, study population, instruments, and analyses used during this study.

Methodology

Research Design

This study utilized a mixed methods approach to examine the relationships between participating in a competitive science experience and academic major choice. The predicative power (e.g., Lent et al., 2001) of science self-efficacy, academic major choice, interest in science, race, and gender in choosing to participate in a pre-college competitive science event was investigated. Participants' retrospective perceptions of participating in a competitive science experience and the relationship to the subsequent academic major choice were explored. This study was conducted in two phases. Phase one used a survey to document each participant's:

1. exposure to competitive science experiences,
2. science self-efficacy,
3. science interest,
4. motivational factors in choosing to participate in a competitive science event,
5. academic major choice,
6. gender, and
7. race.

Interviews were used in the second phase of the study to document the contexts and details of participants' perceptions of the contributions of competitive science experiences on subsequent academic major choice, as well as further investigation of motivational factors to participate in a competitive science event.

Study Site and Participants

Participants in phase one of this research study included all incoming freshman for the 2008-2009 school year enrolled in a large, public university located in the southeastern

region of the U.S. Table 1 illustrates the demographics of the incoming freshman class (N=4,669) and the study sample (n=1,488).

Table 1

Demographics for Study Participants

	New Freshman Population (N= 4,669)	Sample Freshman Population (n= 1,488)
Gender		
Male	2,500	718
Female	2,169	764
Race		
Caucasian	3,653	1, 201
African American	445	120
Asian	247	34
Native Indian	31	9
Hispanic	112	31
Not Reported	130	9
Gender	0	6
Race	0	3
Multi-Racial	0	34
Indian	0	39
Island	0	11
Pacific/Polynesian		

All freshman in the 2008-2009 freshman class (N=4,669) were contacted via email and asked to participate in the study. The survey was available online. In addition, a researcher visited two classes from each of the twelve academic colleges and invited students to participate.

The survey was administered in paper and pencil format.

The second phase of the study included a subsample of 60 students. These participants were randomly chosen from the students who indicated on their surveys that they participated in a competitive science experience. Half of those students who were interviewed majored in a STEM field (n=30) and half did not major in a STEM field (n=30).

Assessment Development

All participants completed the *Competitive Science Experience Survey* (CSES). The CSES is a 29-item survey utilizing a 5-point likert scale. The CSES was piloted during the spring of 2007 with twenty students enrolled in a computer science security networking class. The CSES's internal reliability was established (coefficient alpha= 0.60). A second pilot study was completed during the summer of 2008. Forty-five community college students completed the survey, which had been substantially altered. The second version was revised from forty-nine questions to twenty-nine. Questions pertaining to types of relationships established while participating in a competitive science event were eliminated. The coefficient alpha was 0.97. A panel of four experts including science educators and an educational psychologist reviewed the survey for content validity.

Participants were asked to answer questions pertaining to the variables on the CSES on a continuum ranging from strongly disagree to strongly agree. The CSES is divided into two sections (see Appendix A). Section one of the CSES documented the participant's demographic information such as race, age, and gender, as well as the participant's academic major choice. Section two of the CSES documented participants' experiences with different science competitions (descriptions of the competitive science events documented in this study are listed in Table 2), science self-efficacy (six of the items are from Pajares & Bitner, 2006), participants' motivation for participating (or not) in a competitive science event), whether participants prefer to learn science as a team or alone, and the participants' interest in science.

Table 2

Types of Competitive Science Experiences

Competitive Science Experience	Description
Science Fairs	Participants create individual research projects related to science and/or technology.
Science Olympiad	Participant teams work together to solve problems, construct projects, and test their science and or technology content knowledge.
Academic Science Decathlon	Student teams compete in hands-on science-based tournaments.
Envirothons	Student teams compete in an environmental science competition testing students' content knowledge and science processing skills in different areas of environmental science.

In phase two, the selected participants were interviewed using a semi-structured interview protocol (Appendix B). The interviews asked about participants motivation for participating, hobbies, relationships forged or strengthened during participation in competitive science experiences, participants' perceptions of the influence of being involved in a competitive science experience on their academic major choice, and other information on academic major choice and career goals. The interviews were audio recorded and transcribed.

Limitations

Limitations in this study exists because participants were asked to recall past events and information, that they may not be able to accurately recall. Participants may not have been able to articulate their memories and their perceived motivational influences on participating in a competitive science event and academic major choice.

Analysis

Data collected from the CSES was entered into an excel spreadsheet. Demographic data, participation in competitive science events, and academic major was assigned a numerical value. For example, males=1, females=0; competed=1, not competed=0; Caucasian=1, not Caucasian=0; STEM major=1, non-STEM major=0. Academic major was further categorized numerically with science=1, technology=2, engineering=3, mathematics=4, and non-STEM majors=0. Responses to the survey questions were also entered into the spreadsheet with a corresponding numerical code to the 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree). Using SAS programming versions 9.1.3 and 9.2, data was analyzed and descriptive statistics completed. Comparative analyses were run on the items from the CSES between participation groups in a competitive science event. Students demographics gender, race, and academic major, were further examined by participation, science self-efficacy and event type. A logistic regression model was created and analyzed to establish if the following variables were predictive of participating in a competitive science event: race, gender, science self-efficacy, academic major choice, and interest in science. Comparisons were also made between participation groups by academic major choice (STEM vs non-STEM), and academic majors choice (science, technology, engineering, mathematics, and non-STEM) was analyzed by gender, race, interest, and event type. ¹

¹ Note: A category of competitive science events called “other” was created to allow for grouping of similar academic bowls and “build-it” events.

Qualitative Analysis

Interviews were examined within and across students for patterns in the participants' responses. Using modified grounded theory (Glasser & Strauss, 1967) a list of themes by questions were developed after an initial read through of the transcripts. (See appendix B for a list of interview questions). Another science educator read the transcripts independently of study authors and an inter-rater reliability of 92% was established. Students reported motivational factors to participate in a competitive science event and academic major choice were coded and entered into an excel spreadsheet. Frequencies were determined for each subtheme that developed within the two groups of participants (STEM majors and non-STEM majors).

Results

In the sections that follow results are presented for differences in demographics between students who participated in competitive science events and those who did not. Factors influencing the decision making process for participation and academic major choice were also examined and are presented here. Finally, reported motivations for students' choice to participate in competitive science events are discussed.

Demographic Differences

Total student population versus study population. Overall, more females than males participated in this study (female n=764, male n=718; see Table 1). Eighty-one percent of the study participants were Caucasian, 8% African American, 2% Asian, 0.6% Native Indian, 2% Hispanic, 3% Indian, 0.7% Island Pacific/Polynesian, 2% Multi-Racial, and 0.2% not reported. The study sample was demographically representative of the freshman class of the southeastern public university where this study was conducted (54% males, 46% female, 78% Caucasian, 10% African American, 5% Asian, 0.7% Native Indian, 2% Hispanic, and 3% not reported). Demographic information was unavailable for Mixed-Race, Indian, and Island Pacific/Polynesian races from the university. Science, engineering, and non-STEM disciplines were the most frequently reported academic majors for students who participated in this study. Of those aforementioned academic major disciplines, 33% of the students in the study majored in engineering (n=497; see Table 3).

Analyses were conducted on the entire study population (n=1,488) investigating possible differences in choosing a STEM major or not by race and gender. There were significant differences by gender for choice of academic major, $X^2(1, n=1,488) = 78.69$,

$p < .0001$. Males in this study were more likely to choose a STEM major than females. The chi-square test of independence found no significant differences by race for academic major choice (STEM vs. non-STEM), ($X^2(1, n=1,488) = 0.02, p=.90$). Table 3 shows the demographics by types of academic major for the entire study population.

Table 3

Demographics of Types of Majors (STEM vs. Non-STEM)

	Science	Technology	Engineering	Mathematics	Other (Non-STEM Majors)
Gender					
Male	162	6	384	16	151
Female	284	6	113	33	326
Race					
Caucasian	365	10	402	42	385
African American	43	2	29	6	40
Asian	9	0	11	1	13
Native Indian	1	0	2	0	6
Hispanic	9	0	13	0	9
Indian	13	0	21	0	5
Island Pacific/Polynesian	3	0	4	0	4
Multi-Racial	6	0	14	0	14
Not Reported	3	0	0	0	0
Gender					
Not Reported Race	0	0	1	0	1
Total n	449	12	497	49	477

Note: There were significant differences by gender for choice of academic major, $X^2(1, n=1,488) = 78.69, p < .0001$.

Demographic differences by participation. The demographic distribution of individuals who competed in a pre-college competitive science event and those who did not are shown in Table 3.1. Of those 1,488 individuals who participated in this study, 61% competed in a competitive science event and 39% did not compete. More females than males participated in a competitive science event (52% female, 48% male). Engineering was the most often reported academic major choice. Of those particular engineering majors, 300 (60% of freshman engineering majors) reported having competed in a pre-college science event while 197 (40% of freshman engineering majors) reported not competing in an event prior to college. There were no statistical differences in the demographic characteristics between those students who participated in a competitive science event and those who did not. Further analyses of demographic data were conducted by type of competitive science event. These differences are discussed in the following section.

Table 3.1

Demographics of Individuals Who Competed or Not in a Competitive Science Event

	Competed		Not Competed		Total n	
	n (%)		n (%)		n (%)	
Gender						
Male	431	(48)	287	(49)	718	(48)
Female	470	(52)	294	(51)	764	(51)
Race						
Caucasian	747	(83)	454	(78)	1201	(81)
African American	63	(7)	57	(10)	120	(8)
Asian	19	(2)	15	(3)	34	(2)
Native Indian	5	(0.6)	4	(0.7)	9	(0.6)
Hispanic	22	(2)	9	(2)	31	(2)
Indian	25	(3)	14	(2)	39	(3)
Island	4	(0.4)	7	(1)	11	(0.7)
Pacific/Polynesian						
Multi-Racial	18	(2)	16	(3)	34	(2)
Not Reported						
Race	2	(0.2)	1	(0.2)	3	(0.2)
Gender	1	(0.1)	3	(0.5)	4	(1)
Academic Major						
Science	282	(31)	167	(29)	449	(30)
Technology	7	(0.8)	5	(0.9)	12	(0.8)
Engineering	300	(33)	197	(34)	497	(33)
Mathematics	28	(3)	21	(4)	49	(3)
Other	285	(32)	192	(33)	477	(32)
(Non-STEM Majors)						

Note: There were no statistical differences in students who competed and those that did not by gender, race, or academic major choice.

Demographic differences by type of event. Table 3.2 shows the demographics of those students who reported participating in a pre-college science competition by event. Participants reported most often competing in science fairs (n=770) followed by science olympiads (n=241), envirothons (n=100), “other” competitive science events (n=94), junior science and humanities symposiums (n=53), and academic science decathlons (n=27).

The academic majors of participants were examined by event type. Engineering was the academic major choice most often reported by study participants who competed in science olympiads, academic science decathlons, and “other” competitive science events. Non-STEM disciplines were most often reported for those students who participated in science fairs and envirothons. Participants of the junior science and humanities symposium most often reported both science and engineering as academic major choices (n=18 each).

Demographic data were further analyzed by type of competitive science event and the specific STEM discipline (science, technology, engineering, and mathematics). There were significant differences in the specific STEM majors for participants in science olympiad ($X^2(1, n=907)=8.88, p<.003$), academic science decathlons ($X^2(1, n=907)=4.37, p<.04$), and “other” competitive science events ($X^2(1, n=907)=15.12, p<.0001$). Participants in each of these three competitions were more likely to designate engineering as their academic major.

Table 3.2

Demographic of Individuals by Competitive Science Event Type

	Science Olympiad (n=241)	Science Fair (n=770)	Envirothon (n=100)	Academic Science Decathlon (n=27)	Junior Science and Humanities Symposium (n=53)	Other (n=94)
Gender						
Male	133	359	41	18	27	58
Female	106	409	59	9	26	36
Race						
Caucasian	189	635	74	22	40	81
African American	19	56	6	1	4	8
Asian	7	14	5	1	2	1
Native Indian	0	5	0	0	0	0
Hispanic	5	22	4	0	1	1
Indian	14	17	6	3	5	0
Island Pacific/ Polynesian	1	2	0	0	0	2
Multi-Racial	6	8	3	0	0	0
Not Reported						
Gender	2	2	0	0	0	0
Race	0	2	0	0	0	1
Academic Major						
Science	68	237	32	9	18	34
Technology	4	7	0	0	0	1
Engineering	100	245	25	14	18	47
Mathematics	7	27	5	0	0	2
Other (Non-STEM Majors)	62	252	36	4	15	10

Note¹: Some students reported participating in more than one competitive science event.

Significant differences were found in science olympiad ($X^2(1, n=907)=8.88, p<.003$), academic science decathlons ($X^2(1, n=907)=4.37, p<.04$), and “other” competitive science events ($X^2(1, n=907)=15.12, p<.0001$).

Differences in type of science competitions by participants' gender were also examined. Male students were significantly more likely to report having participated in science olympiad, ($X^2(1, n=907)=10.15, p=.001$), academic science decathlons, ($X^2(1, n=907)=3.95, p=.05$), and "other" competitive science events, ($X^2(1, n=907)=8.10, p=.005$), (See Table 3.3). There were also significant differences in participation in competitive science events by race. Those who reported participating in science olympiad ($X^2(1, n=907)=5.23, p=.02$) and envirothons ($X^2(1, n=907)=4.34, p=.04$) were more likely to be Caucasian.

Table 3.3

Summary of Differences Between Type of Competitive Science Event by Gender, Race, and Academic Major Choice

	X^2	Probability
Science Olympiad		
Academic Major	8.88	.003**
Gender	10.15	.001***
Race	5.23	.020*
Academic Science Decathlon		
Academic Major	4.37	.040*
Gender	3.95	.050*
Race		
"Other" Competitive Science Event		
Academic Major	15.12	.001***
Gender	8.10	.005**
Race		
Envirothon		
Academic Major	—	—
Gender	—	—
Race	4.34	.040*

* $p < .05$, ** $p < .01$, *** $p < .001$

Overall, students who reported participating in pre-college competitive science events tended to be female and Caucasian. When analyzed by competitive event type, males and engineering majors were statistically more likely to report participating in science olympiad, academic science decathlons, and “other” competitive science events. More females reported participating in envirothons and science fairs than other types of events. Significant race differences were found for students participating in science olympiad and envirothons. Most of the students who participated in these events were Caucasian.

Competitive Science Experience Survey

Table 4 shows the means and standard deviations for each question on the *Competitive Science Experience Survey* completed by all study participants. The only items that were statistically different between those who competed in a pre-college competitive science event and those who did not were the value of the competitive science experience (question 9), interest in science outside of school (question 11), and if competitive science events were offered at study participants’ schools (question 12). Of those variables, individuals who competed ($M=3.43$, $SD=0.77$) valued the competitive science experience over those who did not ($M=3.14$, $SD=0.69$), $t(1485)=-7.68$, $p<.001$, reported being more interested in science outside of school ($M=3.64$, $SD=1.03$), $t(1485)=-3.72$, $p<.002$, and indicated that competitive science events were offered at their schools ($M=3.48$, $SD=1.09$), $t(1482)=-8.12$, $p<.001$ than those who did not compete.

Table 4

Differences in Survey Results

	Competed		Not Competed		<i>t Value</i>	<i>(Pr > t)</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
1. Compared to others my age I am good at science.	3.69	0.84	3.65	0.84	-0.96	.34
2. I get good grades in science.	4.05	0.65	3.99	0.67	-1.55	.12
3. Science is easy for me.	3.50	0.93	3.44	0.95	-1.28	.20
4. I am good at science. ¹	3.85	0.94	3.85	0.91	-0.01	.99
5. Learning how to be better in science is easy for me.	3.40	0.83	3.33	0.84	-1.96	.09
6. I have always done well on science assignments.	3.71	0.84	3.71	0.81	-0.12	.91
7. I prefer to learn about science as a part of a cooperative group.	3.40	0.93	3.43	0.89	0.65	.52
8. I prefer to learn about science one-on-one.	3.15	0.92	3.09	0.88	-1.17	.24
9. If I have children, I would want them to participate in a competitive science event.	3.43	0.77	3.14	0.69	-7.68	.001*
10. I am interested in science.	3.92	0.98	3.85	0.93	-1.47	.14

Table 4 continued

11. I am interested in science outside of school (e.g. science hobbies, books, television shows, building models, etc.)	3.64	1.03	3.44	1.05	-3.72	.002*
12. Competitive science events were offered at my school.	3.55	1.09	3.03	1.27	-8.12	.001*
13. I competed in a competitive science event because it was offered at my school. ¹	3.20	1.15	—	—	—	—
14. I participated in a competitive science event even though it conflicted with another extracurricular activity I was involved with. ¹	3.12	1.12	—	—	—	—
15. I would have chosen my academic major in college regardless of participating or not in a competitive science event.	4.06	0.85	—	—	—	—

* $p < .01$, ¹ This question was reverse coded in the original survey.

After finding the differences shown in Table 4, a logistic regression model was analyzed in an attempt to identify predictor variables for those individuals who chose to participate in a competitive science event. These results are described in the section that follows.

Factors Influencing the Decision to Participate

A principal logistic regression model was created to determine the likelihood of students participating in a competitive science event based on these variables: academic major choice (STEM vs. not-STEM), gender, race, science self-efficacy, and interest in science. Table 6 summarizes the overall evaluation of the logistic regression model determined by:

- statistical testing of individual predictors,
- goodness-of-fit statistics (Table 5), and
- an assessment of the predicted probabilities (Peng, Lee, & Ingersoll, 2002).

Table 5

Overall Model Fit for the Proposed Logistic Regression Model

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr>ChiSq
Likelihood Ratio	20.50	8	.009**
Score	20.51	8	.009**

Table 5 continued

Wald Chi-Square	20.22	8	.010*
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*p<.05, **p<.01

Table 5 shows that the logistic regression model contains at least one predictor's regression coefficient not equal to zero. Based on this evidence the null hypothesis is rejected, indicating that the proposed model is significant. Of the variables tested in this model, science self-efficacy is the only statistically significant predictor of participating in a competitive science event ($\beta = .03, p = .04$).

Table 6

Summary of Predictor Variables for Participating in a Competitive Science Event

Predictor							
Variables	β	Std. Error	DF	Wald	Sig.	Exp (β)	
STEM	.03	.07	1	0.16	.70	1.05	
Gender	.04	.06	1	0.63	.43	1.10	
Race	.13	.07	1	3.64	.06	1.30	
Science							
Self-Efficacy	.03	.02	1	4.14	.04*	1.03	

* p< .05

Table 6 continued

Predictor						
Variables	β	Std. Error	DF	Wald	Sig.	Exp (β)
Interest 1	.31	.31	1	1.00	.32	2.04
Interest 2	.18	.18	1	1.05	.31	1.80
Interest 3	-.14	.12	1	1.40	.24	1.31
Interest 4	.04	.15	1	0.07	.79	1.56

* $p < .05$

Interest in science is shown as four separate variables because participant responses were documented as ordinal values on a 5-point Likert scale. For example, strongly disagree=1, disagree=2, neither agree nor disagree=3, agree=4, and strongly agree=5. The logistic regression model compared interest levels against the “middle” Likert response (3= neither agree nor disagree) in an attempt to avoid masking statistical significance.

Science self-efficacy. The logistic regression model showed high science self-efficacy correlated with participation in a competitive science event. Further statistical analysis was conducted to find if there were significant differences in levels of science self-efficacy between students who participated in a pre-college competitive science event and those who did not. Students who participated in a competitive science event ($M=25.52$, $SD=4.29$) had higher science self-efficacy than those students who did not compete ($M=24.94$, $SD=4.27$), $t(1485) = -2.52$, $p=0.0118$. There were also gender differences in science self-efficacy. Males ($M=26.19$, $SD=4.15$) in this study had a higher science self-

efficacy than females ($M=24.44$, $SD=4.24$), $t(1485)=-8.06$, $p<0.0001$. No statistical difference in race between caucasian students ($M=25.34$, $SD=4.24$) and non-caucasian students ($M=25.10$, $SD=4.48$) were found for science self-efficacy in this study $t(1485)=0.81$, $p<.42$.

Science self-efficacy scores were examined further with a two-way ANOVA, by the five STEM disciplines: (A) Science =1, (B) Technology=2, (C) Engineering=3, (D) Mathematics=4, (E) Other=0. There were significant differences in students' majors within the STEM disciplines, $p<.0001$. A post-hoc Tukey test showed students who participated in a competitive science event and majored in a science discipline ($M=43.74$, $SD=6.99$) had higher science self-efficacy than those who did not major in a science discipline ($M=41.77$, $SD=8.38$), $t(904)=-3.68$, $p<.0003$. Those students who participated in a competitive science event and majored in an engineering discipline ($M=44.86$, $SD=7.58$) had higher science self-efficacy than those who did not major in an engineering discipline ($M=41.14$, $SD=7.95$), $t(904)=-6.74$, $p<.0001$. Table 7 shows these differences in more detail.

Table 7

Science Self-Efficacy Means, Standard Deviations, T and P-Values

	<i>M</i>	<i>SD</i>	<i>T Value</i>	<i>p</i>
Competed	25.52	4.29	-2.52	.01**
Not Competed	24.94	4.27	—	—
Gender				
Male	26.19	4.15	-8.06	.001***
Female	24.44	4.24	—	—
Race				
Caucasian	25.34	4.24	0.81	.42
Not Caucasian	25.10	4.48	—	—

** $p<.01$, *** $p<.001$

Interest in science. While the logistic regression model did not indicate that interest in science was a predictor of participation in a competitive science event, there was a significant relationship between interest in science and choosing a STEM major, $X^2(4, n=1,484)=294.88, p<.0001$. Students who were STEM majors had higher interest in science than those who were not STEM majors. Students who were STEM majors ($M=2.87, SD=0.92$) were more likely to report that as a *result* of competing in a competitive science event, their interest in science was higher than those students who were not STEM majors ($M=2.55, SD=0.86$), $t(845)=-4.83, p<0.0001$.

Participation differences and academic major choice. The relationship between pre-college participation in a competitive science event and academic major choice was also examined. Results of the chi-square analysis showed no significant statistical relationships between those who participated in a competitive science event and choice of major, ($X^2(1, n=1488)=0.43, p=.51$). Next the relationship between pre-college participation in a specific competitive science event and their academic major choice was examined. The chi-square test of independence found significant differences between the type of competitive science events students participated in and academic major choice. Of the different competitive science events, students who competed in either science olympiad ($X^2(1, n=907)=4.45, p=0.03$) or the “other” competitive science events ($X^2(1, n=907)=21.02, p<0.001$) were more likely to choose a STEM major.

Motivation

Academic major choice: semi-structured interview responses. Interviews provided additional insights into general academic major choice decisions and the relationship between academic major and participation in a competitive science event. In this section that follows intrinsic and extrinsic motivational factors contributing to academic major choice are discussed.

STEM academic major choice. When asked to reflect on motivational factors that influenced their academic major choices, 73% of the students who were STEM majors indicated examples of intrinsic motivators. Examples of intrinsic motivational factors discussed by students included being “subject oriented,” liking a particular academic discipline, or noting that they were good in a certain academic area. For example, a physics major described his longstanding interest in physics as motivating his selection of a major, “The main reason I chose physics was because I always liked math and science. Physics is basically the mathematical definition of the universe. So it was natural for me to follow that path into physics as my college major.” This was also reported by a mechanical engineer, “I am going into mechanical engineering because I have always liked things like that, machines and planes.”

Participants also referred to extrinsic motivational factors as affecting their academic major choices. Thirty-three percent of study participants recalled teacher influences, while 17% indicated parents as motivational influences. A zoology major remembered a positive experience she had with her father, “Being with my dad while he was working on stingrays. Helping him to collect their DNA and stuff. It’s why I chose to be a zoology major.”

Another student noted his relationship with a high school biology teacher, “Biology was one of the sciences I was most interested in. That was in a large part due to the really good biology teacher I had in high school. He was definitely the best teacher in the school.”

Fifty-three percent of STEM majors that were interviewed noted that their pre-college participation in a competitive science event influenced their choice of major in college. For example, Mike a Mathematics and Engineering major (with a minor in physics), said, “I think part of me was always going to do math. I mean I learned to count before I learned to read. But I think I picked up Physics as a minor because of the experience that I had at Nationals (science olympiad).” Another student noted, “Being here and kind of being on both campuses during the state science olympiad tournament was definitely kind of a plus. Then (also) knowing that it's got a great Engineering school (influenced me). So yeah, the experience definitely influenced my major” (Textile Engineering major).

Study participants also discussed other factors that motivated their decisions to pursue a STEM discipline as their academic major choice. Examples of these factors are the explorations of science outside the formal classroom via television shows, summer research opportunities, and reading during their K-12 years. A zoology major recalled her fascination with the television show host of Crocodile Hunter: “What I’ve seen on TV actually influenced my college major. Steve Irwin, he was a big factor. You know always dealing with reptiles and aquatic animals on his show.” Another participant described the impact of his experience with summer research: “I would not be nearly as interested in pursuing a biology degree if I wouldn’t have had the opportunity to learn so much by doing research. My research group was definitely a big part of me going into biology.” A physics major

recalled books as being a critical factor in academic major choice, “My career goal and choice to major in physics was basically determined by a whole bunch of physics books I read. The first book that made me realize what I wanted to do was called, ‘Alpha and Omega’. That book guided me towards more of the science book genera. They (science books) eventually led me to the more theoretical aspects of physics. The things I hope to deal with in my future.”

Non-STEM academic major choice. Seventy percent of the students who were interviewed and had participated in a competitive science event but majored in a non-STEM discipline indicated that their competitive science experience did not influence their academic major choice. These students indicated intrinsic motivational factors (73% of responses) as an influence in their academic major choice. Examples of intrinsic factors discussed by participants included: specific career paths (13%), an internship experience (3%), and classes that they took in high school (23%). A communications major recalled how her specific career goals motivated her to choose an academic major, “I want to do something in video correction and film making. Communications seems to be the best fit major for what I want to do.” Two psychology majors noted the role of specific classes in influencing their academic major choice: “I took various psychology courses in high school. I was really interested and intrigued by what I learned in those classes. That’s why I chose it as my college major.” Another noted, “It was one of the classes offered in high school. It made me realize that I really liked it and it (psychology) had a lot to offer. So, that’s why I decided to choose that major.”

One example of an intrinsic motivator is simply enjoying a non-STEM subject matter. Steve, a political science major, stated, “I’ve always been interested in politics and government. Actually historical government. That’s why I’m majoring in political science.” Thirty-six percent of non-STEM indicated interest in a subject area as their motivation to choose their college major. Susie, a criminology major, explained, “I’ve always been interested in forensics. I guess it first stemmed from watching those CSI shows.” A graphic design major stated, “Art always made sense to me. I took an (art) class in high school where we got to draw using computers, and it just made sense!”

Intrinsic and extrinsic motivational factors influenced participants’ academic major choices for both STEM and non-STEM disciplines. Examples of intrinsic motivators documented in this study included liking a particular academic subject, specific career path goals, or a class students may have taken in high school. Teacher and parent influences served as external motivational factors. Other motivations that were also discussed included summer research opportunities and science-related books or television shows.

Participation in a competitive science event. Motivational factors that influenced an individual’s decision to participate in a competitive science event were assessed with the *Competitive Science Experience Survey*. Parental, teacher, and peer influence were three factors that were examined. Those students who participated in a competitive science event and majored in a STEM discipline were more likely to report being motivated to participate by a teacher and a parent than those who did not major in a STEM discipline [parental influence: ($M=2.63$, $SD=1.20$), $t(849)=-3.59$, $p<.0004$); [teacher influence: ($M=1.88$, $SD=0.88$), $t(848)=-2.81$, $p<.005$]]. Of those students who participated in a competitive

science event, those who did not major in a STEM discipline ($M=3.18$, $SD=0.98$) were more likely to be intrinsically motivated to participate than those who majored in a STEM discipline ($M=2.74$, $SD=0.95$), $t(844)= 6.17$, $p<.0001$.

Motivation to participate in a competitive science event: semi-structured interview responses. During interviews, students were asked what motivated them to participate or not in competitive science events. Those students who were STEM majors indicated a number of different extrinsic motivational factors that influenced their participation (90% of student responses). External motivational factors mentioned included teachers (67%), parents (37%) and peers (37%). Of those who chose a non-STEM major, 100% reported being extrinsically motivated to participate in pre-college competitive science events, by teachers (90%), parents (37%), and peers (17%). Table 8 shows typical interview responses related to motivations to participate in a competitive science event.

Table 8

Motivation to Participate in a Pre-College Competitive Science Event

	STEM Major	Non-STEM Major
Intrinsic Motivation	<p>“I enjoyed the science fair so much in lower school, I decided in middle school, ‘I’m going to do the coolest science projects ever!’ ”- Biochemistry Major</p>	<p>“I just enjoyed it. It was something I could do with my dad. It was a kind of intrinsic motivation of doing something with my dad.”-Psychology Major</p>
Extrinsic Motivation		
Parents	<p>“As for science olympiad, when I was in kindergarten, my dad was a coach for the middle school. And when I got to high school, my freshman year, what my dad did sounded cool, so I wanted to do it.”-Mathematics Major</p>	<p>“My mom and dad really encouraged and helped me a lot.” -Architecture Major</p>
Teachers	<p>“My teacher sponsor was really involved and she was really nice. And she was one of the reasons why I got into science olympiad, cause I liked her a lot.”-Chemical Engineering Major</p>	<p>“My teachers made me do it. It was mandatory.”- Management Major</p>
Peers	<p>“In science olympiad you get to go out with a bunch of your friends and you go build something.”</p>	<p>“Well my friends played a part in my participating because they were doing it as well.”-Graphic Design</p>

Competition Outcomes: Winning or Losing a Competitive Science Event

Interview data also supplied information on how competition outcomes (winning or losing) influenced students' choice to continue participating in a competitive science event. Those results are discussed in the following section by major choice (STEM versus Non-STEM).

STEM Majors. Sixty percent of STEM majors interviewed reported that losing a science competition did not influence their decision to continue participating in a competitive science event. However, students noted that by winning the competition, confidence levels rose, team bonding increased, and participants reported being more likely to take on leadership roles within their teams. For example, Janie a food science major, remembered her success during a FFA competition, "After being in a lot of competitions and winning, I ended up being an officer for a couple of years." Another student recalls their experience with winning a science olympiad event, "After we won our first event, it got really fun. We hung out together as a team the entire weekend. Studying late into the night preparing for the rest of the competition." A mechanical engineering major explained how winning boosted their confidence level, "If I hadn't won my event, I don't think I would have quite the confidence (about doing science) that I do now."

Other students majoring in a STEM discipline remembered being indifferent towards the competition outcome. They reported that it was the love of competition or just having fun that sustained their participation in a competitive science event. A zoology major explained, "The state (science olympiad) competition is fun regardless if you medal or not. I continued competing throughout middle and into high school because competing was so

much fun.” Another student recalled, “Competing itself and doing the experiment is what did it for me. Actually getting the award was just a perk.”

Of the STEM majors interviewed 17% reported that losing the competition discouraged them from continuing their participation in a competitive science event. Female STEM majors who were interviewed discussed the negative experience in the context of an emotion. An animal science major recalls the impact that losing had on her, “Losing made me feel like I was bad at it (science). It was an all around negative experience for me.”

Abby, a life sciences major, explained her experience, “During the presentation part of the competition, I forgot one of the steps of the scientific method. That’s why I lost. I was so discouraged by that. It’s why I didn’t compete in high school.” In contrast to these results, male students recalled losing their events as a motivator to try harder in science, even though they did not continue participating. For example, an engineering major reported, “Not medaling encouraged me to try a little bit harder in my science classes to make up for losing.” Another student noted, “I mean it’s a competition. If you don’t win, it’s just tough luck. That doesn’t mean you shouldn’t do science.”

Non-STEM majors. Fifty percent of the students who were interviewed and majored in a non-STEM discipline indicated that losing an event did not influence their choice to continue participating in a competitive science event. Students did recognize that rewards and success influenced interest in science and science self-efficacy. A business management major discussed his experience, “When you win and are rewarded with something, you like it more. It makes you want to come back and do it (science) more.” A social science major

recalled a similar experience, “Winning made me really happy. I felt like, ‘Hey, I can do science!’”

Like the STEM majors interviewed 17% of non-STEM majors reported that losing an event turned them away from participation in competitive science events. An elementary education major remembered how losing negatively impacted her perception of science competitions, “After losing my event, I couldn’t say that I enjoyed science olympiad. I just didn’t like competing in science.” Patrick, a business management major, noted, “I really wasn’t into envirothons anyway. Losing didn’t help. It really wasn’t interesting after that.”

Losing a science competition did not deter the majority of students from continued participation in a competitive science event for both STEM and non-STEM majors. STEM majors reported that winning increased confidence levels, team bonding, and the likelihood of participants assuming leadership roles within the team. Non-STEM majors indicated that success in a competitive science event influenced science interest and self-efficacy.

Differences between male and females participants were observed for STEM majors who reported losing a competition as discouraging student participation in a competitive science event.

Conclusion

In summary, science, engineering, and non-STEM disciplines were the top reported academic majors for students who participated in this study. Of those aforementioned academic major disciplines, the most frequently selected major was engineering (n=497; 33%). The statistical analyses of these results showed that for this sample, caucasian males who majored in engineering were most likely to report having participated in a competitive

science event. Males also tended to have higher science self-efficacy. Race differences were found by event type, with caucasian students more likely to report competing in science olympiad and envirothons. A logistic regression model showed that high science self-efficacy was a predictor of students' participation in a competitive science event.

Participants who competed in a science event and chose either a science or engineering major also had higher science self-efficacy than those students pursuing technology, mathematics, or non-STEM disciplines as their college major. Study participants reported being motivated to participate in a competitive science event as a result of their teacher or parents' encouragement. Evidence of competition outcome indicated that losing a science competition did not adversely influence students' decisions to continue participating in a competitive science event.

Discussion

“There is no doubt in my mind that if I had never participated in the first year robotics competition, I wouldn't have ever thought to go into mechanical engineering to design and build prosthetics for war veterans.”-Mechanical Engineering Major

As of 2006, only 32.1% of a bachelors degrees earned in the United States were in a science or engineering discipline (National Science Foundation, 2008). Since 1966, the National Science Foundation (2008) has documented a 2.2% decrease in students pursuing engineering degrees and a 1.9% decrease in physical science degrees. The challenge to science education is to determine the most influential ways to attract students to careers in science and engineering.

The current study investigated the reported influence of participating in a competitive science event on academic major choice, interests in science outside of school, science self-efficacy, and general science interests as influences on students' decision-making processes when choosing to participate or not in a competitive science event. The sections that follow discuss the results of this study in relation to student demographics, participation in a competitive science event, science self-efficacy, interest in science, academic major choice, competition outcomes, and motivational factors contributing to participating in a competitive science event and choosing a college major.

Participants in Competitive Science Events

Differences in gender, race, and science self-efficacy were found between those students who participated in a competitive science event and those who did not, as well as, by specific event type of participants. Interest in science outside of the classroom, valuing the competitive science experience, and potential motivators to participate were also identified as influencing students' choice to compete in a competitive science event.

Gender and race differences of participants by event type. Students who participated in pre-college competitive science events, overall, tended to be female and Caucasian. When statically analyzed by competitive event type, males were more likely to report participating in science olympiad, academic science decathlons, and "other" competitive science events. Females reported participating in science fairs. Research conducted by Jones (1991) found no gender differences in participation in science olympiad. Other studies have also shown males were more likely to engage in science events that were based on scientific inquiry and experimentation (Greenfield, 1995). Science olympiads and

“other” competitive science events are structured to promote student led inquiry and investigation, and it is possible male participants feel more comfortable doing these events as a result of prior experiences with science. Other research suggests that females may be drawn to projects that are centered around library research with the option of a physical display of that research (Greenfield, 1995). This may explain why females in the current study reported participating more often in science fairs that have an emphasis on library research.

Race has been documented as a barrier to participation in extracurricular programs, specifically among African American males (Fashola, 2003). Race differences were found for science olympiad and envirothons in this study, where students who participated in these events tended to be Caucasian. Obstacles that have traditionally been associated with minority students’ participation in out-of-school programs have included availability of transportation, affordability, and how well intended extracurricular programs serve sibling groups (Fashola, 2003). When constructed appropriately science olympiad and envirothon teams can satisfy these obstacles. PTA organizations and donations from local businesses can negate the need for extra monies to pay for supplies and team registration. Practices can take place after school hours on campus, bypassing the need for transportation from one location to the next; and the creation of elementary, middle, and high school teams in a single district may allow for siblings to participate.

Participation in events such as science olympiads and envirothons may also offer minority students opportunities to learn science in contexts that promote and encourage life long science learning. These events also allow parents to become involved in their child’s

science learning. Research has shown that African American parents want their children to participate in out-of-school science experiences that incorporate hands-on learning presented within a real life application (Simpson & Parsons, 2009) such as those offered in science olympiad and envirothons. Simpson and Parson's (2009) study of African American parents also reported that they felt science teaching in formal classroom settings did not offer the learning experiences that they felt were critical for their child's science understanding to develop (Simpson & Parsons, 2009). Understanding the reasons for differential participation in out-of-school science activities by race or gender is important and further research is needed to address the underlying contributing factors.

Science self-efficacy differences by participation. Self-efficacy models suggest students' self-efficacy beliefs are influenced by mastery experiences, vicarious experiences, social persuasion, and physiological states (Bandura, 1997). Students draw upon past performance in an activity or mastery experience as they develop beliefs about their future capabilities to engage in similar experiences.

Results from the logistic regression model indicated that science self-efficacy was a significant factor in predicting whether or not a student would participate in a competitive science event. Those with higher science self-efficacy were more likely to participate. This may be the result of students with higher science self-efficacy seeking out further mastery experiences that can be found in competitive science events. This study did not address if competitive science events could be used as an intervention to improve student science self-efficacy. It is possible that if students have positive experiences while participating in a competitive science event, and engage in both mastery and vicarious actions, their self-

efficacy would change in a positive direction. Further research is needed to address these questions.

Competition outcomes and science self-efficacy. If a student enters a competition and does not succeed (loses the event competition) then self-efficacy models suggest the individuals' self-efficacy would decline. Many of the competitive science events documented in the present study incorporate aspects of cooperation and competition. For example, science Olympiads, envirothons, and first year robotics are all team-based events in which students cooperate and then compete for awards and recognition against other teams. By offering aspects of cooperative environments, these science events could promote high achievement in science, as well as, a positive change in students' attitude towards future science learning experiences (essentially science self-efficacy) (Johnson & Johnson, 1975; Johnson, 1976; Ryan & Schroeder, 1974).

Participants in the present study reported winning as a competition outcome influencing science self-efficacy, team bonding, and interest in science. Research on competition versus cooperation has also indicated the strengthening of peer bonds and increased effective inquiry learning in cooperative environments (Tjosvold, Marino, & Johnson, 1977). It is also possible to utilize the cooperative nature of competitive team science events as a mechanism to decrease students' levels of anxiety when faced with learning science content. Research has shown that when engaged in learning in cooperative environments, students have an increased value for the learning experience and lack of or decrease in anxiety (Humphreys, Johnson, & Johnson, 1982).

Results of the present study indicated that competition outcomes affected students continued participation in a competitive science event. The decision to continue participating or not is an intrinsically motivated process affected by perceived competence and self-determination. Research has shown that external feedback, such as awards and prizes, may decrease intrinsic motivation (Harackiewicz, 1979). However, Epstein and Harackiewicz's (1992) study found that competition can actually facilitate intrinsic motivation for some individuals. Similar evidence was found in the present study for students who competed in a competitive science event. Study participants indicated winning or losing the science competition did not influence their decision to continue competing, but that the joy of competition among their peers intrinsically motivated them to continue participating in competitive science events.

However, negative competition outcomes, losing, have been found to be especially detrimental in competitive environments (Tauer & Harackiewicz, 1999). Gender differences were found in students who reported discontinuing participation in competitive science events because they lost. Females internalized the experience, describing their losing the event as an emotion. For example, "made me feel like I was bad at science" or "I was so discouraged," were phrases they used. In contrast, male participants turned their loss into a motivator, pushing themselves to "make up for losing." These gender differences may be explained by females' preference of cooperative environments over competitive (Owens & Stratton, 1980). Males on the other hand, tend to gravitate towards activities that involve direct competition (Maccoby, 1998). The prevalence of cooperative experiences in competitive science events may be the link to understanding how participation in a

competitive science event can address gender differences in science competitions. The impact of winning or losing a competitive science event needs further research. If participating in science competitions and losing decreases a students' motivation to study science, then these events may be turning off those very students they are designed to attract.

Gender differences in science self-efficacy. Across studies there have been mixed results that have ensued from studies of self-efficacy and gender. Anderson and Betz (2001) found that vicarious experiences and social persuasions were stronger factors that influence science self-efficacy development in women than in men. Another study of middle school students showed mastery experiences predicted general academic self-efficacy for both males and females while social persuasions were predictive only for females and vicarious experiences for males (Usher & Pajares, 2006). Still other studies have found no significant gender differences in the sources of science self-efficacy (Lent et al., 1991; Matsui, Matsui, & Ohnishi, 1990). Results from the current study showed that male participants had a statistically higher science self-efficacy than the females. Males may have been motivated by the competitive aspects of these extracurricular science competitions, while females may have found team cooperation to be appealing. As noted earlier, previous studies have suggested males prefer competitive learning contexts while females prefer cooperative learning contexts (Owen & Stratton, 1980). What is not known is how the actual participation in a competitive science event impacts the science self-efficacy of males and females. The question is further complicated by the issues that surround winning or losing these events.

Participant differences in interest in science outside of school. The *Competitive Science Experience Survey* indicated that students who participated in a competitive science event were more interested in learning about science outside of school (e.g. science related books and television shows, building models, science hobbies, etc.) than those who did not participate. It is likely that these students had science-related interests prior to participating in these extracurricular science activities. One of the unique aspects of competitive science events is that they offer opportunities for informal and formal learning environments to “mesh,” allowing characteristics of both to be expressed in one physical environment. This hybrid environment could possibly offer the best of both formal and informal learning environments to students.

Some researchers have attempted to clarify the distinction between formal, non-formal, and informal learning through cognitive aspects of those learning environments. Greenfield and Lave (1982) established eight characteristics of formal and informal education (Table 8), arranged as completely opposite entities. These characteristics were developed as a result of their cognitive and anthropological research conducted in Samoa, Papua New Guinea, and Liberia.

Table 9

Comparing Formal and Informal Learning Environments and Science Teaching

Formal	Informal
Set apart from the context of everyday life	Embedded in activities of daily life
Teacher imparts knowledge	Learner is responsible for obtaining knowledge and skill
Impersonal	Personal
Explicit pedagogy and curriculum	Implicit pedagogy and curriculum
Change/discontinuity are valued	Maintenance of continuity and tradition
Learning by verbal exchange	Learning by observation/imitation
Teaching by verbal presentation	Teaching by demonstration
Less strong social motivation	Motivated by social contribution of novices to adult life

In contrast to Greenfield and Lave’s (1982) construct of formal and informal learning, Maarschalk (1988) approaches formal, non-formal, and informal science teaching as “interdependent but clearly distinguishable forms of education” (p. 137). Based on the results of his study with the Rand African’s University Scientific Literacy Research Project, Maarschalk argued that informal science teaching, as opposed to learning, needed to be examined within science teaching research. He suggests that teaching does not have to be delivered in the formal context only, but extends beyond school-contexts to be integrated into the non-formal environments as well. For example, in helping to train their students for a science olympiad event, a teacher may use his or her classroom at a specific time of day (formal) while demonstrating how a local aquifer system operates (informal). Maarschalk (1988) defined non-formal teaching as, “proceeding in a planned but adaptable way in institutions and organizations, such as in-service training, field trips, museum visits, and educational television and radio” (p. 137).

Science olympiad, envirothons, and first year robotics are examples of competitive science events documented in this study that have formal and informal characteristics, creating a hybrid learning environment. For example, a teacher may recruit and form teams during the school day (formal), practice for the competitive science event after school (informal), and then travel to compete away from the community. It is possible that students who participate in such events may also be more interested in learning science outside the classroom because they had positive experiences in these hybrid learning environments.

Valuing the competitive science experience. Past research has indicated that extra-curricular science programs have led to positive changes in those students who participated (Stake & Mares, 2001). These changes have included being more knowledgeable about science processes and content, as well as, increased science self-efficacy (Stake & Mares, 2001). The results of the *Competitive Science Experience Survey* found that students who participated in a competitive science event tended to indicate an interest in having their own children to one day participate in a similar event. One interpretation of this result is that students realized the value of participating in a competitive science event as having influenced their interests, attitudes, and pursuits of similar science experiences.

Motivation to Participate in a Competitive Science Event

Students in this study majoring in a STEM discipline reported an array of motivational factors had influenced their decision to participate in a competitive science event. The most frequently reported motivators were teachers and parents. Other studies have documented similar findings, noting that encouragement from teachers was important to student motivation (Stake, 2006). Friends and family members have also been found to be

positive influences on students' motivation (Stake, 2006). In the present study, students commented on the positive role of teachers, parents, and peers in their participation in competitive science events. Previous research (Jones, Taylor, & Forrester, in press) suggests that these relationships may have also promoted students' interests in science, autonomy, competence, and science self-efficacy. Further research is needed to understand the impact of adult and peer relationships that develop within the context of competitive science events.

Non-STEM majors reported most frequently being motivated to participate in a competitive science event through intrinsic motivational factors. These intrinsic motivators included finding the competitive science experience fun and interesting. While these particular students did not choose to major in a STEM discipline, their positive experiences with competitive science events may have influenced their interest in science and science self-efficacy.

Academic Major Choice

Understanding how students make decisions about their academic majors can shed light on career decisions. The results of this study showed there were differences by gender, science self-efficacy, participation in specific types of science competitions, and influential relationships with teachers and parents.

Gender differences in academic major choice. National attention has been brought to the gender differences in students' selection of science careers (Baker, 2002; Ivie, Czuiko, & Stowe, 2002). In the present study there were significant differences by gender for choice of academic major. Males in this study were more likely to choose a STEM major than females. It may be possible to use competitive science events as a platform for closing the

gender gap in science. As noted early in the discussion, positive relationships with teachers and peers could serve as a support to encourage gap female students to stay with science throughout college. Ware and Lee (1988) provided evidence that high school teachers made a significant impact on female students persistence of science during their post-high school education.

Science self-efficacy differences between academic majors. Science self-efficacy has been shown to be a factor that influences both academic major choice and interest in pursuing a science career (O'Brien, Martinez-Pons, & Kopala, 1999; Lent, Brown, & Larkin, 1984). Self-efficacy also has been shown to work as a mediating variable for other factors affecting academic major and career choice, such as, academic performance, ethnic identity, and gender (O'Brien et al., 1999). When science self-efficacy was analyzed by specific STEM discipline (science, technology, engineering, and mathematics) in the current study, science and engineering majors were found to have higher science self-efficacy than technology and mathematics majors. Science majors may have higher self-efficacy because they were able to develop positive efficacy in the K-12 classrooms via vicarious experiences. For example when high school students observed their teacher performing engaging science demonstrations or discrepant events they perceived the experience as a positive one. This idea is reinforced by the study Luzzo, Harper, Albert, Bibby, and Martinelli (1999) conducted that examined the effects of vicarious experiences on a group of college students who were undecided in their majors. Luzzo et al., (1999) had also reported there is a positive relationship between science self-efficacy (which is developed through vicarious experiences) and academic major choice. Engineering majors in the present study may have

had more opportunities outside of the classroom to develop their science self-efficacy through mastery experiences. Jones, Taylor, and Forrester (in press) reported that professional engineers cited tinkering and model building outside of the formal classroom as positive influences on the selection of a major in science or engineering.

Difference in academic major choice by event type. Students who participated in science olympiad and “other” competitive science events are more likely to major in the STEM disciplines. This may be due to the fact that science olympiad and “other” competitive science events are team-based, parent-and teacher- organized, and tend to be hands-on types of experiences. Science fair and junior science and humanities symposium are verbal and written based events. These types of experiences may be more attractive to particular learners, who choose not to major in a STEM discipline.

The students in this freshman class who participated in science olympiad and “other” competitive science events were more likely to be engineering majors. This may be because these types of competitive science events are tailored to the engineering prone student. For example, those students who enjoy tinkering and building models may be drawn to these types of science competitions where they build bridges or shoot off bottle rockets. Students who competed in science olympiad and “other” competitive science events are also more likely to be male. We don’t know if male students tend to be more interested in engineering-types of events and select engineering out-of-school activities and then decide to be an engineering major or if engineering-types of science competitions influence males to select an engineering major. Further studies are needed to understand the progression of events described above.

Other Motivational Factors Influencing Academic Major Choice

Non-STEM Majors. Seventy percent of the students who participated in a competitive science event but majored in a non-STEM discipline indicated that their competitive science experience did not influence their academic major choice. These students indicated intrinsic motivational factors as an influence in their academic major choice. Examples of intrinsic factors discussed by participants included: specific career paths, an internship experience, and classes that they took in high school. For these students other interests influenced their college major choice other than science.

STEM majors. When asked to reflect on motivational factors that influenced their academic major choices 73% of students who chose a STEM major indicated intrinsic motivators. Examples of intrinsic motivational factors discussed by students included being “subject oriented,” liking a particular academic discipline, or noting that they were good in a certain academic area. Participants also referred to extrinsic motivational factors as affecting their academic major choices. Thirty-three percent of study participants recalled teacher influences while 17% indicated parents as influences on their choice of major. Most notably, 53% percent of STEM majors reported that their pre-college participation in a competitive science event influenced their academic major choice. The next step in future research is to find out *how* participation in a competitive science event influences academic major choice.

Interest in Science

Identifying and capturing young children’s interest in science (before the middle school years) has been increasing the number of students who ultimately pursue a science major in college (Osborne & Dillon, 2008; Rocard et al., 2007; Tai, Liu, Maltese, & Fan,

2006). In this study, STEM majors reported having a higher interest in science than non-STEM majors. As science educators we should be trying to capture student interest in science during the K-12 school years in an attempt to sustain the STEM pipeline. Those students who participated in a competitive science event and majored in a STEM discipline reported having higher interest in science after the competitive science experience than those who did not major in a STEM discipline. These results suggest competitive science events may play an important role in sustaining and enhancing students' interests and subsequent selection of a STEM major.

Implications for K-16 Education

The results of this study show how competitive science events possibly influence academic major choice, general interest in science, and interest in out-of-school science experiences. Results also indicated that relationships with teachers, parents, and peers influenced student motivation to participate in a competitive science event and in academic major choice. It is important for parents and teachers to work together in sparking and sustaining student interests in science. Competitive science events can serve as a platform for that initial spark. The informal and cooperative teamwork found in many of the science competitions can be motivating to underrepresented students (females, minorities, and students with learning disabilities) that may not be reached in the formal science classroom.

This study found evidence that participation in a competitive science events can influence students' choice of a STEM major in college. By becoming involved in those competitive science events held on their university campuses, admissions directors, professors, and collegiate recruiters may be able to identify future scientists, engineers, and science educators. While participation in a competitive science event did not motivate all students to chose a STEM major, the positive experiences with science that non-STEM majors had during these events could possibly inspire them to apply their non-STEM interests to science contexts as science writers, photographers, or science policy makers.

Future Research

The present study showed that there are race and gender differences in participation in competitive science events, science self-efficacy, and academic major choice. What is not yet clear is *how* does participating in a competitive science event impact science self-efficacy? Could participation in science competitions be used as an intervention positively changing science self-efficacy for students?

Male students who participated in a competitive science event were more likely to choose an engineering major than females. What is the progression of events that led to this choice? Which comes first, interest in science or high science self-efficacy? We know that competitive science events influence academic major choice, but we don't yet understand how.

Relationships, some of which were forged during competitive science events, were documented as influencing student motivation to choose a specific college major (STEM vs. non-STEM). Further research is needed to understand the impact of adult and peer relationships that develop within the contexts of these events. Other questions surrounding the influence of competitive science events have been spurred as a result of this study. They are: How are students with learning disabilities impacted by participation in a competitive science event? Are there differences in student knowledge for students who participate and those who do not? What is the impact of participation on science identity formation and students' assimilation into the culture of science? How does being involved in competitive science events influence pre-service and in-service science teachers' science self-efficacy and

leadership characteristics? Answering these proposed questions may lead to further understanding the impact that competitive science events have on facets of science education.

Conclusion

This study of 1, 488 college freshman provides evidence that there is a significant relationship between participating in science olympiad and “other” competitive science events and choosing a STEM major. Differences in gender and race documented in this study may lead to using competitive science events to motivate female and minority students to consider science majors and careers. The statistically significant relationship between participation in a competitive science event and science self-efficacy could address the observed decline in science interests and STEM academic major choice. Positive competition outcomes leading to increased science self-efficacy, peer bonding, and interest in science have implications for the K-16 educator. Furthermore, relationships with parents, teachers, and peers are factors that can be strengthened as a result of pre-college participation in competitive science events. For science educators to inspire the next generation of scientists, engineers, and science teachers, we must offer our students every opportunity to develop the factors investigated in this study that positively influence science self-efficacy, interest in science, and choosing a STEM discipline as a college major. Through competitive science events we can influence those future scientists and engineers to, “not be the person who gives the right answer, but who asks the right questions” (Anonymous).

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APPENDICES

Appendix A

Directions for Completion: Please read and answer the following questions to the best of your ability. Do not leave any of the questions blank. Make sure that you mark your answers clearly on the answer sheet provided.

Definition: A competitive science event is any science competition like science fairs, Science Olympiad, academic science decathlons, Envirothons, and junior science and humanities symposium.

Check any of the competitive science events you participated in during elementary school, middle school, and/or high school and indicate the number of years you participated. **If you did not participate in a competitive science event, complete questions 1 through 15 of the survey below.**

1. Science Olympiad:
Number of years: _____ Elementary School, Middle School and/or High School
2. Science Fairs:
Number of years: _____ Elementary School, Middle School and/or High School
3. Envirothons
Number of years: _____ Elementary School, Middle School and/or High School
4. Academic Science Decathlons
Number of years: _____ Elementary School, Middle School and/or High School
5. Junior Science and Humanities Symposium
Number of years: _____ Elementary School, Middle School and/or High School
6. Other science competitions: Please indicate the number of years participated and whether it was in elementary, middle and/or high school.

	Strongly Disagree A	Disagree B	Neither Agree Nor Disagree C	Agree D	Strongly Agree E
1. Compared to others my age I am good at science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. I get good grades in science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Science is easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. I am not good at science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Learning how to be better in science is easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. I have always done well on science assignments.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. I prefer to learn about science as part of a cooperative group.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. I prefer to learn about science one on one.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. If I have children, I would want them to participate in a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. I am interested in science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. I am interested in science outside of school (e.g., science hobbies, books, television shows, building models, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Competitive science events were offered at my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. I did not participate in a competitive science event even though it was offered at my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Disagree A	Disagree B	Neither Agree Nor Disagree C	Agree D	Strongly Agree E
16. My parents required me to participate in a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. My teachers did not require me to participate in a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. I participated in a competitive science event because I enjoy competing.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19. I am good at science compared to people who did not participate in a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. Doing science during a competitive science event was easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. I did not do well in my competitive science event(s).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. After participating in a competitive science event, I wanted to learn more about science.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. I did not get self-satisfaction from participating in a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. After losing an event at a competitive science tournament, I continued to participate on a competitive science team.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28. I have not taken more science classes because of participating a competitive science event.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix B

Semi-Structured Interview Questions

- 1A. I noticed your major is _____. Why did you choose this major?
- 1B. Can you tell me what motivated you to participate in a competitive science event?
(Probe: For example were you required? Were all of your friends involved?)
2. What was that experience like for you? (Will probe about: team make-up and dynamics, competitions, rewards and recognition received.)
3. Were you successful or not in this science competition?
4. If you could participate in a science competition again, would you?
5. If you participated for more than 1 year, how were your experiences across the years different/the same?
6. Did anyone encourage you to participate in a competitive science experience?
7. Before coming to college, did you participate in any other science related experiences out-side of school? (clubs, camps, museums)
8. Did any of the following change as a result of participating in a competitive science event?
 - A. Hobbies
 - B. Career Goals
 - C. College Choice
 - D. Academic Major Choice
9. Did you have an interest in science before you participated in this science competition?
10. Do you have any current hobbies related to science? Any hobbies from middle or high school related to science?