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AN ANALYSIS OF SCIENCE OLYMPIAD PARTICIPANTS' PERCEPTIONS
REGARDING THEIR EXPERIENCE WITH
THE SCIENCE AND ENGINEERING ACADEMIC COMPETITION

BY

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Submitted in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education
Seton Hall University

2011

SETON HALL UNIVERSITY
COLLEGE OF EDUCATION AND HUMAN SERVICES
OFFICE OF GRADUATE STUDIES

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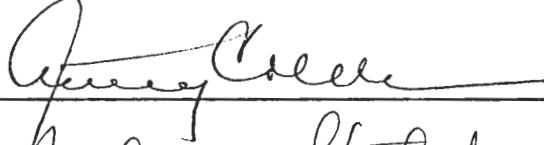
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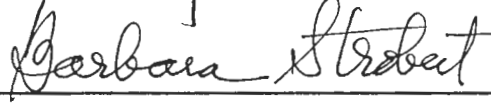
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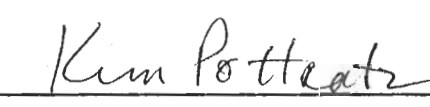
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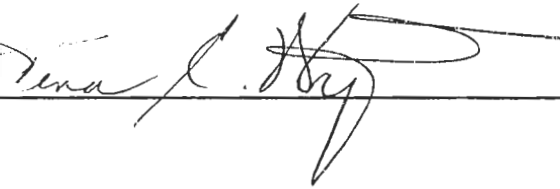
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ABSTRACT

AN ANALYSIS OF SCIENCE OLYMPIAD PARTICIPANTS' PERCEPTIONS REGARDING THEIR EXPERIENCE WITH THE SCIENCE AND ENGINEERING ACADEMIC COMPETITION

Science education and literacy, along with a focus on the other STEM fields, have been a center of attention on the global scale for decades. The 1950's race to space is often considered the starting point. Through the years, the attention has spread to highlight the United States' scientific literacy rankings on international testing. The ever-expanding global economy and global workplace make the need for literacy in the STEM fields a necessity.

Science and academic competitions are worthy of study to determine the overall and specific positive and negative aspects of their incorporation in students' educational experiences. Science Olympiad is a national science and engineering competition that engages thousands of students each year.

The purpose of this study was to analyze the perceptions of Science Olympiad participants, in terms of science learning and interest, 21st century skills and abilities, perceived influence on careers, and the overall benefits of being involved in Science Olympiad. The study sought to determine if there were any differences of perception when gender was viewed as a factor. Data was acquired through the Science Olympiad survey database. It consisted of 635 usable surveys, split evenly between males and females. This study employed a mixed methods analysis. The qualitative data allowed the individual perceptions of the respondents to be highlighted and acknowledged, while the quantitative data allowed generalizations to be identified.

The qualitative and quantitative data clearly showed that Science Olympiad had an impact on the career choices of participants. The qualitative data showed that participants gained an increased level of learning and interest in science and STEM areas, 21st century skills, and overall positive benefits as a result of being involved. The qualitative data was almost exclusively positive. The quantitative data however, did not capture the significance of each researched category that the qualitative anecdotal evidence depicted. The data showed that females were engaged in STEM areas when involved in Science Olympiad.

Recommendations were made for further study to help delineate the data using different research questions and to further study the impact of Science Olympiad utilizing the same research questions used in this study.

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I offer sincere thanks to the Science Olympiad organization who shared their survey database with me. This research would not have been possible without it. Thank you also for starting such a wonderful organization to which I am truly addicted.

Finally, I would like to thank my family and friends who supported me throughout this entire process.

DEDICATION

This dissertation is dedicated to my parents
who were my first teachers and taught me the value of hard work.

The following people were influential in my life and helped shape the person I am
today.

To my mother, Kathleen Wirt, who always encourages me and is there for me.
She started me on my path of loving education by playing school with me at a little
wooden desk in the family room.

To my father, Peter Wirt, who started me on my love of French fries, root beer,
and cookies - in a good way. I indulged in these foods a lot during this journey.

To my sister and brother, Susan and Christopher, who grew up with me. I am
thankful that we are close. Susan – now that I am done with this we can have more “talk
time” and Chris – got you last!

To my FAVORITE kids in the whole world, Ryan, Dean, and Kaylee. I love
playing with you and watching you grow and learn. I hope we are always close and a
part of each other’s lives. I hope you know the value of education and love school and
learning as much as I do.

To all of my teacher friends, thanks for making my teaching days so much fun. School was never work, it was a place to collaborate with a wonderful and dedicated group of teachers who cared about kids and made learning fun, exciting, and meaningful. You have touched many lives in such positive ways.

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To the Science Olympiad teams and students that I have coached. I have had a great time working and learning with all of you.

As Walt Disney said, “Around here... we don’t look backwards for very long. We keep moving forward, opening up new doors and doing new things...and curiosity keeps leading us down new paths.”

TABLE OF CONTENTS

Abstract.....	ii
Acknowledgements.....	iv
Dedication.....	v
List of Tables.....	xi
I. INTRODUCTION.....	1
Background of the Problem/Historical Background of Science Education.....	3
Statement of the Problem.....	7
Purpose of the Study.....	10
Research Questions.....	11
Definition of Terms.....	11
Limitations of the Study.....	13
Delimitations of the Study.....	14
Summary.....	14
II. REVIEW OF THE LITERATURE.....	16
Introduction.....	16
Science Olympiad Overview.....	16
Other Research on Science Olympiad.....	19
Abernathy and Vineyard Research.....	20
Hounsell Research.....	22
McGonigal and Payne Research.....	24
McGee-Brown, Martin, Monsaas, and Stromber Research.....	25
Baird, Shaw, and McLarty Research.....	27
International Test Performance Comparisons.....	28
Comparison of STEM Education between the United States and the World.....	32
Overview of Science Education.....	34
Inquiry Science.....	37
Teaching Science in the 21 st Century.....	38
21 st Century Skills.....	42
Problem Solving.....	47
Extracurricular Activities.....	48
Talented Youth and Competition.....	52
Gender and STEM	55
Summary.....	64

III.	METHODOLOGY.....	65
	Overview.....	65
	Theoretical Background.....	68
	Research Design.....	69
	Data Collection.....	72
	Data Analysis.....	74
	Coding.....	79
	Summary.....	80
IV.	ANALYSIS OF DATA.....	81
	Research Question 1.....	83
	Fun.....	84
	Students.....	84
	College.....	84
	Adults.....	85
	Loved Science Olympiad.....	86
	Students.....	86
	College.....	86
	Adults.....	88
	Life Impact.....	88
	Students.....	88
	College.....	89
	Adults.....	90
	Social Aspects of Science Olympiad.....	91
	Students.....	91
	College.....	92
	Adults.....	93
	Education.....	95
	Competition.....	97
	Students.....	97
	College.....	98
	Adults.....	99
	Quantitative Data.....	100
	Research Question 2.....	106
	Specific Science Content.....	106
	Students.....	106
	College.....	108
	Adults.....	110
	Science Work.....	111
	Students.....	111
	College.....	112
	Adults.....	113

Science Overall.....	114
Students.....	114
College.....	115
Adults.....	115
Science is Interesting.....	117
Students.....	117
College.....	117
Adults.....	118
Quantitative Data.....	118
Research Question 3.....	124
Teamwork.....	124
Students.....	124
College.....	125
Adults.....	126
Problem Solving.....	127
Students.....	127
College.....	127
Adults.....	128
Critical Thinking.....	128
Students.....	128
College.....	129
Adults.....	129
Other 21 st century skills.....	130
Students.....	130
College.....	131
Adults.....	132
Quantitative Data.....	133
Research Question 4.....	139
Students.....	139
College.....	141
Adults.....	144
Quantitative Data.....	146
Research Question 5.....	153
Summarized Quantitative Data.....	153
Summary.....	154

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS..... 155

Research Question 1.....	157
Research Question 2.....	161
Research Question 3.....	164
Research Question 4.....	168
Research Question 5.....	171
Summary of findings.....	172
Recommendations for Research, Practice, and Policy.....	174
Recommendations for Further Research.....	174

District and Educational Recommendations.....	176
References.....	178
Appendices.....	186
Appendix A: Science Olympiad Leading to a Career - College.....	186
Appendix B: Science Olympiad Leading to a Career - Adults.....	188

List of Tables

1. Overall benefits of participating in Science Olympiad – Students.....	101
2. Overall benefits of participating in Science Olympiad – College.....	101
3. Overall benefits of participating in Science Olympiad – Adults.....	102
4. Overall benefits of participating in Science Olympiad – Total.....	103
5. Percentage of females and males within the sub-categories for Overall Benefits – Total.....	104
6. Percentage of responses disaggregated by minor theme and gender for Overall Benefits – Total.....	105
7. Perceived impact on learning and interest of STEM concepts and skills – Students.....	119
8. Perceived impact on learning and interest of STEM concepts and skills- College.....	119
9. Perceived impact on learning and interest of STEM concepts and skills – Adults.....	120
10. Perceived impact on learning and interest of STEM concepts and skills – Total.....	121
11. Percentage of females and males within the STEM sub-categories – Total.....	122
12. Percentage of responses disaggregated by minor theme and gender for STEM – Total	123
13. 21 st Century skills acquired – Students.....	134
14. 21 st Century skills acquired – College.....	134
15. 21 st Century skills acquired – Adults.....	135
16. 21 st Century skills acquired –Total.....	136
17. Percentage of females and males within the sub-categories 21 st century skills– Total.....	137

18. Percentage of responses disaggregated by minor theme and gender for 21 st century skills – Total	138
19. Science Olympiad Leading to a Career – Students.....	146
20. Science Olympiad Leading to a Career – College.....	147
21. Science Olympiad Leading to a Career – Adults.....	148
22. Science Olympiad Leading to a Career – combined college and adults.....	150
23. Percentage of total college students and adults engaged in a STEM field.....	151
24. Science Olympiad Leading to a Career disaggregated by minor theme and gender – combined college and adults.....	152
25. Overall data.....	153

Chapter I

INTRODUCTION

“Everybody starts out as a scientist. Every child has the scientist’s sense of wonder and awe.” ~Carl Sagan (as cited by the National Research Council, 1998)

We are currently in a time of educational conundrums. Local schools and the United States at large are undergoing severe financial hardships. Schools are frequently required to cut programs and activities due to decreasing financial support. Schools often target extracurricular activities as part of the first wave of cuts when trying to minimize costs (Bucknavage & Worrell, 2005). On the other hand, we live in a time of global competitiveness and an ever-flattening world where everyone and everything is interconnected (Friedman, 2005). There is an expanding need for all students to be scientifically literate and gain the skills and abilities to solve complex problems, think critically, and work as part of a collaborative team. Students need opportunities to develop these skills and abilities to be competitive when they graduate and enter the workforce. There is a belief that innovation can lead to a world-class educational system (Fitzpatrick, n.d.). Part of the way to do this is to give students real-world STEM (Science, Technology, Engineering, and Math) experiences and to build partnerships with scientific organizations. Competitions, informal science programs, and organizations that run outside of the school day can stimulate an interest in the STEM fields (Fitzpatrick, n.d.).

Science Olympiad, Inc. is an organization that runs a national science, technology, and engineering competition and is the governing body over state and regional competitions. Thousands of students participate on Science Olympiad teams. In 2010, there were over 6,000 teams competing at the middle school and high school level (Website of Science Olympiad, n.d.). The overarching questions include what students involved in Science Olympiad perceived about their STEM and 21st century skills after being part of a team, whether they saw any overall benefits as a result of participating, and whether or not their experience influenced their career choice. This focus is critical due to the importance of the STEM fields and the importance of students' involvement in the areas of science in and out of the school environment.

The concentration on, and the discussion of, STEM is not isolated to the United States. International testing such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) denotes the rankings of schools on an international scale. Science is a major focus. Citing the TIMSS study, Vitale and Romance (2006), state that those countries that ranked high had curriculum that,

...focused around big ideas, was conceptually coherent, and carefully articulated across grade levels. In contrast the curricula in low-achieving countries (including the United States) emphasized superficial, highly-fragmented coverage of a wide range of topics with little conceptual emphasis or depth. (p. 336)

Some research found that direct instruction from the teacher is more effective than a student's self-discovery approach. This direct instruction is stated to be better for both the students' initial understanding and acquiring of knowledge regarding procedures and

for later application and transfer of that knowledge and understanding. Additionally, focusing on core concepts and the interrelated relationships, as well as both science knowledge and the nature of science, provides a comprehensive science literacy background (Vitale & Romance, 2006). According to Stohr-Hunt (1996), research shows that activity based science programs are effective, but that conversely, the research is not definitive as to whether or not it shows that it is necessarily better than traditional methods of instruction. Science Olympiad is a competition that allows students to work in groups and teams. It is normally run as an afterschool club and not as part of a class during the school day. As such, it does not normally fall under the direct teaching classroom model.

Background of the Problem/Historical Background of Science Education

Historically, there has been an ebb and flow to the focus on science and math education. The literature often refers to the race to space and the launching of Sputnik in 1957 as part of the intense focus on science education and curriculum reform (Bybee, 2006; Price, T., 2008; Stohr-Hunt, 1996). At that time, the United States was in competition with the former Soviet Union, not only to go into space, but more importantly to prove overall superiority. The intense competition resulted in financial support of STEM programs and a focus on the STEM fields. In 1958, Congress passed the National Defense Education Act (NDEA) (as cited in Price, T., 2008). Part of this Act's goals were to improve science and math instruction in the K-12 arena. The overall goal was to produce highly trained people whom the United States could use in the competition against the Soviet Union for superiority in scientific and technical fields

(Price, T., 2008). The National Aeronautics and Space Administration (NASA) was established and President Eisenhower created the Office of Special Assistant to the President for Science and Technology (Price, T., 2008). As a result of this science push, science curriculum development expanded for the next 20 years (Stohr-Hunt, 1996).

Even before Sputnik, there was concern in the United States over the lack of scientific endeavors and the lack of scientists. In 1945, presidential science advisor Vannevar Bush stated that when any country relied on another country for scientific knowledge; the result would be the slowing down of that country's industrial progress and a weakening of its competitive position in world trade. Additionally in 1947, the President's Scientific Research Board stated their concern over the shortage of trained scientists and the danger to national welfare and national security. In 1952, the Labor Department reported a shortfall in 61 different occupations needing scientific or specialized training (Price, T., 2008).

Following the race to space time period, there were other changes and trends regarding the science curriculum and the teaching of science. Part of the timeline focused on reform due to the economy, reform as a result of the comparison of the United States to other countries, and reform based on comparing results on both national and international testing (Bybee, 2006).

In an era of expanding and expansive globalization, the United States needs to both compete and cooperate with other nations. This change requires a workforce that is not only STEM literate, but also one that has the ability to solve problems, think critically, and work cooperatively and competitively. American workers realize the effects of lack of skills in these areas when they compete directly for jobs against much

lower-wage workers residing in other areas around the globe. It is no longer necessary to be geographically located in the place where the job is located. In a world of computers, smart phones, video conferencing, and instant messaging, there are a myriad of ways to communicate and few require that people be in the same location. This phenomenon is referred to as the “Death of Distance” (National Academy of Sciences, 2007.). Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (n.d.), is a document that was jointly created by the Committee on Prospering in the Global Economy of the 21st Century, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. In this document the committee states that they are, “deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength” (National Academy of Sciences, 2007, n.d., p. 3).

Part of the obstacles are the perceptions people have of what a scientist “looks like” and in turn, what it really means to be a scientist. The vast majority of student drawings of scientists over the last 50 years were of middle-aged or older males, with glasses and a lab coat working in a chemistry lab. People’s perceptions of scientists related to their own attitudes toward science, their locus of control, and self-efficacy. A plethora of research has found the same type of stereotypical views. Mead and Metraux’s research in 1957, (as cited in Finson, 2002), studied 35,000 high school students’ written descriptions of scientists. They found the same stereotypes as were depicted in the drawings. In 1981, Chambers, (as cited in Finson, 2002), developed the Draw-a-Scientist-Test (DAST) and found that students consistently drew a lab coat, glasses, facial

hair, scientific instruments, laboratory equipment, and artifacts of knowledge, such as books.

It is clear from various studies that students are not exposed to enough of the variations of scientific and technological jobs, nor have they been exposed to the excitement and wonder of science. They see science as something unrelated to themselves and something that does not encompass the vast world of scientific endeavors. Finson (2002) noted that a student's perception could be changed when they were actually exposed to scientists who were female or who worked in a variety of settings. If this perception can be changed for the better, then it is imperative that it is changed. The vast world of STEM fields are not relegated to dark basement laboratories filled with beakers. Students need to be exposed to all that is possible in the STEM fields so that they can not only be scientifically aware and literate, but so that they can also make more informed decisions about their own academic and career paths.

Today the goal of science education encompasses a push toward the education of scientifically literate people. Science achievement cannot be about tests scores alone, it must also be about the acquiring of problem-solving skills, process skills, and analytical skills (Stohr-Hunt, 1996).

President Barrack Obama started a campaign called "Educate to Innovate." In his speech on November 23, 2009, he stated that, "we live in a world of unprecedented perils, but also unparalleled potential." He stated that the United States must strengthen scientific discovery and technological innovation and that the country has been falling behind for decades. Science and math are seen as a crucial part of today's education and these fields hold the promise of the future. President Obama acknowledged that

government cannot create success alone; there is a need for dedication to learning by students and parents and a partnership with communities, organizations, and businesses. The goal is to move science and math education to the forefront of the world in the next decade. The reason for the renewed focus on the STEM fields is the belief that these fields will lead the United States to a better economy and to ongoing success (Obama, 2009).

Today, India and China are increasing the number of engineers they produce as the United States is producing fewer engineers. Global competitiveness is hinged on the United States' ability to be at the top of the innovation game. Individual states have taken up the goal of improving and investing in STEM related fields. Part of the STEM focus should be on stringent education requirements, student experiences with real-world scientists and organizations, and ensuring that students are STEM literate. Several states have focused on the strategy of supporting STEM not only from inside the classroom, but also from the outside, by supporting informal science organizations (Fitzpatrick, n.d.).

Statement of the Problem

Science Olympiad is a science and engineering competition involving thousands of elementary, middle, and high school students. This study analyzes the perceptions of both current and former participants of Science Olympiad. The research focus is on these participants' perceptions of the impact of Science Olympiad on STEM learning and interest, 21st century skills, career choice, and overall perceptions of the benefits of involvement. According to Bucknavage and Worrell (2005), there is a need for research that examines specific types of academic activities.

Research indicates that there are “windows of opportunity” or a time when a learner’s appetite for learning can be increased. This is a time of optimal learning where the brain is thriving on varied experiences. Students can achieve optimal learning when they are active and have choices, and when the learning is relevant to them (Campbell, 2008).

Campbell (2008) cites research stating that challenging stimuli often create new pathways and increases the likelihood of long-term memory retention. A rich environment contributes to a rich brain. Educators should think about the stimuli that students are getting whether it be through the classroom or through other activities. Variety is a critical component to brain function. Variety can come in the form of creativity, new and different stimulation, and fluctuations of rest and activity. Learning should be exciting for the student and brains need to be stretched to reach their potential. The brain is at its best when it is in an environment that is positive, nurturing, and stimulating. Learners’ want to experience new things; they want to engage in discovery and challenges. Rote learning and memorization on the other hand inhibits brain development (Campbell, 2008). Science Olympiad tournaments are comprised of events ranging across many science, technology, and engineering disciplines. This plethora of events is exciting for the participants, as they can get involved in many different STEM areas.

Campbell (2008) notes that Piaget’s stages of child development revolve around some of these ideas: Children are curious and motivated learners. Children must participate in active experimentation in order to grow. Vygotsky, (as cited in Campbell, 2008) believed in social interaction as the key to cognitive development. Children learn

through social interactions. Learning tasks can be more challenging if there are other individuals with knowledge that can help the learner. Vygotsky, (as cited in Campbell, 2008), says that cognitive growth is an outgrowth of engaging in challenging tasks.

The National Research Council (1996) stated in the National Science Education Standards (NSES) state that science learning is an active process. It needs to be both hands-on and minds-on. One without the other does not allow a student to have a complete education in the world of science. Science learning allows students to actually “do” science, not to just sit as passive receivers of knowledge. Students must question, acquire, construct, describe, test, and communicate (National Research Council, 1996).

There is much rhetoric these days regarding the various types and forms of literacy that students must possess. The one that was important to this study was scientific literacy. Scientific literacy is comprised of two parts. One part is what the student understands, knows, and can do. The other part is how that same student can use this knowledge to be a productive citizen. The National Science Education Standards (1996) document describes scientific literacy as being when a person who can ask, find, question, describe, explain, predict, and evaluate phenomena and methods. A scientifically literate person is a person who is versed enough in the background and ways of science to have intelligent conversations and can understand the issues that are debated at the local, national, and international level. A scientifically literate person will not stop seeking scientific knowledge as they exit the schoolhouse door, they will continue to build their knowledge as they move through their life’s journey (National Research Council, 1996).

The National Research Council (1996) state in the NSES that inquiry is an important part of a student's education and an important part of being a scientifically literate citizen. Inquiry is described as both the way a scientist studies the world and the way in which students engage in activities to enhance depth of knowledge and understanding of the world of science. Just as science education is more than hands-on activities, science inquiry is also more than doing open-ended labs. Inquiry has many components including: observing, questioning, researching information available in the field, experimenting, reviewing results, and communicating results. The NSES also included reading about science as an important part of inquiry. The varied Science Olympiad events incorporate these components (Website of Science Olympiad, n.d.).

The NSES states that schools and specifically the classroom are limited in their ability to provide a complete science education. They encourage schools to reach out beyond their school environment to gather and use the resources of the greater community (National Research Council, 1996).

Purpose of the Study

The purpose of this study was to analyze the perceptions of Science Olympiad participants, in terms of science learning and interest, 21st century skills and abilities, perceived influence on careers, and the overall benefits of being involved in Science Olympiad. The study also sought to determine if there were any differences of perception when gender was viewed as a factor. One of the goals of this study was to determine common themes and trends. These themes and trends looked at frequency of themes as well as specific and general perceptions.

Students spend half of their time in leisure activities. According to research, extracurricular activities are good uses of this time as they often provide opportunities for growth. Students have the opportunity to explore, develop, and work with supportive adults during extracurricular activities. The activities students choose determine their friends and shapes their overall values. Extracurricular activities are associated with **academic success** and positive plans for higher education (Fredricks & Eccles, 2005).

Research Questions

1. What are the participants' perceptions of the overall benefits of being on a Science Olympiad team?
2. What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?
3. What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?
4. What are the participants' perceptions of Science Olympiad's impact on their career choice?
5. Is gender a factor of the participants' overall perceptions regarding Science Olympiad?

Definition of Terms

Science Olympiad: A national organization that oversees science competitions for students in grades 3-12. These competitions are held at the local, regional, state, and

national levels. They also sanction elementary Science Olympiad fun days (Website of Science Olympiad, n.d.).

Science Olympiad Team: A team is comprised of approximately 15 regular members and additional alternates. There are four divisions. The A1 and A2 divisions are for students in grades K-3 and 3-6 respectively and are not the focus of this study. The B division is for students in grades 6-9 and the C division is for students in grades 9-12.

Scientific Literacy: "...the specifications for student learning should focus on science concepts and understanding as well as the abilities and processes of scientific inquiry" (Bybee, 2006, p. 26-27). Another definition of a person who is scientifically literate is one who has knowledge of science concepts and science applications, the use of science processes in solving problems and making decisions; the understanding of the nature of science and scientific enterprise and an understanding of an interaction between science, technology, and society (Stohr-Hunt, 1996).

STEM - Science, Technology, Engineering, and Math: In some contexts this is used as the combination of these fields. In this study, the term STEM is used as shorthand for the four fields. The term science and STEM will be used interchangeably for the purposes of this study.

Coach/Advisor: An adult who organizes and runs a Science Olympiad team.

21st century skills: For the purposes of this analysis, 21st century skills will refer to problem solving, critical thinking, and teamwork. Research refers to a wide range of skills that can be considered 21st century skills. These three are focused on specifically because they are part of the goals of the Science Olympiad organization.

Informal Science: Any science engagement that happens outside a regular school day.

Survey: In this study, the term survey was used to refer to a set of open-ended questions to which participants choose to respond. Answers were given in a written format.

Limitations of the Study

There may be researcher bias, as the researcher has been, and is currently involved at the local and state level in the Science Olympiad organization as both a coach and as the New Jersey state director. However, Patton (2002) states that, “To understand fully the complexities of many situations, direct participation in and observation of the phenomenon of interest may be the best research method” (p. 21).

This study was limited to the possible and professional biases of respondents due to their own ways of working, interacting, reminiscing, and their specific focus when part of a Science Olympiad team.

The participants’ responses were self-reported. This may have created a bias in the study.

The data in the study was obtained from the Science Olympiad organization. The researcher had no control over the available data, the way in which it was collected, nor the questions that were asked.

The data may be biased as the respondents selected to respond to the survey.

Delimitations of the Study

Several delimitations were inherent in this study. These delimitations included, but were not limited only to the following:

This study was limited to the responses and perceptions of Science Olympiad current participants and alumni who chose to answer a survey on the Science Olympiad website (www.soinc.org).

Data used to analyze current and former participant responses were limited to the information provided in the database.

This study was limited to the form of analytical methodology that was chosen by the researcher.

This study was limited to the sample size of the group that responded to the survey.

Summary

Science education is a historical and current topic of conversation and concern. Science education not only impacts the students as they learn it, but also as they grow as global citizens. The focus of this study was to analyze the responses of participants of a science and engineering competition to determine the impact it had on STEM learning and interest, 21st century skills, career choice, and overall benefit for the participant and the influence of gender.

Chapter I included a review of the historical background and need to focus on science education and the STEM fields. The researcher presented research questions as well as definitions of terms and discussion of both limitations of the study and researcher

bias. Chapter II includes a review of the literature that is relevant to this study. Chapter III describes the research methods used to analyze the data. Chapter IV provides an analysis of the qualitative and quantitative data. Chapter V provides a summary of each research question and an overall conclusion.

Chapter II

REVIEW OF THE LITERATURE

“Never forget that science is just that kind of exploring and fun.” ~ Albert Einstein

(as cited in Bianchini, 2008)

Introduction

The focus of this chapter is to review the literature that relates to the five research questions. The following subsections of this chapter will directly relate to either Science Olympiad as a competition, or to one of the five research questions.

Science Olympiad Overview

Science Olympiad is a national organization that oversees competitions for students in sixth through twelfth grades as well as elementary fun days. The competition is often described as being akin to an academic track meet. There are four divisions. Division A1 is for students in grades K-3; Division A2 is for students in grades 3-6, Division B for students in grades 6-9, and Division C for students in grades 9-12. Divisions A1 and A2 do not compete at the national level. Teams in Division B and Division C compete in approximately 23 science, technology, and engineering focused events. The students can compete individually in an event, but the overwhelming majority of students compete in pairs and groups. National rules state that teams are comprised of 15 student members with a few additional students serving as alternates. Individual states may modify these rules. Winners of individual events receive medals while the overall winning teams receive trophies. Each year some of the events are rotated to keep the competition

interesting and to reflect the changing trends in the STEM fields. There is an emphasis placed on active, hands-on group participation and teamwork as is needed in STEM fields today (Website of Science Olympiad, n.d.).

There are over 240 regional and state tournaments run throughout the country leading toward the winning teams participation in the national tournament (Website of Science Olympiad, n.d.). At the national level, many students receive scholarships. Science Olympiad reports that over \$2,500,000 have been awarded to students winning events at the national level. National tournament gold medal-winners demonstrate levels of knowledge and ability for science research work. This is one reason they often get university scholarships. The fact that a range of grade levels can be involved in Science Olympiad is important because it popularizes science for a large number of students and it identifies young talent (Orlik, 2008).

The Science Olympiad organization has garnered various awards, including the Society of Manufacturing Engineers Building the Future Award, Combined Federal Campaign and Independent Charities of America “Best in America” Award, and the “Champions in Education” Award for Best K-12 Volunteer Activity in the Midwest. It also was a NASSP Student Contest and Activities Approved for 2008-2009. Sponsors of Science Olympiad have included: The American Egg Board, Texas Instruments, The College Board’s Young Epidemiology Scholars (YES) Program, Centers for Disease Control and Prevention, Discovery Education’s Young Scientist Challenge, DuPont and the DuPont Center for Collaborative Research and Education, Lockheed Martin, Science Chicago, The Academy of Model Aeronautics, the Chandra X-Ray Center, and the Society for Neuroscience (Website of Science Olympiad, n.d.).

Part of the Science Olympiad mission is to improve the quality of science education, increase interest in science for all students, as well as working towards creating a passion for learning science, creating a technologically-literate workforce, and improving recognition for the outstanding achievements of students and teachers in the STEM areas. The Science Olympiad organization wants to change the way science is perceived and taught by emphasizing problem solving and hands-on, minds-on, constructivist learning practices. Students should gain an understanding of science concepts and how science really works as well as learning problem solving. The way in which the tournaments are run creates a partnership among members of the community, businesses, industry, government, and education (Website of Science Olympiad, n.d.).

Across the nation, there are inter-school and intra-school tournaments, as well as regional and state tournaments. The culminating Science Olympiad activity is a national tournament held at a college or university. The national organization provides training workshops and there are several informal web groups dedicated to helping students and coaches. The events are academically rigorous and motivational. There are a range of science, technology, and engineering events that require a variety of skills and abilities. Some of the events focus on knowing science concepts; some require the application of science process skills, and some require the application of science, technology, or engineering. The tournaments often feature science demonstrations. Scientists, professors, and career STEM employees serve as judges of events and resources to students (Website of Science Olympiad, n.d.).

The appeal of Science Olympiad has to do with the fact that unlike other science competitions, it is not just a paper and pencil test completed by individual students and

focused on one area of science. This competition is focused on numerous aspects of science, technology, and engineering, and uses group and team collaboration.

Teamwork, group planning, and cooperation are emphasized. Science Olympiad creates an atmosphere equal to that of a sporting event; teams and students compete head to head with the goal of learning, demonstrating knowledge, winning medals and trophies, and truly being excited about science and engineering. One school district uses the phrase “intellete” to describe their team members (Website of Science Olympiad, n.d.).

Science Olympiad can be considered a successful program when viewed from many different angles. There are over two million students participating in the state of Michigan. In Delaware, 95% of the secondary schools participate. In 2010, there were 6,000 teams competing at the Division B and Division C level. This level of participation is not limited to these two states, but is seen across the country. Many students return every year to be a member of their school team. The Science Olympiad website, (www.soinc.org), reports that many schools indicated in increase in science interest among the students and an increased enrollment in science classes. A whopping 14,000 elementary and secondary schools across the nation participate in Science Olympiad programs (Website of Science Olympiad, n.d.).

Other Research on Science Olympiad

Each year, countless students participate in after school activities. Thousands of these students are participating in science fairs and Science Olympiad. However, there has been very little research conducted on science fairs and far less research conducted on Science Olympiad (McGee-Brown, n.d.). Even though science fairs are popular,

according to Abernathy and Vineyard (2001) research suggests that science fairs may not be a positive experience for students due to the possibility of poor judging and ill defined or poorly clarified rules, too much teacher and/or parent control, and required student participation. Participation is often individual and isolating. Science Olympiad on the other hand, is almost diametrically opposed to the organization of science fairs. The emphasis is on teamwork and participation by students is usually voluntary (Abernathy & Vineyard, 2001). Additionally the competition does not focus on one area, but features a range of events focusing on various disciplines within science, technology, and engineering (Abernathy & Vineyard, 2001; Science Olympiad, 2010).

The fact that there are students of mixed grade levels working together is part of Science Olympiad's success (McGee-Brown, n.d.). The program, which uses the National Science Standards, had been cited as a model program by the National Research Council (McGee-Brown, Martin, Monsaas, & Stomber, 2003). Baird, Shaw, and McLarty (1996) cite a meta-analysis study conducted by Johnson, Maruyama, Johnson, Nelson, and Skon in 1981 that found that "the ideal type of group arrangement seems to be 'cooperation with intergroup competition'" This "cooperation with intergroup competition" is the model used by Science Olympiad (Baird, Shaw, and McLarty, 1996, p. 87).

Abernathy and Vineyard Research

Students who participate in Science Olympiad solve problems using science process skills (Abernathy & Vineyard, 2001). In fact, for many events there is no specific solution and students need to rely on their creativity and problem solving skills to

determine a workable solution (McGee-Brown, n.d.). Students are recognized at regional, state, and national levels (Abernathy & Vineyard, 2001; Website of Science Olympiad, n.d.).

Educational research rarely focuses on the student's point of view. Abernathy and Vineyard (2001) conducted a study surveying 453 Science Olympiad participants, 284 junior high and 169 high school students. Of these students, 254 were males, 184 were females, and 15 students did not indicate their gender. Female involvement was higher at the junior high school level than at the high school level. Females comprised 45.1% of junior high school respondents and 32.5 % of the high school respondents.

Abernathy and Vineyard (2001) reported that the respondents to their survey ranked "fun" as the number one reward for participating in a Science Olympiad competition. Abernathy and Vineyard (2001) presented the reasons students participated in Science Olympiad disaggregating by female, male and total rankings. The top five reasons females participated were: Fun, learning new things, working with friends, being on a team, and preparing for the future. The rankings for males were: Fun, learning new things, competing, working with friends, and winning prizes. When not disaggregated by gender, the combined total top five rankings were: Fun, learning new things, working with friends, winning prizes, and preparing for the future.

According to Abernathy and Vineyard (2001) the students' responses seemed to counter the idea that competition pushes students toward performance rather than learning. The students indicated that they enjoyed "learning new things" and ranked it as the second highest reason for participating. According to Abernathy and Vineyard (2001), some research indicates that adolescents may need external motivators to peak

their interest initially, while other research on competitions indicates that competition results in loss of motivation. This research has mainly focused on internal classroom competitions, and may not accurately reflect extracurricular competitions. Abernathy and Vineyard (2001) also found that responses and rankings from Science Olympiad members and science fair participants differed. This is most likely due to the inherent differences in the specific goals and organization of the two different activities. There was some indication of gender inequity in the number of males and females that participated in the two activities. Science Olympiad had more males participating, while more females participated in sciences fairs. The authors indicated that this discrepancy necessitated further research (Abernathy & Vineyard, 2001).

Hounsell Research

A dissertation by Thomas Sidney Hounsell (2000) entitled, *An Examination of Perceived Characteristics of Career Scientists and Delaware Science Students Who Do and Do Not Participate In The Science Olympiad*, found that students involved in Science Olympiad tend to gain an abundance of varied experiences. The participants gain pure knowledge, self-confidence, real life experience, problem-solving skills, as well as the tangible medals and awards. Hounsell (2000) suggested that a possible area of future research was to determine if participation in Science Olympiad influenced career choice. He also suggested replicating his study with a larger national group.

Students who participated in an academic competition had a broad and fulfilling experience. These student competitors reported a growth in self-esteem, self-confidence, ability to communicate, and the ability to work cooperatively (Hounsell, 2000).

Hounsell cited a study by the National Science Teachers Association in 1998 that said that a survey by Bayer Corporation in 1998 found that more than 50% of scientists were interested in science by age 10 and that their parents and teachers encouraged that interest. The report, called “Scientists on Science,” included responses from 1,400 scientists (Hounsell, 2000).

A group of scientists and science educators from The American Association for the Advancement of Science, as cited in Hounsell, (2000), compiled a list of the abilities and skills they deemed necessary to have in the STEM fields. The list included, but was not limited to oral and written communication skills, the ability to gather and use evidence, the ability to use logical reasoning, curiosity, critical thinking, and the ability to use science skills such as observation, measurement, estimation, and prediction.

Students have influence on their peers. When a student’s friends are involved in science, that student influence tends to be positive. Without this peer support, the trend is that 40% of undergraduates majoring in a STEM field will drop that major by their senior year. Hounsell (2000) cites the February 1990 issue of Phi Delta Kappan in which it is suggested that teams fulfill a sense of belonging and power.

A 1995 study of a middle school Science Olympiad team in Georgia, (as cited in Hounsell, 2000), found that the program made science fun, exciting, and challenging. The research indicated that coaches felt that, among other things, Science Olympiad increased student interest in science and improved the quality of science education (Hounsell, 2000).

According to Hounsell’s (2000) study, students both involved in and not involved in Science Olympiad, as well as teachers, coaches, and judges, felt that the top

characteristics of successful science students were: intelligence, being a team player, being creativity, being a problem solver, being self motivated, and being a good communicator. “Intelligence” and “problem solver” ranked high on every group’s list. Interestingly, “team player” ranked in the top four on the list from school personnel, but ranked the lowest on the list of important attributes gathered from scientists. Although school related personnel said that being a “team player” was important, they ranked “communication” skills very low. Student groups also ranked “communication” skills lowest. Those people that were familiar with the Science Olympiad program felt that the rewards for participation were medals, self-confidence, problem solving experience, knowledge, real life experiences, hands-on science, and interaction with the scientific community (Hounsell, 2000).

McGonigal and Payne Research

McGonigal and Payne (2007) presented a paper on their experiences as coaches and their students’ experiences on a Science Olympiad team. The students expressed interest in delving further into science topics, working with peers as friends, and talking about ideas. One student expressed the fact that she enjoyed working with peers who were as interested in science as she was and that the close working relationships with these peers allowed for a culture of trust to develop. The student indicated that she did not find that the classroom could replicate the same type of environment because she felt that other students in class were not necessarily engaged in science and there was the added pressure of getting good grades. Koh, Want, Tan, Liu, and Ee (2009) found that elementary and middle school teachers tend to use cooperative learning and although they

found that students seemed to gain social skills, they were concerned about possible lack of motivation and the balance of effort exerted by each member of the group. They also found that teachers were not sure if their students thinking skills were improved as a result of them being involved in project work. According to Koh et al., the students working in groups had less anxiety and stress and were more motivated to reach a goal. Cooperative work was positively associated with student achievement (Koh, Want, Tan, Liu, & Ee, 2009). Herreid (1998) cited a meta-analysis of over 1,200 students on cooperative learning by Johnson and Johnson. Use of the cooperative learning technique resulted in higher individual knowledge when compared to competitive and individualistic learning, a higher retention of knowledge, increased social skills, as well as the students having a more positive attitude toward the subject. The student mentioned in the McGonigal and Payne (2007) work said that she enjoyed the freedom to expand her own learning. She also did not find that gender, race, or age was an issue for participating in Science Olympiad. The teachers felt that they focused too much on the project itself, but learned that the students valued the process leading up to the final product (McGonigal & Payne, 2007).

McGee-Brown, Martin, Monsaas, and Stomber Research

In a three year (1999-2002) longitudinal, NSF grant funded study, McGee-Brown, Martin, Monsaas, and Stomber (2003) found that students, teachers/coaches, parents, and administrators all thought that the most important results of participation was the exposure to collaboration, problem-solving, and creativity. Coaches specifically felt that students

increased their knowledge by being able to study areas in more depth and/or study areas that they were not exposed to in school.

According to McGee-Brown et al. (2003), students involved in Science Olympiad described their experiences as challenging and fun. They noted that they could see that scientists do in fact collaborate. Students liked the competition and saw it as a chance to demonstrate their knowledge. All parties involved, from students to coaches to parents felt that the experience allowed the participant to gain positive recognition. The majority of students attributed Science Olympiad to their increased enjoyment of science and felt that they learned new science content and skills. Parents saw this as well along with seeing an improvement in problem-solving, critical thinking, and creative skills from their children (McGee-Brown, n.d.). Coaches thought that most of the problem solving and creative thinking surrounded the design and engineering events, with fewer of these skills needed for some of the other events (McGee-Brown, Martin, Monsaas, & Stomber, 2003). Some of the other benefits that students saw as part of their participation in Science Olympiad were the learning of specific content knowledge as well as general science skills and the ability to work in a group. They also felt that participation reinforced their belief that males and females were equally good in science (McGee-Brown, n.d.).

There are several models used for participation in Science Olympiad. Some schools make it a purely extracurricular activity, some integrate selected events into their classes, and some run it as a gifted and talented or exploratory course (McGee-Brown, n.d.; McGee-Brown et al., 2003). Additionally, there is some difference between the organization of middle school and high school teams. At the middle school level,

coaches and parents seemed to be more active; guiding and coaching the students. At the high school level, students were more independent; often working with a few team members on an event, usually without the coaching of an adult (McGee-Brown et al., 2003). According to the students, the biggest challenges came from finding time, both to meet with their partners and for balancing other activities. The coaches struggled with funding, time, and support. According to McGee-Brown (n.d.), Science Olympiad is a model of collaboration and competition and students should be involved in the program.

Students' perspectives on collaboration were that they felt more effective, efficient, and had increased ability to be creative and solve problems. They enjoyed the chance to share knowledge. The majority of students felt that they learned content specific to their event, and in addition, they learned other skills such as organization, measurement systems, engineering principles, experimental design, and logical thinking. Students thought that they learned more about the work of scientists such as trial and error, the need to be precise, the ability to repeat an experiment, and that science was fun even though it could be difficult and time consuming (McGee-Brown et al., 2003).

Baird, Shaw, and McLarty Research

Baird, Shaw, and McLarty (1996) researched whether or not a student's score on a process skills or logical reasoning abilities test was a useful way to pick students to participate in Science Olympiad. Most of the middle school students who participated indicated that they had a B average or higher and the 60.1% of the high school students indicated a 3.5 or higher GPA. Out of the 462 high school students who completed surveys in the Baird et al. 1996 study, approximately 60% were male and 55% of the 77

middle-school students were male. Variables such as type of school attended, number of Science Olympiad tournaments the participants competed in, and the number of science courses a student took had an effect on the success at a tournament. Other factors included a student's grade level and the amount of time spent preparing. Baird et al. (1996) stated that it was unwise for a coach to use process skill and logical reason abilities tests as a sole determinate for a student being selected to be on the team (Baird, Shaw, & McLarty, 1996).

International Test Performance Comparisons

Recently there has been a focus on standardized testing and comparative international testing. Two of these tests are The Programme for International Student Assessment (PISA) and Trends (originally Third) in International Mathematics and Science Study (TIMSS). The PISA 2006 is a 2-hour test with both open-ended and multiple-choice questions. More than 400,000 students in 57 countries took part. The PISA showed the United States performing below the Organisation for Economic Co-operation and Development (OECD) average. PISA also highlighted that "females were stronger in identifying scientific issues, while males were stronger at explaining phenomena scientifically" (PISA, 2006, p. 3).

The biggest contributing factor to school performances in the United States was attributed to the students' socio-economic differences. Students with a higher socio-economic background usually showed more of an interest in science. Having a parent in a science-related career was also an influence. PISA also surveyed students' attitudes toward science. It was reported that 93% of all students thought that science was

important for understanding the natural world. Seventy-two percent of students agreed that it was “important for them to do well in science” and 67% said, “that they enjoyed acquiring new knowledge in science.” Only 37% of students said that they “would like to work in a career involving science.”

“Within each country, students who reported that they enjoyed learning science were more likely to have higher levels of science performance. While this does not show a causal link, the results suggest that students with greater interest and enjoyment of science are more willing to invest the effort needed to do well” (PISA, 2006, p. 6).

The United States had interesting dichotomies. It was the only country that had a proportionate number of students in the lowest and in the highest level on the PISA. The United States performed below the OECD average while Korea was among the highest performing countries. Both countries however had a similar percentage of students at the Level 6 mark, the highest level on the PISA. Students in the United States also had a very high self-efficacy in science while also having a lower mean performance. Even with the lower mean performance, United States’ students were more aware of environmental issues than students from other countries. The United States excelled in the areas of Earth and space systems; having an average of 15 points higher than in the content areas of living systems and physical systems (PISA, 2006).

The TIMSS results showed eighth-graders in the United States ranking in the middle in both math and science. High school seniors ranked at or near the bottom in science literacy, physics, and advanced mathematics. Some of the poor performances are thought to be related to the number of hours students worked at an after school job. Students who worked less than 20 hours actually had a score that was slightly higher than

the international average. The students' scores went down as the number of hours of worked increased. Bracey (2007) stated that he believed some of the problems with the performance of the United States was the fact that the test was given in May, a time when seniors were about to graduate from high school and were most likely already accepted to college and would not care about the test. Additionally, he stated that the United States education system tries to incorporate too much with too brief a coverage (Bracey, 2007). This echoes the sentiments of Dewey back in the early 1900s. The curriculum, especially in science, is too broad and shallow. Dewey said that there are so many areas of science and so much information in each area that teachers are constantly faced with the challenge of randomly picking the areas to focus on or must attempt to teach a little bit from every area (Drayton & Falk, 2002).

This gives rise to the comment that the United States curriculum is a mile wide and an inch deep. Bracey (2007) states that the system of ranking on the TIMSS is flawed. The United States' students got 58% of the questions right. The international average was 56%. The United States ranked 19th out of 41. A 5% increase in questions right would have moved the United States up to a 5th place ranking and 5% fewer correct would have moved the United States down to 30th. Ranking may not be the best interpretation and reporting of results of students.

The Programme for International Student Assessment (PISA) World Executive Summary (2006) stated that science and science knowledge is more important than ever. Science teaching and learning are especially important. The summary states that science is something that is and must be relevant to everyone's life and an understanding of

science is an essential tool for people to have to achieve their goals (PISA, 2006).

PISA's (2006) description of a scientific literacy is the extent to which an individual:

Possesses scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues.

Understands the characteristic features of science as a form of human knowledge and enquiry.

Shows awareness of how science and technology shape our material, intellectual and cultural environments.

Engages in science-related issues and with the ideas of science, as a reflective citizen. (p. 12)

More and more non-U.S. citizens are getting engineering degrees from colleges and universities in the United States. The United States ranks below 15 other countries in the percentage of students who graduate from college with a degree in science or engineering. The United States is ranked 14th in the overall proportion of the 25-34 year old population that has a college degree. These rankings are low, due in part to the rest of the world improving and catching up to the previous success of the United States. Despite these rankings, the United States is thriving. The country is a high-tech, economic, and innovative leader. The components that allow for the country's leadership in these areas are the commitment to freedom, creativity, risk-taking, and the tolerance of failure and the commitment to trying again. Even though there are dire statements made regarding the United States ranking in the world, the United States still has a hold on being the most scientifically advanced nation. The country leads the rest of the world in the number of patents issued, the number of scientific articles published, the quality of

university education, and the interest and investment in research and development (Price, T., 2008).

Even with all of the reports regarding the United States world rankings, parents think that only basic science and math are important for students to learn. They do not think that students really need to take more of the advanced science courses such as chemistry and physics (Davies, 2007).

Comparison of STEM Education between the United States and the World

For the past 25 years, The National Assessment of Educational Progress (NAEP) has been the “United States only ongoing assessment of K-12 students’ educational progress” (National Research Council, 1998, p. 4). The NAEP is a congressionally mandated test that measures a student’s actual knowledge against what they are expected to know. It is given in the 4th, 8th, and 12th grades. A student’s level of knowledge, ranging from basic to proficient to advanced, is determined by the results of the test. In this way, it is unlike the Trends in International Mathematics and Science Study (TIMSS), which is a comparative test on an international scale. The 1996 NAEP showed that students had a deficiency in their ability to apply scientific knowledge, to design experiments, and to explain the reasoning behind their answers. By the end of high school, students demonstrated a basic understanding of scientific facts and principles. The 1997 TIMSS revealed that fourth graders in the United States outscored students in 13 other nations in science. Only Korea performed better. By eighth grade this performance dropped significantly; the United States’ rank was just average, with five

countries – Singapore, Czech Republic, Japan, Korea, and Hungary, all performing better (National Research Council, 1998).

Inquiry, according to the National Research Council (1998), is one of active learning where the students are engaged both with hands-on and minds-on learning. Students should be investigating, observing, questioning, gathering information, predicting, explaining, and communicating. In this way, students learn how to think critically and how to seek information. Learning and knowing how to learn gives students the tools to research, ask and answer questions, and solve problems on their own (National Research Council, 1998).

A national survey of Science and Mathematics Education in 1993, as cited in the National Research Council's 1998 work, "Every Child a Scientist", found that three quarters of teachers believed that hands-on activities were an important part of science education. Unfortunately, these teachers did not practice what they preached; one-half to two-thirds of the teachers actually focused primarily on facts and used lecture and discussion during the majority of their classes (National Research Council, 1998).

Part of the reason that students in the United States perform at or below the level of students in other countries in math and science is attributable to the fact that K-12 science education is often traditional. The focus is on memorizing facts. It is far less common for science education to focus on student understanding of concepts. The belief is that there needs to be a focus change from the traditional attention on memorization of facts to a more concentrated focus on inquiry. Students need to work together to investigate, question, determine, and explore. The use of collaboration with peers is a way students can help each other clarify concepts and understandings. Teachers need to

be not only positive; they also need to be enthusiastic about science. They need to be clear, with both themselves and their students, by underscoring the fact that it is just not possible to know everything about a field of science. Students need to use resources to seek out answers (Moreno & Tharp, 2006).

According to Jorgenson and Vanosdall (2002) a focus on inquiry-based science should pull the United States out of the poor performance ranking on international tests. Inquiry focuses on students being active, not passive learners; it is hands-on and minds-on. It is about science knowledge leading to discovery; not about rote memorization of facts. According to Jorgenson and Vanosdall (2002), students who were taught in inquiry-focused classrooms did better on achievement tests than students who learned in text-focused classes. Fragmentation of subjects, the typical way that students learn science, math, and reading, as separate subjects contributed to the United States' poor performance on international comparison test such as TIMMS (Jorgenson & Vanosdall, 2002).

According to Goldsmith and Pasquale (2002), students in the United States are not scientific thinkers and problem solvers. Students spend too much time memorizing definitions rather than engaging in inquiry of scientific ideas. Students need to be involved in curriculum that has at its core, conceptual understandings, problem solving, and communication of scientific ideas (Goldsmith & Pasquale, 2002).

Overview of Science Education

Students' desire to continue to take courses in science is dependent on their attitude toward science. Unfortunately, positive attitudes decline as students move to

each successively higher grade. There is a major slide in interest in science between middle school and high school years. This fact holds for all students, but even more so for girls than boys. Middle school seems to be the crucial time for the change. Science attitude is a crucial factor as to whether or not girls take more science courses each year that they are in school. Girls begin to believe that science in general and actually being a scientist is masculine. There is a social stigma of females engaging in the study of science because of this belief. Girls who are of high ability do not differ much from girls of average ability in allowing their attitudes about their performance in science, rather than their actual performance, steer them into the fields of science. Both genders feel more successful, as well as enjoy science more, when they have a supportive family structure. Families that involve children in informal science activities, ranging from going to museums, to learning about science, increase their children's interest and attitude toward science. There are numerous educational researchers, including Rousseau, Pestalozzi, Montessori, Dewey, and Piaget that support the fact that having a background and a learning experience in an area makes it more interesting to the student (Farenga & Joyce, 1998).

Science literacy is important in numerous careers especially when there is an understanding of scientific analysis as well as the interrelationship of science and culture (Shafer, 1996). Scientific literacy is the goal of science education (Sadler, 2004). There is debate over what is meant by scientific literacy. Sadler (2004) cites *Science For All Americans* stating that there are numerous factors to being scientifically literate. Scientific literacy includes understanding that STEM fields interact, that these fields involve human understandings and thought processes and inherently have limitations as a

result, thinking scientifically, and use the knowledge for personal and social purposes. Additionally, Sadler (2004) cites the National Science Education Standards as saying that a person is scientifically literate if they can use the knowledge to participate in debates about matters that involve the STEM fields. Science and science related issues are in the news daily. A scientifically literate person should be able to understand the discussions and make informed decisions. Expecting a scientific literate population is not to pretend that every student or even most students will pursue a career in the STEM fields (Sadler, 2004), but that they are versed enough to understand and fully participate in the world.

The topics of science and gender are usually linked with discussions of science education. The discussion revolves around the physical sciences as well as technology. The disconnect between girls in science is not noticeable when defined by academic grades, as girls do well: It is when focusing on female involvement and interest in careers in the STEM fields is there a noticeable discrepancy. All students must be exposed to and immersed in doing science to gain a real understanding that science, even the “hard” sciences of physics, are part of life and not something only relegated to a lab. Allowing students to “do” science fosters the creativity that is essential to being a scientist (Shafer, 1996). The topic of science and gender will be reviewed in more depth in a later section of this chapter.

Experience with hands-on science is associated with science achievement. Teachers must serve as a guide that fosters an environment that allows students to construct knowledge. Teachers lead students to understanding. Hands-on methodologies should not necessarily be used for a whole class period or be used to the exclusion of

other methods. It should be used to motivate, involve, and extend the students' understanding and knowledge of science (Stohr-Hunt, 1996).

“Scientists are detectives and solution makers. They are curious, inquisitive, focused, skeptical, creative, and observant – and a strong science curriculum should dynamically cultivate these attributes in learning” (Jacobs, 2010, p. 45).

According to Subotnik, Miserandino, and Olszewski-Kubilius (1996), students who select a STEM field often change course and change to a humanities field. This is true for those students who excelled in science in high school, as determined by research on Westinghouse winners. The fleeing of science is partly due to the pedagogical methods employed by professors in the first few years of a student engaging in a science or math major (Subotnik, Miserandino, & Olszewski-Kubilius, 1996).

According to Freedman (1997), research has shown that hands-on learning increases students attitudes toward science as does students being exciting about science lessons. Liking science is correlated with improved achievement in science. Attitude in science influences achievement as opposed to the opposite (Freedman, 1997).

Inquiry Science

The nature of true science and true inquiry is the topic of debate. Part of the debate revolves around what type of science teaching practices are the most beneficial to students (Pasley, Weiss, Shimkus, & Smith, 2004). Teachers sometimes abandon all directions in a hope that students will discover something on their own. This is not effective inquiry. Inquiry should not be just hands-on activities: It should be intellectually stimulating and engaging. According to Drayton and Falk (2002), effective

inquiry involves a great amount of student-to-student interaction. This interaction should incorporate problem solving, investigation, and discussion. Students stay engaged in science and therefore become more scientifically literate when they enjoy science, understand it, can use this understanding to explain, research, apply, analyze, search for new problems, and practice the creativity that is involved in science (Drayton & Falk, 2002; Dunkhase, 2003; Pasley, Weiss, Shimkus, & Smith, 2004). According to Drayton and Falk (2002), there is a huge difference between “school science” and “real science.” Real science is an endless loop of searching for answers that continually leads to new questions. The sheer amount of science fields and science knowledge is so vast and so quickly evolving that it is impossible to know all of the “facts.” It is important that a student knows how to ask questions, reason, and think critically to be able to process what is already out there and what has not been discovered as of yet. Students need to learn to scientific habits of mind (Drayton & Falk, 2002).

Teaching Science in the 21st Century

Dyasi (2006) cites the National Research Council (NRC) as saying that students should,

...have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanation, constructing and analyzing alternative explanations, and communicating scientific arguments (p. 71).

Darling-Hammond (2007) refers to the knowledge economy characterizing the 21st century. According to her, both the PISA and the NAEP (National Assessment of Education Progress) showed that United States students are not able to apply information even though they may know it. Students are not well versed in problem solving and critical thinking. Other countries emphasize these skills and teach fewer concepts, but on a deeper level. This method gives students a foundation in which to move on to higher order learning as they progress through school (Darling-Hammond, 2007).

Science inquiry is not allowing students to explore haphazardly. Science inquiry should be structured for the needs of the students. Inquiry includes students posing their own questions, students selecting from questions given to them and asking new questions, taking questions and sharpening or clarifying them, or engaging in a question from someone else. Inquiry is not only working hands-on it must also be “minds-on.” Students who search for information in a book engage in a quest for knowledge; this promotes growth and gives them a strong background to engage in more science inquiry (Dyasi, 2006). Dunkhase (2003) calls these frameworks set forth by the teacher, “guided inquiry.” He said teachers use this when they are not fully engaged in science inquiry because of problems with time and material management or have a low comfort level with guiding rather than controlling the students. Dunkhase (2003) refers to the National Science Education Standards (NSES) in stating that science inquiry should incorporate asking questions, designing and conducting investigation, interpreting the data and presenting the findings.

The goal of science education needs to be understanding rather than memorizing a group of facts. Bruce Alberts, the former president of the National Academy of Sciences,

said that one of the most important parts of science learning is curiosity for science and building science knowledge (Moreno & Tharp, 2006). Unfortunately, the system in place in many schools is an emphasis on rote memorization and disconnected facts. This squashes students' enthusiasm and excitement for learning (Dunkhase, 2003; Moreno & Tharp, 2006). Pasley, Weiss, Shimkus, and Smith (2004) do not demonize facts; they state that students need facts so that they can construct deep understanding. These facts should not be a means to an end though. Through their research, Pasley et al. (2004) found that only 21% of science lessons across the nation give students experiences that show them that science is investigative in nature. Most lessons represent science as a set body of facts and never move past that thought into the inquiry skills that students need to be scientifically literate.

One of the important aspects of science learning is the component of social learning; of consensus building, peer reviewing, and communicating. An ideal learning situation is one in which students can work together in small groups to "conduct investigations, evaluate evidence, and formulate explanations" (Moreno & Tharp, 2006, p. 297). Students learn from each other and offer help and explanations in a way that a teacher sometimes cannot. A teacher, however, can encourage and build a real enthusiasm for science. A teacher's enthusiasm and attitude can improve students' learning. Additionally, if students feel that science is fun, there is an increase in the student's understanding of science processes. One important factor in having a positive attitude toward science and science teaching is to understand that it is not possible to know everything about science. The most effective science teachers acknowledge that

they do not know everything and encourage students to help seek out the answers (Moreno & Tharp, 2006).

One of the problems with schools is that students move from one class to the next, one teacher to the next, and in such a manner that they do not develop a rapport and the adults do not really get to know them as individuals. There is little opportunity for these adults to really work with a student as a whole person and not just a flyby student. Students often work individually, passively memorizing facts. Effective schools create a structure for caring. Students in these institutions have close working relationships with adults (Darling-Hammond, 1995).

According to Juliana and Andrews (2005) a study of teachers who had created an atmosphere of passionate learning in their classrooms, were found to be collaborative and co-learners with their students. Students and teachers talked and shared knowledge with each other. Teachers pushed their students to think: They accomplished this by the strong rapport they had with the students. Students had autonomy to direct their own learning and the teachers allowed that learning to be flexible and fit the individual needs of the students. One of the teachers said that his definition of inquiry was, “having a direction in which to go, but allowing different paths to get there, and then seeing what other kinds of learning happened along the way, and pulling it all together at the end” (Juliana & Andrews, 2005, p. 22).

Liston (as cited in Price, K.R., 2001) stated that research indicates that play and fun fosters learning and produces new neurological pathways to form. These connections link previously held knowledge with new learning (Price, K.R., 2001). Teachers can promote fun in their classrooms without losing the direction or focus of their lessons.

K.R. Price (2001) indicates that teachers often put little emphasis on whether or not the learning is fun. In fact, sometimes teachers say that learning is not about fun. This is such a sad statement. Price found that fun was very important to the respondents of her research. Price says, “The access of the participants to Serious Fun science and enjoyable science experiences resulted in the participants’ science motivation and achievement while also influencing their career choices” (p. 73). “Serious Fun” involves the teacher as facilitator and students engaged in creative activities (Price, K.R., 2001).

A student’s science teacher has a powerful impact, whether it be positive or negative. One experience with a phenomenal teacher can help to negate all of the negative feelings toward science even if all past science teachers and science classes held a negative connotation for the student (Price, K.R., 2001).

21st Century Skills

The term *twenty-first (21st) century skills* is difficult to define. Part of the problem is that these skills and abilities are not new to the 21st century. From the time of Socrates it was known that the ability to think critically and be analytical as well as creative, was important. The reason that these skills are coming to the forefront of conversation now is that jobs that do not require these skills, jobs that are routine, can and are being done by computers. Critics believe that these skills cannot and should not be emphasized over basic core content. Silva (2009) states, “An emphasis on what students can do with knowledge, rather than what units of knowledge they have is the essence of 21st-century skills” (Silva, 2009, p. 630).

Silva (2009) cites the U.S. Department of Education National Mathematics Advisory Panel (2008) as stating that the basics must be learned right alongside learning to think and problem solve. They also dispute the belief that young children only have simplistic thinking and cannot handle complex thinking. Other groups agree that the basics and more complex skills should be taught and used in conjunction with each other (Silva, 2009).

According to the National Center on Education and the Economy (as cited in Ghysels, 2009), employers are looking for competent people who are creative and innovative. Employees will need not only to be well versed in content and core subject areas, but also be competent enough to be self learners as well as have the ability to critically think, problem solve, and communicate. According to Ghysels (2009), the way to engage students in creativity is to have them enrolled in art and music classes. According to Jerald (2009), it is possible to foster creativity in many subject areas.

Jerald (2009) also said that the 21st century skills are not easy to define. Students and employees must be versed in the skills and abilities that will allow them to focus on the complex jobs; jobs where there is no routine tasks and no predictable pattern to follow. Routine jobs, even though they may in fact be complex, can and will be completed by a computer or robot. There are two skills that are important - expert thinking and complex communication. Complex communication is working with others both to gain information and to disseminate it. Expert thinking is the ability to solve problems that have no pattern or predictable solution. This is not to say that understanding patterns, and being able to follow rules and directions are not important, but that people will need to be able to follow directions and then move to the next level.

Research has shown that today's jobs and occupations are moving more and more toward the analytical and interactive and away from the purely cognitive and routine (Jerald, 2009).

Jerald (2009) succinctly frames the need for 21st century skill development in schools by saying,

Any school curriculum that emphasizes following direction to find a single correct answer is, by definition, preparing students for jobs that probably will not exist by the time those students graduate. That does not mean following directions is not an important skill, but rather that is no longer a sufficient skill....(p. 6)

Experts do not just know facts; they know how they are linked. This linking of information allows experts to see and understand the big picture. Memorizing a series of facts does not make one an expert, the ability to really understand the concepts and the interrelationships and patterns are what is important. A person needs to see the whole picture.

The importance of the trend toward globalization highlights the need for 21st century skills. There is a movement from vertical production to horizontal collaboration. There is more outsourcing and it is important to have skills and abilities that allow employees to work with the world. Unfortunately, the students in the United States are not competing with others in the area of problem solving as defined by the Programme for International Student Assessment (PISA). Students rank below average in math and science literacy and only average in reading literacy. The United States has had the advantage of having a great number of students who have been educated at the high

school level and the United States' higher education system is renowned. This trend is changing and more and more nations are catching up if not surpassing the United States educational system. Since the marketplace is global, students and employees will need to be competitive, not just at home, but all over the world (Jerald, 2009).

Important skills include learning to learn and the ability to identify and solve problems without the need for direction from a supervisor. Employees will need to have outstanding interpersonal skills as well as the ability to acquire information and learn new skills. None of this means that schools should shy away from core subjects. It will be more important than ever that students have a strong foundation in core subjects along with continuing their education to include more advanced courses. Employees need to apply knowledge, not just reproduce it. Students will work in a world where they will need to critically think, solve problems, communicate, collaborate, create, and adapt to change. These 21st century skills cannot be taught without a thorough understanding of core content knowledge; nor can these skills be taught independent of content (Jerald, 2009).

A strong background in content is more important than ever. It is often stated that it is not necessary to know facts, because a person can just find the information online or in a book, but this foundational content provides a strong foundation to allow analysis and innovation. A person cannot solve a problem or think critically about a topic if he or she does not have a strong background or foundation in the content. According to Jerald (2009), a research group called Mathematica found that strong math skills were more important than good work habits, leadership skills, or teamwork in predicting success. There are three core skills and knowledge areas that Jerald (2009) describes:

Foundational knowledge, which is core academic knowledge; literacies, which is the ability to apply this academic knowledge; and competencies, which is the ability to use these skills in life. Scientific literacy is broken down into several parts: knowledge about science, knowledge about how science works, and understanding of how science impacts the world.

According to Jerald (2009), the Conference Board in 2006 surveyed employers about the skills they believed were important. They noted basic skills such as reading comprehension along with the ability to communicate, collaborate, think critically and solve problems, work as a team, as well as collaborate, be creative (which requires broad knowledge in a lot of different areas as well as experts who say that it also requires knowledge in the specific area), and be innovative. Schools therefore must focus on oral and written communication as well as the other skills. There are several states that have developed a national Work Readiness Credential that includes communication skills, interpersonal skills, decision making skills, and lifelong learning skills (Jerald, 2009).

According to Jerald (2009) schools must not look at learning as a “this or that” proposition, but rather a “this and that” requirement. Students must have deep knowledge in core areas and use that knowledge to solve problems. Problem solving must be intertwined with the learning of basic facts and should not be an independent lesson. School must foster an environment of curiosity and creativity, problem solving, and responsibility, and a true comfort level with having no specific right answer.

Wagner (2008) states that there are seven skills students need in the global economy of the 21st century. These skills start with critical thinking and problem solving. Part of critical thinking and problem solving require the ability to ask the right questions.

Additional skills include collaboration and leadership, as well as agility and adaptability. Jobs and job requirements are more fluid and employees need to be able to adapt and learn to move forward and to take initiative. People need to **feel** at ease with taking risks and to be comfortable with experiencing failure. They must be able to speak and write effectively. They must be able to access and analyze information, as the sheer amount of information that is available is overwhelming. People need to be able to identify and focus on what is important. They must possess curiosity and imagination (Wagner, 2008).

Problem Solving

Problem solving is often difficult for students because they need to analyze the situation and not just memorize the facts. Students need to be able to devise a plan and determine a solution. Students often have the requisite knowledge to understand the problem, but do not have the skills that go along with problem solving. Students are not taught how to problem solve and it is not an easy task for students to improve this ability on their own. One thing that is important in the learning of how to problem solve is that students work with peers and cooperate to support each other. Peers who work together and can give detailed explanations discuss their confusion, improve their ability to problem solve. In fact, “Cooperative learning in science education is effective when students are given a common task, have a clear division of work and are actively involved in sharing ideas and helping each other in completing the task” (Harskamp, Ding, & Suhre, 2008, p. 308).

There is a difference in male and female group work styles, especially in the realm of science education and more specifically physics. Males often take the lead in groups with females. They also offer more opinions and suggestions while in contrast female students tend to focus on asking questions. Females consequentially do less well in mixed-gender groups than they do in all female groups. Partner gender is a significant factor in learning achievement for females. Females achieve at a higher level in physics when paired with other females than when paired with males (Harskamp et al., 2008).

Problem solving is an essential skill that sometimes requires knowledge in one area and sometimes requires knowledge from various areas and creativity to solve. There is a difference between single dimensional thinking and multi-dimensional thinking and problem solving. People need problem solving skills in order to adapt and live in the world. Some problems are simplistic and there are right ways of solving them, others are more complex and not only is there not one simple answer, but a person must employ interdisciplinary knowledge and creativity to solve them. To solve problems people need to also be able to be flexible and be comfortable making mistakes (Ozdemir, Hacifazlioglu, & Sanver, 2006).

Extracurricular Activities

Extracurricular and co-curricular activities are a staple of the American high school. These activities can foster interpersonal competence, help define life goals, and promote educational success, especially when the person is interested in the activity, when it is structured, and when the activity is challenging. These volunteer activities allow students to interact in a positive way with both their peers and their teachers and in

a way that is different from the interaction in the classroom (Mahoney, Cairns, & Farmer, 2003). A study by Logan and Scarborough (2008) found that most club leaders and students involved in a club enjoyed the relationships they developed with each other. This interaction allowed for social acceptance from other students and increased support from adults. These factors are associated with expectations for high academic achievement. Participation in extracurricular activities leads to an increase in educational aspirations and positive plans for the future. Students involved in these activities have a chance to set individual and group goals and figure out ways to reach these goals. This experience can later filter into other parts of the participant's life (Mahoney, Cairns, & Farmer, 2003).

Quality after school programs allow for engagement and motivation of learning and emphasize higher-order thinking skills, as well as creative thinking and problem solving skills. Recognition, acknowledgement, and rewards are often essential during the early stages of talent development. Not until students are fully invested and near the pinnacle of their fields, does motivation become internal (Schroth, 2007). Structured activities allow for personal and social development as well as increased academic achievement (Logan & Scarborough, 2008).

Science and math competitions increase student interest in the subjects. Some states have decided that the value of programs such as Science Olympiad, MathCounts, and Odyssey of the Mind, deserve financial support (Christie, 2008).

Research is unclear as to whether or not academic competitions are made better or worse because of tangible external motivation. The National Science Teachers Association position statement on science competitions says that science fairs should

emphasize learning rather than competition (Website of National Science Teachers Association, n.d.). Student feedback indicated that the awards motivated them. It is unclear to what extent competition encourages some students and discourages others. Although some research indicates that students need the external motivation so that they can find success and then slowly acquire an ability to be motivated by the intrinsic rewards alone. Academic competitions can fulfill this need (Ozturk & Debelak, 2008). Some research indicates that without this competition students cannot accurately gauge or fulfill their capabilities (Subotnik, Miserandino, Olszewski-Kubilius, n.d.). Part of the extrinsic motivation is feedback that is positive and informative. Accomplishments are part of what builds a child's self-esteem and self-respect. In competitions with other students, children can appreciate other peoples' work as well as accurately assess their own skill and abilities in comparison (Ozturnk & Debelak, 2008). In fact, "learning to equate effort with achievement is an important lesson too often missed by those who are never sufficiently challenged, and results in the belief that anything requiring discipline or persistence is 'boring,' or indicative of mediocre ability" (Subotnik, Miserandino, Olszewski-Kubilius, n.d, p.4).

Obviously not every child can be the winner at a specific competition. A loss can be a learning experience especially when students can rely on adults to help them learn how to improve performance. Self-esteem is not about meaningless compliments, but about what a person garners from real success and failures. Another benefit of academic competitions is that experts in the field often help supervise the competition. Students have the opportunity to interact with these people as well as have their work judged by people other than their teacher. This interaction with people who work in the field that

the student is interested in can help to break stereotypes. Female STEM employees can show both boys and girls that STEM fields are not only for males. Competitions should provide an enriching experience, not just a way for one school to dominate over another school (Ozturnk & Debelak, 2008). The competitive experience is only truly valuable when a student works with a caring adult who coaches them and helps prepare them in advance of the competition rather than just thrusting them into something the day of the competition (Logan & Scarborough, 2008; Ozturnk & Debelak, 2008). Preparing before the competition is exactly what happens with Science Olympiad. These competitions can be a great setting for gifted students. “As a nation heavily relying on inventions, discoveries, and breakthroughs, we should not lose even the smallest opportunity to tap into and develop our pool of genius” (Ozturnk & Debelak, 2008, p. 53).

Grote (1995) found in his study of competitions and science fairs that although teachers were slightly in favor of awards for science fairs, the responses were fairly evenly split between having the awards. There was a more clear-cut indication that science fairs promoted interest and enthusiasm for science and that it was a valuable experience; promoting communication skills, and allowing students to interact with others who were interested in science. Teachers also strongly felt that some of the benefits could not be replicated through regular classroom instruction (Grote, 1995).

Research indicates that extracurricular activities are an important aspect of school life because they increase commitment to school, the students like school more, and involvement subsequently has an indirect link to academic success (Bucknavage & Worrell, 2005). The Mathematica study, as cited by Jerald (2009), also found that participation in extracurricular activities developed leadership and teamwork skills. They

found that students who were involved in extracurricular activities had higher earnings when they entered the workforce than those who were not involved in extracurricular activities (Jerald, 2009).

Bucknavage and Worrell (2005) surveyed 823 students and found that 24.6% middle school students, 52.4% high school students, and a combined 41.14% total students participated in an academic club. A replicated study with a population size of 283, found that 26.9% of middle school students and 49.7% of high school students, for a total of 39.2% of all students participated in an academic club in school (Bucknavage & Worrell, 2005).

For all of the negative rhetoric regarding academic competitions, there are thousands of students who participate in athletics, music and performing arts groups that are designed for performance and competition. These are seen as beneficial due to the structure, coaching, and a chance for participants to hone talents (Subotnik, Miserandino, & Olszewski-Kubilius, n.d.). The same should hold true for those skilled in the STEM fields.

Talented Youth and Competition

Even though Science Olympiad as a program is not geared exclusively or primarily toward gifted and talented students, the majority of students participating are students who earn A's and B's in school. This is not to say that they are science "nerds," as most of the students were well rounded and participated in several extracurricular activities ranging from sports to service clubs, to drama, arts, and publications (McGee-Brown, Martin, Monsaas, & Stompler, 2003).

Teaching and learning begins at an early age as exploratory and informal. The child or family may initiate it at various times depending on interest and appropriateness. School is usually much more formalized. There are guidelines and curriculum with little time for deviation and exploration. Playing and engaging in exploratory activities is seen as very different from the serious task of learning (Bloom & Sosniak, 1981).

Some students find that they have an intense interest and special talent in one field or area over all others. These talent fields often have events associated with them such as concerts or competitions. This allows the students to display their talent for rewards and group approval. There is a significant amount of time devoted to preparing for these events and greater learning occurs as a result of the preparation. Students gain rewards in the form of praise and tangible awards. The fact that these are more public than regular school activities, makes them more real and important to the child. These activities also serve to bring peers and adults with an interest in the topic area together. There is a synergy of connecting and learning from each other in this type of arena (Bloom & Sosniak, 1981).

Schools used to have more public events highlighting and exhibiting the academic talents of students. Schools have become places of work – students get instruction and assignments, and any demonstration of knowledge is done mostly within the classroom. This narrowing of the public display of knowledge creates a world for students where school and learning are separate from the real world and the larger society. Public displays and recognition are important for specific talent development rather than for overall academic school learning (Bloom & Sosniak, 1981).

In intense talent development, as with those individuals completely immersed in developing their talents toward some sort of showcase (concert, competition, etc.), there is a focus on relating the student's learning of the talent to long term goals in addition to current life. This differs from the individual classroom, where learning is often presented as a series of isolated tasks (Bloom & Sosniak, 1981).

There is a general assumption is that competition and cooperation are diametrically opposed. However, sometimes this competition is not in direct opposition to cooperation. For some children, and especially gifted children, academic competitions gives them a place to learn the skills of creativity, problem solving, critical thinking, leadership, group dynamics, goal setting, communication, self directed learning, and autonomy. When individuals come together as a team, cooperative learning can actually be enhanced and strengthened rather, than diminished. Often research into competition looks only at the effects of winning versus losing and does not delve into the other types of competition that relate to doing one's best, nor does it look at the student's motivation to compete. The various views of competition can be subtle. According to Udvari and Schneider (2000), there is task-oriented competition which focuses on doing better than before. This type of competition is often viewed as favorable, as the individual is always looking to improve a situation, rather than to beat out others. Other-referenced competition where the main focus is to win and outdo is usually looked at as a negative thing by others. There are two camps on the view of competition; some felt that the emphasis on winning should be discouraged while others see competition as something to be encouraged. There is some research on the fact that gifted students feel more positive

about competition than non-labeled students do, though they sometimes hide their abilities in order to be liked by peers (Udvari & Schneider, 2000).

There are various ways a school can view those students intensely involved in talent development. The school can view the talent development as purely an outside of school endeavor and although the school might make minor adjustments to the student's schedule or requirements, the two realms usually do not overlap. The student's talent is rarely discussed or acknowledged in school, as it is not part of the sequence of learning and/or the curriculum. The other type of talent development is focused on by the school. Supportive teachers' own excitement and enthusiasm for the area is contagious and they inspire the students. Students who worked on their talents in school often found peers with the same interest. These students worked with and competed against each other (Bloom & Sosniak, 1981)

Having talent in an area often shows up at a young age. This talent should be nourished. One way to do this is to have the student compete in award competitions. "In the United States, the transition from elementary school to high school is a critical crossroad in student academic and personal achievement" (Subotnik, Miserandino, Olszewski-Kubilius, n.d, p. 3).

Gender and STEM

There is much discussion and study regarding gender and STEM fields. There are far less females than males involved in working in science and technology fields. Interestingly, K.R. Price (2001) found that female Science Olympians felt encouraged and supported in their interest in science by their parents, teachers, peers, and friends.

K.R. Price reported that the interviewees felt that their parents were supportive overall, that their science teachers instilled a love of science in them. Peers involved in Science Olympiad served as both support groups and friends. K.R. Price (2001) quotes one of the high school respondents in her study as having said, “Yeah, the people in Science Olympiad support me big time; we’re like a little family” (p. 48).

The continual and progressive underrepresentation of women in the STEM fields is referred to as the “leaky pipeline” (Blickenstaff, 2005). There are those that see no problem with this trend. The question asked is, what does it matter what the gender of the scientist is? Blickenstaff (2005) states several problems with this type of thinking. He states that everyone should have access to choose their profession, and that there are important contributions that might be buried when females are externally excluded or self-selected out of the STEM fields. Various perspectives in a field of study helps it to grow, this is especially true in STEM fields that are trying to understand and explain the world, and solve major problems (Blickenstaff, 2005).

Blickenstaff (2005) states that there is a plethora of research looking at gender and STEM fields. He has found that some of the research presents faulty information or refers to skewed numbers. He has found that biological differences in males and females are minimal and do not justify the leaky pipeline of women in STEM fields. Unfortunately, women leave the STEM fields in greater numbers than men, even though they are just as prepared, or in some cases more prepared than men. Blickenstaff (2005) refers to a study by Baker and Leary (1995) that found that young elementary school aged girls liked science but could not see themselves as scientists. They also made a

“distinction between a ‘scientist’ who studies biology or zoology and a ‘scientist scientist’ who uses chemicals or works with rockets” (Blickenstaff, 2005, p. 375).

The females in K.R. Price’s (2001) study stated that overall they did not experience gender bias. Even though the high school students said that they did not experience bias, they did give examples of things that happened that definitely highlighted bias against them. The college-aged students who attended a university known for their STEM programs, were more specific about occurrences of bias that they had experienced. These women cited specific examples of being the targets of negative gender comments and gender bias. It is interesting that for the most part they did not feel the bias even though it was articulated in their examples. Students in K.R. Price’s (2001) study also pointed to the fact that their parents and coaches and other role models encouraged them in science. They were less concerned about the gender of the role model than whether or not the person instilled in them a love and an interest in science.

K.R. Price (2001) cites Hatchell’s statement that “praise and encouragement served as major influences to female’s self-esteem in science and this attributed to their science success” (p. 55). K.R. Price revealed that the respondents were vague about their career choices and whether or not that career choice would involve science. The college students were more specific than the high school respondents were, most likely because they were further along in their career pursuits. K.R. Price thought that the respondent’s vagueness was due to their lack of work experience rather than bias against females in science. Most of the respondents indicated that they were high achievers in science and took as many science courses as possible in high school. The respondents indicated that they gained confidence from their teachers and from participating in extracurricular

activities. K.R. Price (2001) stated that many respondents said, “science is fun.” (Price, 2001, p 62) One person in K.R. Price’s study articulated it in this way,

Science Olympiad is fun because you are always learning about new things, and you are competing with your peers, and it gives you more of an opportunity to bond with other people from other places that have the same love of science that you do. (p. 62)

K.R. Price (2001) found that the main themes that were prevalent in her focus group interviews were: Importance of support, Science Needs Serious Fun, Teachers Matter, and the Focus of Extracurricular Activities. K.R. Price found that females liked Science Olympiad because of the team work and the collaborative nature of it. This fits with the research that states that students are more interested in learning science when collaborative model is used (p. 72).

The trend of females shying away from science starts in the middle school grade levels. There is a perception that certain fields such as the physical sciences and engineering are male or masculine fields (Adams, 1996). According to Kennedy and Parks (2000), the view that science is viewed as a masculine occupation starts early in a student’s education. The American Association of University Women’s (AAUW) statement in 1992 (as cited in Kennedy & Parks, 2000), said that teachers tend to give special treatment to boys, girls observations of the roles of females in society, and parents subtle and not so subtle beliefs shape girls by what they are given to play with, wear, and do. There is an established belief system that science is diametrically opposed to femininity; with science being logical, analytical, rational, and impersonal and the

femininity encompassing the emotional, personal, intuitive and holistic (Kennedy & Parks, 2000).

Play is differentiated for boys and girls (Adams, 1996). The problem begins early with the type of paths into which parents and teachers lead and push children (Tindall & Hamil, 2004). Typically, boys build, fix, move, and play with construction and problem solving toys. Girls play with more domestic toys such as dolls and kitchen materials. These toys do not give the same opportunity for moving and experimentation. These early childhood experiences set children on to a path. Research states that exploratory play is aligned with problem solving ability (Adams, 1996). Boys play with things that are more geared toward science, math, and engineering and girls play with things that are geared toward verbal and interpersonal skills. It has been noted that those who have positive experiences in early childhood with science and the STEM fields will be more interested in these fields as a career (Tindall & Hamil, 2004).

Part of the issue is that girls, from a very young age, are taught to be quiet and to be a good girl; to follow the rules. If they do not, they are considered bossy or worse. Interestingly enough, in high school it is common that females that scored higher than males in science, felt that they were not as gifted in the area. Females tend to have a negative correlation between perceptions of their ability and the confidence as they go through their years of schooling (Adams, 1996).

Adams (1996) cites Otto, (1991) as listing five reasons that females may avoid scientific fields. These include, “disparity in cognitive abilities, personality characteristics, attitudes toward science, differences between in-school and out-of-school learning experiences, and gender differences in mathematics preparation” (p. 2). There is

a theory that science needs to devote more time to cooperation, communication, and connection. It is believed that doing this will engage more women. The creation of a scientific environment and fostering the love of science should be started as early as preschool (Kennedy & Parks, 2000).

According to Adams (1996), Walker and Mehr did a longitudinal study in 1992 on those who were not achieving at the high level associated with their ability. The finding was that students had a fear of being known as smart or a risk taker.

Attitude is strongly associated with a woman's success, and attitude toward math and science is intertwined with girls' self-esteem. A positive attitude toward these fields declines from grades 6 through 10. However, there is some debate as to when the actual decline starts. Gifted girls especially hide talents and skills in an order to socialize with less talented friends (Adams, 1996).

Research has also noted that boys tend to participate in more extracurricular science activities. Adams (1996) cites a study on female valedictorians and Westinghouse Science Talent Search winners showing that very few of these students continued with a pursuit in the fields of science. Although there were several factors leading to this, one involved a concern about being able to balance career and family. A way to remedy this trend is to show all students the connections between science and society, involve all students in the critical, independent thinking, allow and encourage girls to be leaders, and foster an environment of risk taking (Adams, 1996). Intermixed should be a chance to try and to experience both critical thinking and problem solving scenarios (Kennedy & Parks, 2000).

STEM fields are associated with rigor. Rigor increases at the same time that girls are presented with more social pressure, stereotypes, and the chance to delve into other areas of study. Although this rigor is engaging to gifted students, it is often the gifted boys who stay involved, while the girls move to something else (Subotnik, Miserandino, & Olszewski-Kubilius, n.d.).

There is a lack of female role models for young students. Blickenstaff (2005) states that an influx of role models is unlikely to solve the problem on its own. There are numerous reasons, both small and seemingly insignificant and large, that combine to determine the extent to which a person would be interested in a career in science (Blickenstaff, 2005).

Parents have a big influence on children. Fathers can influence a child's future career ambitions. As their gender stereotypes increase a girl's interest in math decreases and a boys increases ("How dads influence their daughters' interest in math," 2007). In addition, part of the problem causing the leaky pipeline has to do with teachers that hold to stereotypical views of girls and boys and believe that science is a boy's subject. Although times have changed and there is less stereotyping of boys and girls, it still exists. To some extent, this is because teachers who held these beliefs 20 years ago, are still in the classroom, and are impacting views on science (Blickenstaff, 2005).

Blickenstaff (2005) also speaks of the belief that science is seen as masculine, but that some female scientists do not hold to these beliefs, stating that the totality of an individual female's experience is not the same and that not all females look at science through the primary lens of mother or caregiver (Blickenstaff, 2005).

The divide between masculine science seems to revolve around those science areas that deal with economic production and weapons. Biology is seen as less masculine, and in fact, more females are engaged in it than in physics. Blickenstaff (2005) offers several suggestions to move toward plugging the pipeline. They include: eliminating sexist language, images, and behavior both in educational materials and in the classroom itself; giving everyone equal access to information; showing how science can improve life; using cooperative groups; increasing the depth and reducing breadth of courses; and acknowledging that scientific inquiry is political.

Science classes are seen as being competitive in nature. This along with the fact that there is gender bias in society makes it difficult for females to see themselves in STEM related careers (Tindall & Hamil, 2004). Girls do not see math and science as something they need as part of their futures goals. Girls who are strong in both verbal and math areas tend to lean toward non-quantitative fields of study (Subotnik, Miserandno, Olszewski-Kubilius, n.d.)

It is stated repeatedly that there is a decline in science and STEM field involvement by females as they move from elementary to high school. These fields are seen as masculine, especially the physical science fields. Girls who exhibit typically masculine traits such as being assertive, active, and questioning, are viewed as being bossy, rude, and obnoxious. Part of the sharp decline of females in science and related fields has to do with the increase of peer influence as they move up in grades. There is evidence that gifted girls especially try to minimize their talents to fit in. Parents and teachers also fall into a stereotypical pattern of encouraging boys more enthusiastically than they do girls to pursue interests in STEM courses. Teachers can help by having

more cooperative activities in class. Interestingly, girls tend to do better in school and tend to make connections and synthesize information, however standardized tests use a forced choice set up. Boys outperform girls in this type of testing situation (Tindall & Hamil, 2004).

Females tend to leave STEM fields more than their male counterparts. Of all the sciences, this is most true in physical sciences. Even though women are awarded more than half of the bachelor and master degrees in the majority of fields, in fields that are typically associated with men, they receive far less – only 28% of degrees in computer science and 18% of degrees in engineering (Tindall & Hamil, 2004).

The feminist theory on the STEM fields is that science is denoted as an analytical and detached field. Women tend to focus on feelings and connectedness. Teachers need to negate gender stereotypes and highlight the important contributions of women in science (Tindall & Hamil, 2004).

Ravitch (1996) states in her article “The Gender Bias Myth,” that rhetoric about boys having an advantage in school and having more opportunities, is itself a myth. She states that girls in fact are more academic than boys, taking more classes, graduating from high school in greater numbers and attending college. Ravitch states that a little less than half of the students enrolled in the very rigorous programs of law and medicine are female. And that more girls study advanced algebra and geometry, biology and chemistry. She concedes that there are more boys in physics. Ravitch collected the data from the National Center for Education Statistics of the U.S. Department of Education. Other than this, Ravitch provides no research or corroborating evidence for her

statements. Ravitch states that there is no bias in school, but that there may in fact be gender bias in the workplace and in society at large (Ravitch, 1996).

Studies have shown that, especially for the physical sciences, early exposure is a catalyst to later career interest. Joyce and Farenga (1999) found that even before going to school and enrolling in science courses, a person's perception of science is developed. Students decide through these experiences if they like science. As a result of this, both teachers and parents need to provide students with exposure to science and exploratory behavior. These things lead to high achievement in science later on. Girls need to be pushed in this area more than boys, because typically they have not been. Girls are often taught to conform rather than explore. Both boys and girls need this exploration, and self-directed learning as the theory states that this makes a difference in the ability to problem solve (Joyce & Farenga, 1999).

Summary

It is clear from the related literature the study of science competitions is warranted. Since Science Olympiad is organized and run in a different way than some other competitions it is worthy of study. Science Olympiad's purported goals are engaging students in hands-on minds-on science and engineering. The 21st century skills of teamwork, problem solving, and critically thinking are encouraged by the very nature of the competition. Many students are involved across the nation. This is a time when nations are competing with each other for scientific and technological superiority and when the STEM fields are a national focus. This study will use the related literature as a starting point to analyze the perceptions of participants of Science Olympiad.

Chapter III

METHODOLOGY

Overview

The purpose of this study was to analyze the perceptions of Science Olympiad participants in terms of science learning and interest, 21st century skills and abilities, perceived influence on careers, and the overall benefits of being involved in Science Olympiad. The study also sought to determine if there were any differences of perception when gender was viewed as a factor. The research questions are as follows:

1. What are the participants' perceptions of the overall benefits of being on a Science Olympiad team?
2. What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?
3. What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?
4. What are the participants' perceptions of Science Olympiad's impact on their career choice?
5. Is gender a factor of the participants' overall perceptions regarding Science Olympiad?

This study used qualitative data and a mixed analysis approach to look at the data. A type of mixed methods approach is the combining and use of both thematic and statistical strategies to analyze the data (Teddlie & Tashakkori, 2009). According to Patton (2002), "Qualitative descriptions can be converted into quantitative scales for

purposes of statistical analysis...” (p. 253). All of the data came from a database compiled by the Science Olympiad organization. The researcher used this data because it was information rich. It included the perspectives of 635 current Science Olympiad participants and alumni.

The use of qualitative methods and the focus on what Science Olympiad participants perceived about their involvement generated a rich study. The Science Olympiad organization collected all the data and provided it to the researcher. Since the database was very large, the use of quantitative methods of theme counting and descriptive statistics, such as frequency, served to enrich the analysis. An exclusively quantitative study would have yielded some results, but quantitative results alone would not go into the depths that allowed for a clearer understanding of being a participant immersed in Science Olympiad.

The data provided brief quotations from current participants and alumni regarding their Science Olympiad experience. As qualitative inquiry depends upon quotations from participants, their perceptions were brought directly to light in this analysis.

Patton (2002) describes qualitative designs as being real and naturalistic, because they take place without the researcher manipulating the program or area of study. He also describes direct quotations as a major part of qualitative data. It is a study of a person’s perspectives and experiences in a situation (Creswell & Plano Clark, 2007; Nicholls, 2009; Patton, 2002). These quotations allow the researcher to understand the participant’s perspective and to delve into their world. Qualitative research gives the researcher a more in depth understanding of an area of study. The quotations allow the researcher to study the participants’ thoughts and experiences. Qualitative data can

provide description in a way that quantitative data alone does not and cannot (Patton, 2002). The use of quotations in a qualitative study helps to strengthen the claims of the researcher. The balance between the participants' own words and the researcher's words allows the reader to make determinations about the validity of the analysis (Fossey, Harvey, McDermott & Davidson, 2002). The qualitative focus allows the participants' perceptions to be brought to light. The addition of the quantitative analytical methods of counting and descriptive analysis allows for the grouping of information and the development of generalizations.

The use of mixed analysis was clearly needed. According to Onwuegbuzie and Leech (2005), research states that using a significance level of .05, which is typical in social science quantitative studies, is very low and akin to flipping a coin to determine significance. Conversely, the "anything goes" attitude of some qualitative research can result in an analysis that winds up saying virtually nothing (Onwuegbuzie & Leech, 2005).

Historically it was considered good research for the researcher to be removed from that being studied. That idea has changed. It is now considered good research when the qualitative researcher is deeply interested in the topic of the study. A criticism of qualitative research is that there can be too much subjectivity and bias by the researcher. According to Marshall and Rossman (2011), rather than allowing this criticism to stop the research, the researcher concedes that social science research, in its entirety may be subjective, but subjectivity alone does not make for a bad study. It is up to the researcher to prove that their research is significant, relevant, and trustworthy (Marshall & Rossman, 2011).

Theoretical Background

According to Patton (2002), there is no specific way that a researcher can determine how to focus a study. The researcher needs to determine the purpose of the study as well as the available resources and time. These things as well as the interest of the researcher will help guide the direction of the study. Patton (2002) explains that there are various units of analysis for comparison of data. According to Patton (2002), it is not even necessary to use a specific theory or really be concerned about theory at all. Theory is the background of qualitative research, but it is not necessary to find the right category to produce good quality research. Even though it is not necessary to determine a category or theoretical background, this study had some elements of phenomenology.

Phenomenological studies look at the experiences of individuals as they themselves view those experiences (Patton, 2002). A phenomenological study can look at the experiences of individuals who have a similar world. Phenomenological research relates to how people experience the world (Fossey et al., 2002). This study focused on how participants viewed their participation in Science Olympiad.

This study took several approaches, even though they seem to be diametrically opposed. It was phenomenological in nature. Each person's perspective was their truth about their experience, and cannot be right or wrong (Patton, 2002). Qualitative research must acknowledge that people have their own perspectives and create their own realities (Nicholls, 2009). In this case, it was how participants viewed their experiences of being involved in Science Olympiad. Conversely, there was also such a great quantity of responses in the database, it was possible to look at responses and group them by words, phrases, and themes. Those words, phrases, and themes that formed a majority

determined a general truth as to the perceptions of Science Olympiad participants. This marriage of individual perspective and group generalization was the reason for the use of mixed methods analysis.

It would have been remiss of this researcher to ignore the feminist perspective as part of the data analysis. Feminist perspectives use gender as a basis for inquiry and focus on females as part of the study (Marshall & Rossman, 2011). Gender and its relationship to the STEM fields was such an overwhelmingly prevalent topic in the literature, that it would have been negligent not to include it as part of the analysis. Although it may appear that this researcher was trying to fit many theoretical tenets into the analysis; the researcher feels that it was a realistic way to conduct the analysis without trying to pigeonhole the study and its wealth of information into a specific category.

To summarize the need for the various analytical strategies and acknowledge the various theoretical backgrounds it is important to refer back to Patton. Patton (2002) quotes, Schwandt, 2001, as saying, "...labeling is dangerous, for it blinds us to enduring issues, shared concerns, and points of tension that cut across the landscape of the movement, issues that each inquirer must come to terms with in developing an identify as a social inquirer" (p. 135).

Research Design

The use of written documents that include records, publications, and written responses to questionnaires are considered a qualitative data collection method (Patton, 2002). The data used for this analysis was a collection of responses to a survey for

Science Olympiad participants. Participants that responded to the survey were those people that shared a similar experience, in that they were all involved at some level and for some length of time in Science Olympiad. In this analysis, the term survey referred to those questions that were asked by the Science Olympiad organization. This survey should not be confused with the terms survey or questionnaire as defined by quantitative studies. Quantitative surveys primarily have forced answer choices.

According to Patton (2002) the raw data of a qualitative study is suppose to provide descriptions that allow the reader to enter the world being researched. The descriptions and quotations are the data; the points of view of those that participate in the research. Open-ended questions allow the voice of the participants to shine through and, unlike quantitative only studies, the respondents are not limited to the preconceived notions of the researcher. The researcher does not designate answers that the respondent has to choose from; instead, the respondents are given the flexibility to answer the questions in their own words and to share their voice and perspective (F. Strydom, personal communication, July 2008).

Although all questions asked in the survey were open-ended, some did not yield a range of answers. Demographic questions resulted in specific factual information. These questions, although not forced choice responses, were questions that did not allow for much variation in response. Other questions were open-ended and allowed the respondent to answer with full sentences and thoughts. The participants responded to specific questions, and their answers were their own; as opposed to being required to select from pre-determined answers (Patton, 2002).

Patton (2002) states that there is no right way or wrong way to gather data and that every way requires some sort of trade-off. The researcher needs to determine which trade-offs are workable and necessary for the research. There are also no specific numbers of people or respondents that are required to be part of a study (Patton, 2002). The number of study participants is determined by the number needed to gain depth and describe fully, that being researched (Fossey et al, 2002). In this case, the trade-off was between longer in-depth answers that may have been gathered through one-on-one interviews and the use of an expansive database that yielded a plethora of responses that included respondents who were both previously and currently involved in Science Olympiad and were diverse, in terms of geography, age, participation, and continued interest in the organization. According to Corbin & Strauss (2008), “it is important to obtain as many perspectives on a topic as possible.” (p. 26) This data clearly provided a multitude of perspectives.

The data for this analysis came from current and former participants of Science Olympiad. Criterion sampling was used. Criterion sampling is when the participants meet pre-determined criteria (Patton, 2002). In this case, the criteria were that the participants had to be a former or current participant of Science Olympiad. The survey allowed the respondents to enter both their first and last name and decide whether they would allow that information to be shared. There is debate as to whether or not, and to what extent, a subject should be identified. The debate also surrounds the question as to whether or not it is wrong to deny the participants the choice to decide if they wish to be identified (Patton, 2002). As I was not the primary collector of the data, the respondents were referred to only by their first names and the state where they competed, which was

included in parenthesis next to the respondent's name. This allowed for individualizing of responses, but was not intended to be an analysis of data by geographical location.

Data Collection

There are various methods of collecting data. Although, the most common and well known is the use of the interview, there are various other ways to collect data.

Patton (2002) uses the phrase, "creative qualitative Modes of Inquiry" to describe these alternative methods (p. 395). Patton (2002) described the practice of data collection by the staff of the program under study. The data for this analysis was collected and provided by the Science Olympiad organization to me. Sometimes there are concerns when the program staff collects data that they are too close to the participants and may not be objective or may have too vested an interest in the results to not contaminate the data collection, the data itself, or the results. There are positive aspects of having the program staff collect the data. This held true for this analysis. There was data validity because the staff was immersed in the program and engaged the participants. This can and did result in cost and time savings. The participants were invested in Science Olympiad enough to respond to a survey that was available on the Science Olympiad website. The program questions were almost completely open-ended and did not force the participants to choose from preselected answers.

Although the questions were asked and answered in a written format, they followed a standardized open-ended structured interview format (Nicholls, 2009; Patton, 2002). The questions were the same for everyone who chose to answer and they were listed in the same order. The data was from the years 2006-2010. Over the years, the

questions were changed slightly, however there were enough similarities in the questions to make the data useful as a whole.

The pre-2008 Science Olympiad survey included approximately 700 respondents. The information requested included contact and demographic information such as: name, title, gender, email address, and whether the Science Olympiad organization could use the provided information for promotional purposes. Information was requested about the respondent's work including, their occupation, employer, and whether involvement with Science Olympiad led them to a career. Respondents were asked how they knew about the survey, the years they competed at tournaments, their year of graduation, what state they competed in, what was the competition level, as well as, which events they were in, and if they won any medals. The survey questioned if the respondent's children were involved in Science Olympiad, if they had any additional achievements or other information they wanted to share, and if they were still involved in Science Olympiad.

The survey that was used from 2008 to present included approximately 134 respondents. The questions in this survey were very similar to the pre-2008 survey. This version of the survey also asked for information on the middle school and high school the respondent attended. It asked, not only if the person won medals, but if their team was successful. It asked about career influence as well as the impact Science Olympiad had on the respondent's life. This survey also asked if the respondent would be willing to serve on a Science Olympiad foundation advisory committee or attend an alumni reunion.

Although the later form of the survey asked for additional information, most additional questions dealt with the respondent's interest in continuing with the organization in some capacity. There were enough similarities in the data to use all of the

responses, excluding those that were clearly jokes, those that did not give clear information or did not complete the majority of questions or those that were from respondents that stated that they did not want their information used to promote Science Olympiad. The database was narrowed to 635 useful responses.

Data Analysis

Often it is just quantitative, not qualitative research that is considered generalizable. Qualitative research does not normally allow for generalizations (Fossey et al., 2002; Patton, 2002). Nicholls (2009) says that qualitative data can be generalized. Although qualitative research is interested in what individuals have to say, it also allows for the generation of theories. Patterns and themes emerge and are often generalizable, especially with a large sample group. There are generalizations that were determined from this analysis due to the sheer number of respondents, even though each perspective was unique to the person and their experience. These experiences were generalized, but the researcher did not disregard or discard the outliers as is done in a statistical evaluation (Fossey et al., 2002). These generalizations and findings may not be generalizable to other STEM competitions or programs.

Although I did not go into the field to gather the data, my work with the organization allowed for close insight and understanding during the analysis of the data. According to Patton (2002), “closeness does not make bias and loss of perspective inevitable; distance is no guarantee of objectivity” (p. 49). The critics of qualitative research say that the researcher’s closeness creates a bias that results in too much subjectivity (Patton, 2002). According to Patton (2002), the words objective and

subjective have become overburdened by negative debates and connotations. It is better to focus on trustworthiness, authenticity, and the credibility of the researcher. The researcher should have a goal of neutrality. Patton describes neutrality as the researcher not trying to prove a perspective and avoiding trying to get a predetermined outcome by manipulating the data or information.

A researcher can choose from various qualitative theoretical schools of thought to focus the research. Patton (2002) describes several analytical strategies. These include Pragmatism, Inductive Analysis and Creative Synthesis, Holistic Perspective, Feminist Inquiry, Content Analysis, Inductive and Deductive Analysis, and Narrative Analysis. Since this was a mixed methods analysis, none of the qualitative theoretical models precisely fit. I chose to take elements of several theoretical models along with the use of descriptive statistics in order to conduct a thorough mixed methods analysis of the data.

Pragmatism is a theory often used in mixed methods research. This study used elements of both inductive analysis and informal deductive analysis approaches, or a pragmatic approach. “In pragmatism, the approach may combine deductive and inductive thinking, as the researcher mixes both qualitative and quantitative data” (Creswell & Plano Clark, 2007, p. 23).

The focus of pragmatism is on the “...importance of the question asked rather than the methods, and multiple methods of data collection inform the problems under study. Thus it is pluralistic and oriented toward ‘what works’ and practice” (Creswell & Plano Clark, 2007, p.23). Focusing on the issues was the best way to organize and look at the data in this study. The data was organized around the issues that were relevant to Science Olympiad and the STEM fields.

Inductive analysis is a process in which the researcher looks at the data and identifies patterns within it. In this type of analysis, there is no purporting beforehand as to which way the patterns may emerge or lead. This analysis is diametrically opposed to that of deductive analysis in which a hypothesis is stated beforehand (Patton, 2002). Analytical induction allows the analysis to begin deductively and then move toward inductive analysis when looking for new patterns and understandings (Patton, 2002). Analytic induction historically was touted as a way to state “universal causal generalizations.” It is now viewed as “a strategy for engaging in qualitative inquiry and comparative case analysis that includes examining preconceived hypotheses...” (p. 493). Part of this strategy is to analyze the data to see if it fits with the current beliefs about the discipline (Patton, 2002).

A dissertation by its very nature requires a hypothesis as to what one is looking for in the data. A literature search is conducted before the collection and analysis of data and the researcher makes some presuppositions as to what information the data will reveal. In this case, I chose to focus on 21st century skills, science education, and issues of gender in STEM fields. Although these areas were hypothesized to be important prior to the analysis of the data, the data also provided a plethora of open-ended responses that could conceivably have gone in any direction. I did not change variables to test a hypothesis, and therefore had to use inductive analysis to look for general patterns and categories of responses within the data. Additionally, the questions themselves, although not forced-choice, were deductively determined by the organization based on the data it was seeking and the prior knowledge of the program. Patton (2002) indicates that qualitative researchers will often teeter back and forth between these approaches.

...over a period of inquiry, an investigation may flow from inductive approaches, to find out what the important questions and variables are (exploratory work), to deductive hypothesis-testing or outcome measurements aimed at confirming and/or generalizing exploratory findings, then back again to inductive analysis to look for rival hypotheses and unanticipated or unmeasured factors. (Patton, 2002, p. 57)

This study also had some elements of narrative analysis, as the data came from participants written responses to questions. Patton (2002) quotes Barone (2000) saying narrative analysis is “stories of and by students”, and Kushner (2000) as saying narrative analysis is “stories of participants in programs” (p. 118).

The Inductive Analysis and Creative Synthesis model allows the respondents to set forth their perceptions about reality and what was happening in their setting. The researcher looks for patterns to determine what the reality is for the people involved (Patton, 2002). In this study, there was a search for themes among all of the respondents’ answers. The holistic perspective allows that there is more to the research than is allowed by studying just the parts as individual things. There is a realization with the holistic perspective that individual parts are part of a larger whole; a more complex system (Patton, 2002). Science Olympiad participants are individuals, but they participated in Science Olympiad competitions as teams. This team approach to the competition colored their view and responses. Content analysis looks for patterns and themes in the data (Creswell & Plano Clark, 2007). It is a study where one type of data is collected, but both quantitative and qualitative data analyses are used. Creswell and Plano Clark (2007)

note that "... a researcher would collect only qualitative data, but would analyze the data both qualitatively (developing themes) and quantitatively (counting words or rating responses on predetermined scales)" (p. 12). Content analysis is a mixed methods data analysis. The data collected is qualitative while the data analysis is both qualitative and quantitative (Creswell & Plano Clark, 2007).

According to Patton (2002), "...content analysis is used to refer to any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (p. 453).

Although qualitative research often refers to patterns and themes, they are not completely distinguishable. A pattern most often refers to finding the same word or phrase used in various respondents' answers. A theme refers to analyzing what is written to find similarities of thought that can be categorized. This analysis consisted of some inductive analysis, although my closeness to the program allowed for some hypothesizing as to the nature of the content, the data itself lead to a determination of patterns and categories (Patton, 2002).

It is important to consider gender as part of the analysis and to include elements of Feminist Inquiry for the research question, is gender a factor of the participants' overall perceptions regarding Science Olympiad? According to Patton (2002), "A feminist perspective presumes the importance of gender in human relationships and societal processes and orients the study in that direction" (p. 129). Since gender and STEM fields are linked in the related literature, it would have been remiss not to include the perspective in this study.

With qualitative analysis, regardless of the theoretical model, it is important not to lose the low-level analysis among the higher-level analysis. Minor concepts might get lost as the researcher links more and more concepts in to abstract themes. It is always good to go back and clarify the basic while describing the more abstract (Corbin & Strauss, 2008).

Coding

Data analysis starts with basic coding and then progresses as the researcher gains insight into the data and can identify patterns (Nicholls, 2009). Coding was used to find and determine patterns and connections among all of the individual thoughts (Fossey et al., 2002) and as a way to group data into concepts. A researcher looks for the “hidden treasures contained within the data” (Strauss & Corbin, 2008, p. 66).

I looked for patterns in the data. It is important that the coding made sense. The coding aligned with the research questions. All the layers of the data were made obvious. Some things were very clear and there was no need for interpretation nor searching for the meaning, other elements of the data required me to search, interpret, categorize, and mine the data to bring important information to light.

Thematic analysis necessitated a continual search for patterns and categories that were constantly refined and developed as the researcher became immersed in the data. This was done in an inductive way. I was transparent with the data analysis to show the thinking that contributed to the analysis (Fossey et al., 2002). As this was a mixed approach analysis and not purely qualitative, coding identified recurring words and

phrases as well as identified major themes. The use of frequency and percentage was used to enrich the analysis.

Summary

The data was comprised of numerous responses by current and past participants of Science Olympiad. Participants were members of local school-based teams and competed in the continuum of local, regional, state, and national tournaments. The analysis addressed several research questions surrounding the area of STEM learning including, 21st century skills, careers, gender, and overall benefits of participation. Due to the type of data being analyzed, there was no one specific theoretical methodology to follow. The analysis, although having elements of several different qualitative methodologies, was primarily pragmatic.

Chapter IV

ANALYSIS OF DATA

Five research questions were used to review and analyze the data.

1. What are the participants' perceptions of the overall benefits of being on a Science Olympiad team?
2. What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?
3. What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?
4. What are the participants' perceptions of Science Olympiad's impact on their career choice?
5. Is gender a factor of the participants' overall perceptions regarding Science Olympiad?

The data was categorized by students (those currently engaged in Science Olympiad), college students (recent Science Olympiad participants), and those already in careers (adult Science Olympiad alumni). To avoid confusion with the research questions regarding careers, those people already in the workforce, were referred to as workers, adults, or alumni. Each of the categories was disaggregated by gender and current participation versus alumni participation. The respondents were divided into these three categories to identify their recentness to the Science Olympiad experience. This was especially important in terms of the respondents' perceptions regarding career

choice. Most students were not in a position to think about careers, college students were in the process of picking majors, and adults were already engaged in careers.

Respondents focused on different areas of their Science Olympiad experience when they responded to the survey. These themes were grouped and categorized under the research questions. Each of the major themes were subcategorized into smaller subsections that were based on the most prominent references made by the survey participants.

The survey did not specifically ask the research questions being addressed. The only exception to this was a question regarding careers. To analyze the data and address the research questions, the statements of each respondent were analyzed as a whole, rather than how the response answered the specific survey question. This procedure was followed because the questions were open-ended and respondents did not limit their answers to the question being asked. This procedure also allowed the research questions to be addressed as the Science Olympiad survey questions did not specifically address the research questions. Portions of the participants' responses could and did fall into more than one major and minor category. Hence, some quotes were used to highlight several different themes. Quantitative data may have included the same respondent in more than one major or minor category. Analyzing the data in this manner allowed the researcher to see the big picture and to analyze what each respondent was saying rather than determining how the statement answered the specific survey question.

The data was analyzed for each research question. The data was also analyzed and disaggregated by gender for each question. The responses were edited for quotes that pertained specifically to the sub category. The respondent's full statement was not

included in representative example quotes if the whole statement did not relate to the subcategory. Quotes were edited for spelling, but not for other content. These edits did not affect the meaning of the statements; rather it made for clearer reading. Not all quotes that related to the category or subcategory were included in the examples, though they were included and counted as part of the statistics. The quotes used as representative statements were representative of the statements of respondents as a whole. Respondents were noted by first name and state. Those that did not give a state were noted as “no state.” Other identifying information in the quotes were removed.

Research question number 5, “Is gender a factor of the participants’ overall perceptions regarding Science Olympiad?” was imbedded within each of the four other research questions and was addressed accordingly. This question therefore does not have a separate section addressing it.

Research Question 1

What are the participants’ perceptions of the overall benefits of being on a Science Olympiad team?

All of the data was reviewed and grouped around prevalent themes and statements. The major subcategories included fun, enjoyment, major life impact, socialization, competition, education, and the affective feeling of just simply loving Science Olympiad or it having a major impact on their life. The data was analyzed specifically for statements that were about the Science Olympiad experience itself and not for specific areas or topics within Science Olympiad. For example, responses were

included when a respondent said that he or she loved Science Olympiad but not if the respondent said that she loved science. A love of science was included under research question number two, which referenced STEM learning. There were many respondents in all three categories that made statements that could be interrupted as saying that Science Olympiad was a great experience. These were not included in the statistics.

Fun

Students. Fun was an important topic for students. Nine female and 11 male students wrote about their experience with Science Olympiad being “fun.” Four more females and one male said that they enjoyed their time with Science Olympiad.

College. Female college students focused on the fun of Science Olympiad more than the males did. Thirteen females and six males wrote about fun. Christina (CO) said, “It made science, math and design fun.” Alicia (TX) said, “Science Olympiad has shown me what fun science can be.” Jade (IL), describes the atmosphere this way,

Science Olympiad not only aided me academically but it really was one of the most fun experiences of my teenage years. I would say that the unofficial motto of our team was to work hard and play hard. Some of the fondest memories come from our 'study/practice/building/pizza' sessions in the junior high science room.

Two of the female college students said that the fun came from getting to learn science outside of the classroom. Laura (no state) “Science Olympiad made science fun. It was no longer something that was just merely facts and formulas and words in some boring textbook. I learned what it felt like to actually apply the knowledge that I had

learned.” Kathy (AL) said, “SO helped show me the fun side of science- get me out of the books- and introduce me to new subject areas.”

Elinor (RI) credited her coach with making the experience fun. “I studied molecular biology as an undergraduate- both because of the fun I had doing Science Olympiad and the influence of our team coach- my high school biology teacher.”

Will (CA) also credited his coach for making the experience fun. “I just really want to thank my school Science Olympiad coach... She has made Science Olympiad so much fun and I really enjoy what she does. She has inspired me to really like science...”

Hogan (MI) was only involved for a year, but said that he had fun. “I only regret that I didn't do SO earlier. I did it senior year, and it was the most fun I ever had in high school.”

Adults. The adult alumni were a little more explicit as to what was fun about their Science Olympiad experiences. Fourteen females and 18 male adults referred to the fun of Science Olympiad. The fun part of being on a Science Olympiad team ranged from having fun working with people on the team, traveling to competitions, learning, and having fun at the competitions.

Christa (CA) said, “I enjoyed it and had fun. I miss it, especially nationals. It was so much fun to travel and meet the people from other states.” Jenna (IN) said, “Science Olympiad was wonderful. It was so exciting to go to a competition where loving science was fun and everyone was thrilled to be there.”

Alicia (CO) said,

Science o really helped me find my place in the world and discover that there are people out there who love the same things I love and are still socially acceptable

and fun people. Basically, having a focus for exploring interests that went beyond what you usually studied in high school encouraged us to spend time together exploring and, quite often, just goofing off, while being productive at the same time.

Jennifer (PA) compared Science Olympiad to the classroom. “Events like Science Olympiad are important. It makes science and engineering interesting and fun. Regular school work tends to take the fun right out of it.” Jackie (MO) wrote about the fun of competition, “Science Olympiad was a way for me to excel in a school dominated by athletics. I wasn't a good athlete, but I got medals for my knowledge and winning them was a lot of fun.” Sean (IL) wrote about the fun of working with peers. “It was a fun way to hang out with people of the same interests and to apply the fundamentals learned in the science curriculum of HS into interesting and creative forms of competition.”

Loved Science Olympiad

Student. Twenty-two females were put in the category of loving Science Olympiad. These respondents used terms such as enjoyment, awesome, love, like, and great experience. Six male students expressed the same feelings.

College. Numerous college students said that they loved Science Olympiad. They expressed love for it, saying it was an excellent, great, or worthwhile activity. Fourteen females and 12 males said that in some way they loved Science Olympiad. Many times their love of Science Olympiad led them to pursue certain areas that were in concert with Science Olympiad. Heidi (MO) said, “I loved SO and after I graduated continued to coach so I could be involved in it.”

Jami (UT) said,

It has made me want to be a science teacher and get as many children interested in science, and participate in Science Olympiad because it really helped me growing up having something that I loved to do that was also academic at the same time.

Kaitlyn (no state) said that her love led her to spend hours on her events. “Mostly I just loved it. My parents would come down to the basement at 1:30 in the morning to tell me to stop building.” Jamie (no state) used the term “love” to sum up everything she felt about Science Olympiad but could not describe adequately, “I love Science Olympiad. It is a simple statement- but it's as true as it comes. If only there were actual words to describe the true magnitude of its importance to me.”

Jaclyn (NJ) was not eager to join at first, but loved Science Olympiad anyway. “I originally did not want to do Science Olympiad. My eighth grade science teacher tricked me and my best friend into participating in a class bottle rocket competition. I fell in love with Olympiad right away.”

Male college students described their affection for Science Olympiad in much the same way. One person actually called it “addictive.” A few males said that they thought that Science Olympiad was important for the greater good, “I love science olympiad and think it is an extremely positive thing for not only kids, but society.” Another, Ryan (TX) said, “I think that Science Olympiad is an amazing program that has the potential to bring about a new golden age of science in the United States.” Cody (MI), tried to get others interested and involved,

I loved Science O. and really miss all the fun times that I had as a student participating. I would encourage any student interested in science, building, or learning in general to at least look at Science Olympiad and to give it a try. Once you do try it I am sure that you will fall in love with it.

Adults. Although several people in the adult category said that they enjoyed Science Olympiad, only one person (female) said she loved it. An almost equal number of males (five) and females (six) made statements indicating that they enjoyed Science Olympiad.

Kay (no state) said, “Science Olympiad was- by far- the most enjoyable and meaningful activity that I participated in while I was in high school.” Krista (MI) said, “I have such varied interests- but most of my success and joy came from my experiences with SO...” Chris (no state) seems almost surprised that he enjoyed the work required for Science Olympiad. “I am greatly thankful to Science Olympiad for teaching me to dedicate myself to something- stick with it- achieve success in it- and enjoy doing so.”

Life Impact

Student. Six females and five males wrote specifically about Science Olympiad having a major impact on their life. As one student Rhee-Soo (no state) said, “Science Olympiad has been a life-changing and memorable experience. I would encourage everyone to be involved--I have made some great friends- and seen the success of my team and my hard work pay off.”

Daniel (CO) said, “Science Olympiad has probably been one of the greatest things ever in my life- as well as one of the best things that I have ever done in Junior High. I am very very proud to be going to Nationals this year and plan on continuing in High School.”

Christina (CO) said,

I have spent a ton of time dedicated towards Science Olympiad. It helped me stay on track academically and pushed me to strive for excellence. It also showed me what hard work can accomplish.

Science Olympiad is an amazing activity that allows students to thrive in academics. It's an awesome opportunity and I couldn't imagine what my high school career would have been like without it.

College. College students were able to look back at their time with Science Olympiad and see its overall impact on their life. There were 13 female college students and seven male college students that wrote about the impact on their life. Statements included, “big part of my life,” “huge impact,” “best part of my middle and high school life,” “one of my most significant High School experiences,” and “It completely changed my life.” Kristen (NC) said that the whole experience influenced her.

Science Olympiad has really impacted me in so many different ways. It has led me to choose my major in geology with a coastal influence.... It has also influenced me to continue my education to graduate school. I absolutely loved the event and try to get as many people involved as I can. I still help out with both the regional and state events... I am hooked for life!

Elisabeth (PA) focused on the team aspect, “My coaches- team- and being a part of that team had a profound impact on my life. Their passion- determination- and hard work inspired me. Their trust in my abilities and their incredible kindness changed my life.”

The college males made similar statements about the perceived impact of Science Olympiad on their life. They included, “the most important and influential activity I participated in during my middle and high school career,” “experiences in SO were what

really defined my in High School,” and “one of the more memorable aspects of my junior high and high school experiences.”

Junxiao (OH) compared Science Olympiad to other competitions,

Science Olympiad was the greatest influence on me during my grade school years. It trumps Science Fair, Chemistry Olympiad, Math Bowl, etc. because it is like all of those put into one competition that is an "olympiad."

Charles (AL) wrote about how much time he spent working on events and worthwhile he felt it was, “I put in countless hours to science olympiad- way more than a person probably should- and I would not trade it for anything. You get back everything you put into it.”

Adults. Almost an equal number of males (seven) and females (nine) said that Science Olympiad had a major impact on their life while they were involved.

Alicia (CO) was quite verbose about the impact Science Olympiad had on her.

Science o really helped me find my place in the world and discover that there are people out there who love the same things I love and are still socially acceptable and fun people. Basically, having a focus for exploring interests that went beyond what you usually studied in high school encouraged us to spend time together exploring and, quite often, just goofing off, while being productive at the same time. I was involved in high school level sports, music, etc, but it wasn't until I started science olympiad that I really felt like I fit in. Being a naturally competitive person, the competition aspect of it was attractive to me, but it truly was mostly about exploring things you were interested in with a group of people you liked being around.

This was a LARGE part of my high school experience...our team got a lot of recognition within our school when we did well, and we had athletes, teachers, and people from many social circles congratulating us. I feel like it really legitimized my friends' and my interest in science (although they are the type that would have been involved in it even without science o...just not having as much fun or getting as much out of it!) and helped me find my "place" in this world.

Tiffany (OH) echoes much of Alicia's (CO) statement.

This program was amazing and some of my best memories came from being a part of the team. The opportunities that were opened were so limitless. Much of what I learned during my time in Science Olympiad is still with me because of the practical and hands-on method of learning that was used. The impact this made on my life is too much to put into words...

Emily (NY) wrote about the huge impact Science Olympiad had on her.

It changed my life because it was the only time in high school--and really in life--that I was able to make any significant contribution to a team I really felt a part of. Even better than our considerable success as a team was the feeling of belonging to something as an extreme nerd. Our coach made us t-shirts celebrating our nerdiness and generally stressed our sense of community above competitiveness.

Fred (NE) put it very succinctly, "My participation in Science Olympiad was the single biggest defining activity of my middle and high school life."

One current teacher gave credit to Science Olympiad for helping him choose his current profession. "One of the aspects of Science Olympiad that had the greatest impact on me was to develop relationships with my teachers outside of the typical class periods. This led me to choosing teaching as a career."

Social Aspects of Science Olympiad

Students. Many students wrote about the social aspects of being involved in Science Olympiad. Twenty-one females and eight males expressed the importance of the social aspects of their involvement in the organization. Shannon (NC) said, "It has also brought me best friends and practically, another family." Genifre-Lynn (IN) said, "It has also helped me make friends that have the same interest in science that I have." Jason (NY) echoed the sentiment of friends and family. "I have met tons of people from all over my state and the country in addition to forming a family like bond with my own

team.” Alex (TX) said, “I’ve met so many people- and my best friend- through Science Olympiad.”

College. The social aspects of the experience were important to the college respondents. Twenty-two females and 16 males wrote about the social aspects of Science Olympiad. One female described the experience as fun insanity. “I really grew up with my team and nothing could replace the lessons learned- fire alarms set off- tears- hugs- laughter and pure insanity that we had.” Several of the college students described the team as a family. Alexander (NY) said,

Science Olympiad has led me to form lifelong best friendships with a small but tight-knit group of people. Our team- while not always as successful as others- became truly a family and was able to form bonds beyond partnerships in an event...

Jamie (no state) said, “The impact Science Olympiad had on my life is not easily stated. I became family with my teammates and coaches. We loved and hated each other like real family- especially when it came down to the crunch.” Stephen (MO) looked at it more as a community. “I’ve always loved science; NSO certainly reinforced that passion and gave me a great community to foster that interest.”

Many college students wrote about making lifelong friends. Limor (NY) said, “My SciO teammates have remained lifelong friends.” Kate (IL) said,

Being a part of Science Olympiad was one of the best choices I have ever made, I made so many friends that I still keep in touch with throughout the years, I learned so much, and I have so many great memories with my team mates. I was a part of something, and it grew to be a part of me.

Allison (OH) attributed the great friendships to the time spent together. “The bonds I formed through Science Olympiad are stronger than formed through any

other organization I participated in due to the team size and the many hours spent together.”

Siobhan (no state) felt like the team was family, “SO was a huge family to me. I miss it a lot sometimes.” Another respondent said she eventually married one of her teammates. Two of the males said that they met more friends in college because they had Science Olympiad in common. Scott (MI) said, “SO gave me a good distraction from the boring everyday school work- a social outlet during junior high and high school- and many many stories to share with friends I met in college who participated in their home town.” Mark (CA) felt strongly about Science Olympiad and he discussed it “with several of my friends who competed alongside me- and also some friends from college who competed for other schools during high school.” Kyle (no state) felt that the social aspects led him to a career, “Science Olympiad led me to make several acquaintances which in turn pushed me into the aeronautical/aerospace engineering field.”

Adults. The working adults valued the social aspect of Science Olympiad too. Twenty-four females and 17 males wrote about friends, friendships, camaraderie, and the social aspect of their Science Olympiad experience. Several people reflected the feeling of finally fitting in. Emily (NY) said,

It changed my life because it was the only time in high school--and really in life-- that I was able to make any significant contribution to a team I really felt a part of. Even better than our considerable success as a team was the feeling of belonging to something as an extreme nerd.

Megan (CO) said, “All my friends were nerds and all my friends were in Science Olympiad. Participating in science and hanging out with friends made everything fun

and exciting.” Rebecca (CO) like others in the student and college groups spoke of the family feeling of Science Olympiad. “Science Olympiad helped me find friends who were driven- kind- supportive- and very much like a family.”

Shannon (no state) said, “Science Olympiad led me to find friends who liked me for who I was. It was wonderful to be surrounded by people my age who loved science as much as I did. Science Olympiad it helped me 'fit in' in high school...”

Several people wrote about their connection to the adults that mentored them. Lori (MN) said, “I formed a close bond with my coach... We keep in touch all these years. Both Science Olympiad and Mr. K... helped make my career decision to be a teacher and want to show to all students how much fun science can be.” Mary (OH) wrote extensively about her mentor,

My freshman year in high school I met a great man named V...H... who agreed to mentor me in the Wright Stuff. Over the years, Dr. H..., affectionately called Hack, and I became very close. I stayed at his home a number of times, and eventually came to think of him as a surrogate grandfather. Despite my stray from the field of science, Hack always encouraged me to do the very best that I can, always believing in my ability to do more. I owe a great amount of my success to him and to my junior and high school coaches. In addition, I met my fiancé in junior high when we competed together in Science Olympiad. Our years of working together long nights and weekends formed a great friendship that now serves as the base of a great relationship.

One female, Vanessa (MI) made a point in saying that the camaraderie with other girls was important, “As a young girl- being on the Science Olympiad with other girls created an important support group....”

Several people felt that the shared interest of Science Olympiad helped to create friendships. Chris (ND) said, “It helped me meet great friends and meet new people that had similar interests.” Michael (IL) “...participating in the ISO reinforced my interest in

science and introduced me to a large peer group that felt the same way. As result of this enlarged perspective I felt like less of an outsider.”

Many in the workforce category spoke of making lifelong friends.

Christopher (RI) said, “Some of my friends to this day were friends that I made during Science Olympiad.”

Education

Although most of the respondents wrote about learning science, one of the other STEM fields, or a life skill, some wrote about education or academics in general. These statements were sometimes intertwined with other categories; and were therefore included in those areas, and were not included in this section. A number of responses were not included in this section because it would be misleading since the interrelated areas were not included. Responses are included here, for the enlightenment of the reader, but were not broken down by student, college, or adult and not included in the quantitative data for the reasons previously stated.

Catye (no state), said, “Science Olympiad is wonderful and has gotten me excited about so many new things.” Another girl explained in great detail how it helped her love learning, “Studying for something outside of school has always made me look at studying and learning new things as something that’s intrinsically pleasurable- which is a very different experience form studying for school ...” In quintessential student speak, a girl from MN said, “SO makes you learn a lot of new stuff.” Kelly (no state) summed it up as, “Everything I’ve done in Science Olympiad has been a learning experience.” Seven

male students focused on education. Carols (no state) described it as being “surrounded by those who enjoy to learn and explore new ideas.”

Kate (OH) said, “The experiences with Science Olympiad not only propelled me as a student into Advanced classes and various scholarship opportunities, but also encouraged my desire to learn and explore science and the arts.” Katelyn (OH) said, “Science Olympiad allowed me to branch out and explore.” Kristen (KS) said,

Science Olympiad got me involved in school more than anything else could have at that point in my life. It got me engaged in learning. It also taught me how to study- which has helped me at every educational level.

Nick (NY) said, “I can't think of a better way for students to learn about science and yet become educated in many other facets of life (i.e. success- failure).” Amber (OR) said, “it helped me embrace a love for learning and independence. We had to do the research and the work with little help or supervision.”

Jonathan (CO) said, “We spent a lot of time and effort on an initiative that was not school-related- yet was a worthwhile and exciting endeavor. This encouraged me (and others- I believe) to pursue and excel at activities of academic interest....”

Two college students specifically wrote about how they liked working on things after school. Christina (CO) said, “It helped me stay focused in school and gave me something to be excited about after school that challenged me academically.” In addition, Allison (IN) said, “It was a great extracurricular for me in middle school and high school, as I was very involved and got to learn a lot of interesting things outside of class.”

Competition

Students. Competition was a prevalent theme in the student statements. Females and males were split almost equally, with ten females and eight males writing about competition. Shannon (NC) said,

I've always had an interest in Meteorology, but Science Olympiad showed me that there's so much more I can learn. From tornadoes to winter storms to climate, I've learned so much more about the topic than I could have ever imagined and getting to compete with other kids who have the same interests really was an honoring experience.

Katie (no state) spoke about the good feelings that she had from competition,

Science Olympiad gave me a place to fit in- a place to excel. I have never been good at sports and I had gotten used to losing at competitions... I wish every child in the world would be able to find something that made them feel as good as Science Olympiad made me feel- no matter what it is.

Kelly (no state) said,

Science Olympiad has been one of my most honorable achievements and the amount that I have learned has just been out of this world. It's been so exciting and so much fun to go to nationals and compete with the brightest kids in the nation....

One of the boys also compared this academic competition to his involvement in sports, "Sci O has really given my high school career a focus - sports were just a pastime- and I was never academically competitive- but science olympiad allowed me to satisfy my competitive urges...."

Jeff (IN) thought that the competition made the learning fun. "It is the most fun academic competition I have ever competed in. The way that you can always feel good about your performance at the end of a stressful day is why I like the competitions."

Marc (no state) liked being able to test himself against other students, “It has had a great impact on my life and being able to put my devices up against other student's devices in the area.”

College. There were an equal number of male and female college students, eight of each, who wrote about the actual competition. Several of the students compared the competition of Science Olympiad to sports.

Jennifer (PA) said, “My high school was super focused on athletics- and SO was one way for "nerds" to contribute to school spirit and get some respect- as well as being tons of fun.” Jennifer (MO) said, “It was also nice to see the friendly inter-school competition in an area besides athletics!” Joshua (no state) said, “Science Olympiad is a great tool and experience for young people to foster a love for the science and gives academics a competition that can be promoted just like sports.” Several college students related the competition to a feeling of accomplishment. Denise (no state) wrote about the “...thrill of competition and feeling of accomplishment when I placed in an event.”

Isaiah (KY) said,

It taught me more responsibility and how to have a good time in competition. How to make some new friends and always push and strive to accomplish your best. I really enjoyed Science Olympiad. The competition and training was mentally tough, but it was all worth it in the end to be called to the stage to receive a medal. You know you had to work for it.

Faisal (NC) said it gave him something that regular school did not. “The work I was given in school was never a challenge- so I had no motivation to work on it. SO though provided competition that I sought.” Aryn (no state) wrote that she learned both about winning and losing, though losing did not seem to damper her spirits. “Science

Olympiad taught me about winning- and it also taught me about losing. Either way- it taught me that science not only can be- but IS fun!”

Adults. The male adults outnumbered the female adults in writing about the competitive part of their Science Olympiad experience. Twenty-five males and 11 female adults referenced competition. Several adults compared the competition to the competition of sports. Kelly (MI) said,

Besides finding learning as a fun challenge- it gave me a chance to participate with other students who were always pushing to be better. In addition to the sports that many of us participated in- it was nice to have the specialized mental competition.

Even though I participated in many school sports- I was the most proud of my achievements- and our group achievements in Science Olympiad.

Kari (OH) said, “We enjoyed helping one another, and since very few of us were athletic, it gave us an avenue to satisfy our competitive spirit.” Jackie (MO) “Science Olympiad was a way for me to excel in a school dominated by athletics. I wasn't a good athlete, but I got medals for my knowledge and winning them was a lot of fun.”

Christopher (MO) “The Olympiad taught me that competition could be healthy and intellectually based, not just sports. It taught me to appreciate what I could accomplish with my mind.”

Lori (MN) wrote about the Science Olympiad competitions importance to her. “The National Science Olympiad competition was held during my senior prom and I chose to miss prom in order to compete. It was an opportunity I didn't want to miss out on.”

Many of these adult alumni thought the competitive aspect of Science Olympiad was fun and exciting. Scott (SD) statement was very similar to many of the others. “The regional and national competitions opened my eyes to the fact that science could really be fun and rewarding.” Jennifer (IN) “It was so exciting to go to a competition where loving science was fun and everyone was thrilled to be there.”

Several adult alumni wrote about the respect and confidence they got from competition. Eric (no state) felt that he gained respect from competing. “Science Olympiad gave me something to excel at in school that was public and at a National level to give me self-respect.” Jeff (IN) said, “Science Olympiad provided me with self-confidence. I could win if only I tried hard enough.”

Howard (NY) cherished his time in competition. “Well My medals are framed and hang in my office. The opportunity to compete and succeed at such a high level is one of things I will always carry with me!”

Quantitative Data

Tables 1, 2, and 3 disaggregate the quantitative data for the research question: What are the perceptions by participants of the overall benefits of being on a Science Olympiad team? Tables 1, 2, and 3 disaggregate the minor themes within the research question. Table 1 includes the student data, Table 2 includes the college data, and Table 3 includes the adult data.

Table 1

Overall Benefits of Participating in Science Olympiad – Students

	Total	Female	Male
Total Student Survey Respondents	188	102	86
Overall Benefits (Total)	82	53	29
Fun	20	9	11
Love	28	22	6
Major part of life	11	6	5
Social	29	21	8
Competition	18	10	8

Table 2

Overall Benefits of Participating in Science Olympiad - College

	Total	Female	Male
Total College Survey Respondents	206	104	102
Overall Benefits (Total)	104	57	47
Fun	19	13	6
Love	26	14	12
Major part of life	20	13	7
Social	38	22	16
Competition	16	8	8

Table 3

Overall Benefits of Participating in Science Olympiad - Adults

	Total	Female	Male
Total Adult Survey Respondents	241	112	129
Overall Benefits (Total)	98	43	55
Fun	32	14	18
Love	12	7	5
Major part of life	15	8	7
Social	41	24	17
Competition	36	11	25

Table 4 combines the quantitative data for the student, college, and adult categories. Raw numbers for total respondents, female respondents, and male respondents are given. Also noted are the percentages of responses against the total survey respondents of N = 635 for both the overall benefits of participating in Science Olympiad as well as the minor themes that are within the category.

Table 4

Overall Benefits of participating in Science Olympiad - Total

	Total	F	M	Percentage		
				Total	Female	Male
Total Survey Respondents	635	318	317	100%	50.1%	49.9%
Overall Benefits	284	153	131	44.7%	24.1%	20.6%
Fun	71	36	35	11.2%	5.7%	5.5%
Love	66	43	23	10.4%	6.8%	3.6%
Major part of life	46	27	19	7.2%	4.3%	3.0%
Social	108	67	41	17.0%	10.6%	6.5%
Competition	70	29	41	11.0%	4.6%	6.5%

Table 5 disaggregates the percentages of females and males within each minor theme for research question number 1.

Table 5

Percentage of Females and Males within the sub-categories for Overall Benefits – Total

	Total N	Females		Males	
		n	%	n	%
Overall Benefits	284	153	53.9%	131	46.1%
Fun	71	36	50.7%	35	49.3%
Love	66	43	69.4%	23	30.6%
Major part of life	46	27	58.7%	19	41.3%
Social	108	67	62.0%	41	38.0%
Competition	70	29	41.4%	41	58.6%

Table 6 compares the number of females who made statements that comprised the minor themes and compared it to the overall number of females that responded to the survey. This table compares the same data for the males.

Table 6

Percentages of Responses Disaggregated by Minor Theme and Gender for Overall Benefits

	<u>Females (n=318)</u>		<u>Males (n=317)</u>	
	n	Percentage	n	Percentage
Overall Benefits	153	48.1%	131	41.3%
Fun	36	11.3%	35	11.1%
Love	43	13.5%	23	7.3%
Major part of life	27	8.5%	19	6.0%
Social	67	21.1%	41	12.9%
Competition	29	9.1%	41	12.9%

Research Question 2

What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?

The data for this question was divided into four major themes. The data was subcategorized into Specific Science Content, Science Work, Overall Science, and Science is Interesting. Specific Science Content included any specific reference to a STEM area or Science Olympiad event. Examples included botany, meteorology, and water quality. Science Work included going about the processes of doing science. Areas included hands-on science, working in labs, scientific reasoning and thinking, science skills such as measuring, observations, and methodology. Overall Science included any reference to science that did not specify a specific topic, learning about science, gaining a broad background in science, exploring the sciences, or learning that went beyond the regular classroom. Science is Interesting included any statements that referred to loving science, liking science, thinking science was important, or thinking that science was interesting.

Specific Science Content

Students. Specific Science Content referred to any respondents writing that directly related to a named science topic or Science Olympiad event. An example of this is when a female student said, "Water Quality from five years ago continues to help me in my classes like AP Environmental Science." Thirteen female students wrote about a specific science topic, while only three males wrote about a specific science topic. All

three of the male students wrote about physics. Keith (IL) said, “It has kill my athletic career in wrestling. Also improved my grades in physics. I can stand the lost of one of my 3 sports, I love doing science projects.” Jonah (no state) said, “It increased my interest in science- particularly physics; I am considering majoring in physics or chemistry in college.”

The topics that the female students wrote about varied from aquifers to water quality from cell biology to catapults. There were several females that stated that Science Olympiad got them interested in a subject area that they had not even considered before.

Nicole (CA) said:

before science olympiad, i had never even considered things like forensics a science. i tried the event because a friend asked me to. since then, it has been my goal to get a degree and work in criminal justice as a forensic scientist.

Several female students wrote about the sheer range of topics that they learned and became more interested in. Kelly (no state) wrote, “Science Olympiad has taught me so many things from chemistry and epidemiology to responsibility and determination. Everything I've done in Science Olympiad has been a learning experience.” Kimberlee (no state) said, “I know how to build- what trees are what- solve Crimes- Design Experiments- and more about weather.” Another student wrote about how she learned about all of the nuances of a larger topic. Shannon (NC) said,

I've always had an interest in Meteorology, but Science Olympiad showed me that there's so much more I can learn. From tornadoes to winter storms to climate, I've learned so much more about the topic than I could have ever imagined....

Several students focused on one topic or event they liked or learned more about.

Kate (MO) said, “Science Olympiad has led me to the conclusion that I want to be a

meteorologist eventually. Since I'm only in eighth grade- my interests may change- but I LOVE METEOROLOGY!”

Two girls wrote specifically about the science of water and two girls wrote about biology. Only one female student wrote about a physics topic. One student related her learning of a specific topic to her success in her regular school classes. Madeline (NC) said, “Water Quality from five years ago continues to help me in my classes like AP Environmental Science.”

College. The college students responses also ranged from referencing one specific topic to listing many new topics and STEM areas that they learned about. Several female college students wrote about biology related topics. Kelly (no state) said, “While studying for events such as Cell Biology- Designer Genes- and Science of Fitness- I developed an interest in biology.” Corinne (no state) said, “I first learned about reptiles and amphibians through science olympiad. Now I am a PhD student studying tropical amphibian conservation.” One student, who indicated that an engineering event was her favorite, nevertheless choose a biology field to pursue.

When competing in Science Olympiad, I chose to compete in the events that held the most interest to me. The Wright Stuff was my favorite but I also loved Oceanography, Remote Sensing, Dynamic Planet, and Ecology because I have always had an interest in the environment. As it turns out, I am a Natural Resources major at Northland College with an emphasis in Wildlife and Fish Ecology. I have chosen to specialize in fisheries and the oceanography and remote sensing events at Science Olympiad have given me a background for some of the classes I have taken.

A few females wrote about chemistry. Mackenzie (OH) said, “From all of the Chemistry events I participated in throughout my Science Olympiad career- I got a better understanding of what fun chemistry could be.”

Several females at the college level, unlike at the student level, wrote about engineering topics. Jessica (MI) said, “Science Olympiad is what inspired me to become an engineer. My favorite event was always Polymer Detectives- so it just made sense to major in Materials Science and Engineering.”

One student who wished to remain anonymous credited a specific in Science Olympiad, oceanography, for changing her whole direction in life.

SO sparked my interest in science. I had originally intended to be a music major and Science O. was something random I picked up in my junior year. I had never been particularly interested in science and had never realized I had a special talent for science and mathematics. The ease with which excelling at SO came to me was quite a surprise. My performance in SO most likely gained me acceptance to MIT. (I probably would not have even applied if my performance during my first year in SO hadn't given me confidence in my intellectual abilities!) It also made me interested in other science competitions, in which I had a great time :) It moved my interests towards Oceanography/Earth Science/Chemistry. I am now a chemistry major with a minor in Earth Science. I guess that overall SO gave me the desire and courage to follow my abilities in science. I never really thought of myself as particularly smart or geeky, and four years ago I would never have pictured myself where I am now-- at the world's foremost scientific university, with several science scholarships under my belt and an upcoming internship at a prestigious oceanography institution! Picking up that first oceanography textbook to study for SO was definitely a major turning point in my life.

The college males were the first group that mentioned math and computers.

Christopher (NJ) wrote, “Science Olympiad really got me interested in science, and from there I moved on to mathematics and computer science.”

Many of the male college students wrote about engineering. Nathan (MI) “Participating in Science Olympiad- particularly in the Mission Possible event helped develop my interest in engineering. I later got involved much more with the Wright Stuff event which helped me to realize that I wanted to be an aerospace engineer.” One college student actually looked back at the experience of learning to engineer a solution as a

defining moment. Craig (IN) said, “I think a defining moment in my high school career was when I "engineered" a solution to bungee egg drop.” One college student credited Science Olympiad and the range of topics as helping him find something he loved.

Geoffrey (CO) said,

I had never found an area in science that I was much good at and Science Olympiad helped me to try a lot of different branches of science and it really helped me narrow down what I love to do. The Earth Sciences became my favorite subject and I excelled well in them at the competition level. After figuring that out, I was intrigued by the Remote Sensing competition that dealt with exploration of Mars and it was there that I found my love for the planetary sciences. I am now pursuing a degree in Geological Engineering with a concentration in Minerals and Petroleum Deposits concentration and an area of special interest in Space and Planetary Science Engineering from the Colorado School of Mines. Science Olympiad helped me to hone down my study skills and I came into college with a greater knowledge of the Earth Sciences because of this resource.

Some of the other topics and areas of interest indicated by the college students included geology, astronomy, biology, chemistry, and physics.

Adults. Unlike the K-12 students and college students, the female adults seemed more geared toward chemistry, physics, and engineering. In fact, the female adults group is the first time that a female mentioned physics. Kathleen (MI) said,

I enjoyed getting to learn about many areas of science in Science Olympiad, and I continue to be interested in lots of science disciplines. In particular, Science Olympiad showed me that I love chemistry and physics, which ultimately were my majors for my undergraduate degree.

Jennifer (NM) said, “It definitely opened my eyes to careers in math and science. It helped me to appreciate physics as well as team problem solving.” Tiffany (OH) provided a litany of topics that she felt that she learned as part of Science Olympiad.

I still remember the names of most of the organisms from "Water Quality", I can tell anyone about how muscles are constructed and work because of my time in Science of Fitness, and the ability to apply the scientific method to real life problems is an invaluable gift I took away from "Experimental Design". The impact this made on my life is too much to put into words...

The remaining female adults wrote about geology, chemistry, genetics, and engineering.

Four of the male adults focused on physics and engineering. Some of the statements were, "I enjoyed doing the building events, which helped my decision to study mechanical engineering further" and "It helped me discover my passion for computer and electrical engineering." One male adult was interested in both engineering and computer science. "SO got me interested in both engineering and computer science...." Another respondent was non-specific, but said he enjoyed exploring technology.

Two male adults wrote about physics, and one was very specific about the type of physics that Science Olympiad got him interested in. "Science Olympiad is responsible for parking my interest in theoretical physics, particle physics and astrophysics, as well as science in general." Three male adults wrote about chemistry.

Science Work

The next theme in the science area revolved around the work of being involved in science. These respondents wrote about science being hands on, their interest in doing labs, and the application of science.

Students. The student responses were split evenly between two female and two male respondents. The two female students wrote about being observant and doing hands on work. The one girl said, "It helped me be more observant and notice details in the

world around me.” The two males wrote about gaining an “understanding of scientific reasoning” and doing “hands on things and labs.”

College. Each of the statements by the college male and females had a slightly different focus. Two of the male college students focused on seeing their learning expand outside of the classroom. As one male said, Science Olympiad gave him a venue to “explore science beyond the rigid structure of classroom instruction.” John (no state) said, “SO has helped me realize my love of experimental science. It fueled my interested in biology and chemistry and let me see these subjects in a practical environment- not just in a textbook or a seemingly irrelevant school lab.” The other male college students wrote about getting to do more hands on science, learning how things work in “real life,” and that what working in a “scientific collaborative process” is like.

Three of the female college respondents also wrote about learning differently than they did in a regular science class. Laura (no state) said, “It was no longer something that was just merely facts and formulas and words in some boring textbook. I learned what it felt like to actually apply the knowledge that I had learned.” One female college student commented on the fact that she not only learned the scientific method and experimentation, but also got to do so with other females. Kara (CA) said,

I enjoyed the opportunity to explore science and compete when I was young, and being exposed to the scientific method so early provided me with a strong base when I got to high school and then college when I had to write real lab reports. I look forward to applying what I learn about feminist pedagogy and hands on teaching techniques to really make an impact upon kids who are not successful with or do not enjoy traditional science class, and hopefully provide them with the supportive environment that nurtured my love of exploration and experimentation.

Other statements that were grouped in this category included learning to be observant, learning research skills, expanding scientific abilities, and learning to use science materials and apply information.

Adults. There were approximately equal number of females and males whose statements referred to science work. Several females in the adult category wrote about their learning being different than in the classroom. Kay (no state) said, “It allowed me to reach beyond the text books and learn more than I thought I was going to have the opportunity to.” Jennifer (no state) said, “If I had not joined Science Olympiad, I would not have made the jump between the kind of science that is taught in school, and the real world of experimentation and frustration.” Three of the female adults referred to their hands-on experience with science. Tiffany (OH) said, “Much of what I learned during my time in Science Olympiad is still with me because of the practical and hands-on method of learning that was used.” Jennifer (ND) said, “Science Olympiad taught me a lot about the fun I could have in doing science- rather than just learning facts.” Other respondents wrote about developing skills and scientific methods and concepts. One person focused on her exposure to labs. She said, “It exposed me to the labs and facilities of large universities....”

Two of the male adults wrote about scientific application. Michael (AZ) said, “It gave me success in science and math- as well as showing application of those subjects.” One adult wrote about being engaged in the scientific process as one in which “you never rest on findings, you can always improve your results, push further, make more

discoveries.” Other respondents wrote about experimentation, tinkering, inquiry, and getting a hands-on experience.

One male indicated that he had gained skills in a scientific way of thinking. He said, “It gave me an opportunity to further develop my scientific and engineering mind....” Another male adult detailed learning about “prioritizing data” and “analytical skills.”

Science Overall

Students. Seven of the female students saw a correlation between their involvement in Science Olympiad and their schoolwork. Isabella (CA) said, Science Olympiad “helped me study for my classes especially my ap science ones so i guess it was like an extra tutor.” Brittany (WA) said, “Science Olympiad has helped me become more successful in science class.” Jillisa (IL) said, “It also helped my choose my classes for school, because Science Olympiad showed me my weak and strong points of science.” Three females wrote about how they learned about many different areas of science. One girl stated, “It is a wonderful way to learn about different kinds of sciences and maths and other fields.”

Other female students that wrote about science overall, focused on the amount of science they learned. One girl summed it up as getting to “learn even more about science that I would have thought of studying.”

The male students also wrote about the impact of Science Olympiad and their regular science classes. Marcos (ME) said, “...prepare to be amazed in how much knowledge you will learn. this will be a huge boost in you science grade.”

The other seven male students all wrote about learning more science.

College. Unlike the K-12 students, only one female college student wrote about the impact of Science Olympiad and regular school science class. She said, “SO exposed me to many different areas of science- especially those that I would not have otherwise encountered in the regular school curriculum.” Thirteen other female college students wrote about learning more science and learning about a variety of sciences.

One male wrote about the connection between learning science in Science Olympiad and in a regular classroom setting. He said, “Science Olympiad gave me a venue to explore science beyond the rigid structure of classroom instruction. By being a member of the team, I was exposed to new ideas and new procedures and I carried my experiences into college.” Another college student said, “The amount of knowledge that I gained that is outside the scope of what you are generally taught is remarkable.” Ten male college students also wrote about learning more and varied areas of science. Some males wrote about realizing that they had access to science. Geoffrey (CO) said,

I had never found an area in science that I was much good at and Science Olympiad helped me to try a lot of different branches of science and it really helped me narrow down what I love to do.

Nabil (LA) said,” Actually, the most important thing SO has done for me was that it made me realize that science was universal and that it could be understood at extremely high levels by virtually anyone, even high school students.”

Adults. Seven female adult alumni compared Science Olympiad with the regular classroom. Jill (KS) said, “Science Olympiad opened the door to exploring more than

what the ordinary classroom offers.” Another adult wrote, “If I had not joined Science Olympiad, I would not have made the jump between the kind of science that is taught in school, and the real world of experimentation and frustration.”

Similar to the other demographic categories, most of the female adults whose statements were grouped into the overall science category, wrote about learning more and learning about the diversity of science. Eight females wrote about learning more. One person said, “It made me realize there were many aspects of science I could explore....” One female adult said that the learning gave her confidence, “I feel science Olympiad participation gave me confidence in my ability to learn and understand scientific concepts.” Another female adult focused on the overall science skills that she learned. Jennifer (PA) said, “I use the fundamental skills I learned by being on the science team every day.”

Some of the male alumni wrote about how science made a difference for them in their regular classrooms. Sean (IL) said, “It was a fun way to hang out with people of the same interests and to apply the fundamentals learned in the science curriculum of HS into interesting and creative forms of competition.” Paul (no state) said, “SO brought other kids like me together to further enjoy and explore science which you just can’t get in school alone.” Scott (MI) wrote that Science Olympiad got him to learn science in a way that did not require studying a textbook, “Through the SO program I was introduced to other experiences in scientific fields outside of what was in the textbook or curriculum.” Andrew (CA) credited Science Olympiad for helping him make connections to what he learned in science class, “It rounded out my science education- letting me connect what I was taught in different classes.”

Six males, wrote about learning more science in general. One male said, “SO cemented my foundation in Science.” Two of the male adults wrote about how they learned that science was important in everyday life. John (PA) said,

Science Olympiad helped feed my ongoing interest how things work, both in technology and in nature. The complexity and the harmony that exists, particularly in the natural order, continues to fascinate me. It is relevant to everyday life and is often at the center of critical issues facing us in our culture and around the world.

Science is Interesting

Students. Eight female students and 10 male students wrote about their feelings and perceptions about science. Six males said they loved science, one said he liked science, while only two females said they loved science. Four females said that they thought science was interesting, while only one male did. Other statements included enjoying science and appreciating it. One male said that he had a “much greater understanding and excitement for science.” Another said he was “now very motivated in science class.”

College. There were 33 females and 28 males who wrote about science on an affective level. Both groups talked about being interested in science more than any other feeling. Seventeen males and 15 females spoke about their interest in science. Far less people wrote about their love of science. Only five females and four males wrote that they loved science. Five females indicated that science was fun, while only one male said it was fun. Three females that said that they had a passion for science, two enjoyed it, and there was one mention of appreciating science, learning and exploring science, having excitement for science and being inspired for science. The remaining males wrote

about their passion and enjoyment for science. One male wrote about his getting to explore science and one said that he was “hooked on science!”

Adults. Thirty-six females and 33 males made statements that reflected a good feeling about science. This group had a much greater disparity of statements. Females mentioned their love of science 17 times (with one additional comment of liking science), while males only mentioned it seven times. Conversely, 15 males and seven females noted being interested in science. All other comments were reiterated far less. Three female and two male adults wrote about science being fun. Females also said that they enjoyed science, had a passion for science, were motivated by science, they were excited by science. Male adults wrote about similar areas. They mentioned passion for science, having a curiosity or appreciation for science, enjoying it, finding it exciting, and that “Science Olympiad magically made science cool in the eyes of ordinary teenagers.”

Quantitative Data

Tables 7, 8, and 9 disaggregate the quantitative data for the research question: What is the perceived impact by participants of Science Olympiad on their learning and interest of science and other STEM related concepts and skills? Tables 7, 8, and 9 disaggregate the minor themes for the research question. Table 7 includes the student data, Table 8 includes the college data, and Table 9 includes the adult data.

Table 7

Perceived Impact on Learning and Interest of Science and Other STEM Related Concepts and Skills - Students

	Total	Female	Male
Total student survey respondents	188	102	86
Total Science	52	33	19
Specific Topic	16	13	3
Science Work	4	2	2
Overall Science	25	16	9
Science is Interesting	22	12	10

Table 8

Perceived Impact on Learning and Interest of Science and Other STEM Related Concepts and Skills - College

	Total	Female	Male
Total college survey respondents	206	104	102
Total Science	88	46	42
Specific Topic	36	17	19
Science Work	12	7	5
Overall Science	28	14	14
Science is Interesting	67	37	30

Table 9

Perceived Impact on Learning and Interest of Science and Other STEM Related Concepts and Skills - Adults

	Total	Female	Male
Total adults survey respondents	241	112	129
Total Science	89	45	44
Specific Topic	23	10	13
Science Work	21	10	11
Overall Science	31	17	14
Science is Interesting	70	37	33

Table 10 combines the quantitative data for the student, college, and adult categories. Raw numbers for total respondents, female respondents, and male respondents are given. Also noted are the percentages of responses against the total survey responses of N = 635 for both the overall benefits of participating in Science Olympiad as well as the minor themes that are within the category.

Table 10

Perceived Impact on Learning and Interest of Science and Other STEM Related Concepts and Skills - Total

	Total	F	M	Percentage		
				Total	Female	Male
Total survey Respondents	635	318	317	100%	50.1%	49.9%
Total Science	229	124	105	36.1%	19.5%	16.5%
Specific topic	75	40	35	11.8%	6.3%	5.5%
Science Work	37	19	18	5.8%	3.0%	2.8%
Overall Science	84	47	37	13.2%	7.4%	5.8%
Science is Interesting	157	86	71	24.7%	13.5%	11.2%

Table 11 disaggregates the percentages of females and males within each minor theme.

Table 11

Percentage of Females and Males within the STEM Sub-Category - Total

	Total	<u>Females</u>		<u>Males</u>	
		n	%	n	%
Total Science	229	124	54.1%	105	45.9%
Specific topic	75	40	53.3%	35	46.7%
Science Work	37	19	51.4%	18	48.6%
Overall Science	84	47	56.0%	37	44.0%
Science is Interesting	157	86	54.8%	71	45.2%

Table 12 compares the number of females making statements that comprised the minor themes and compared it to the overall number of females that responded to the survey. This table compares the same data for the males.

Table 12

Percentages of Responses Disaggregated by Minor Theme and Gender for STEM- Total

	<u>Females (N=318)</u>		<u>Males (N=317)</u>	
	N	Percentage	N	Percentage
Total Science	124	39.0%	105	33.1%
Specific topic	40	16.6%	35	11.0%
Science Work	19	6.0%	18	5.7%
Overall Science	47	14.8%	37	11.7%
Science is Interesting	86	27.0%	71	22.4%

Research Question 3

What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?

The data was grouped into four themes for this research question. The themes were teamwork, problem solving, thinking, and other 21st century skills. Teamwork included ideas such as working as a team, bonding as a team, and working as a group. Problem solving included figuring things out and finding solutions. Thinking included analyzing, thinking creatively, and critically thinking. Other 21st century skills included leadership and communication.

There were 26 total students who had responses that related to 21st century skills. Fourteen of these respondents were female and 12 were male. Forty-three total college students wrote about 21st century skills; 18 were female and 25 were male. Sixty-six total adults wrote about 21st century skills. Of this total, 26 were female and 40 were male.

Teamwork

Students. Eleven total student responses were related to teamwork; seven were female and four were male. The student statements were consistent. Students wrote about “helping my teammates prepare.” Three students actually wrote the exact same thing, stating, “Science Olympiad has helped me with teamwork.” One student indicated that “It made me realize my love of science and teamwork”

College. There were 17 college students who wrote about teamwork. Six of these respondents were female and 11 were male. Two females thought that teamwork was the most important attribute to come from her participation and believed it would be useful in the future. Katrina (AL) said, “Most importantly SO has taught me teamwork skills that come from working closely with a small group of people for several years. These skills will be useful to me as I work towards a career as a research scientist.” My-Linh (MO) said,

I feel that being involved in Science Olympiad taught me many life skills including: organization-time management- and teamwork. The biggest of those being teamwork has been an active part of my life throughout and something I’ve always glad I developed.

Another respondent saw the value and said that, “It was a great experience and definitely helped not only with my technical and scientific knowledge – but also in team building and working with others.”

A few college respondents focused more on the team bonding experience of being on Science Olympiad and less on teamwork as a skill. Tad (PA) said that, “The team bonding aspect of science Olympiad is what makes it special, compared to other academic competitions....” Junxiao (OH) said, “I think the greatest thing about this system, though is the teamwork, team-building, and friendships that it encourages throughout the academic and competitive process.” Another male said, “The goal of Science Olympiad can go beyond competition. With education comes relationships and cooperation.” One male simply said, “It made me a team member.”

Two college males saw the teamwork aspect of Science Olympiad as giving them more insight. Michael (SC) said, “Science Olympiad taught me a lot about the scientific collaborative process; working with my teammates opened my eyes to the give-and-take

innovation that a group of talented people can create.” Jason (IL) said, “Science Olympiad gave me a venue to explore science beyond the rigid structure of classroom instruction. By being a member of the team, I was exposed to new ideas and new procedures and I carried my experiences into college.”

One female felt that she became a “better teammate for competing with [her] team.”

Adults. Ten female and 12 male adults referred to teamwork. Several females referred to learning teamwork skills. “I learned invaluable teamwork skills...”, “...I developed skills in working with others and working without the direct help of an adult.”

Several respondents thought that having learned teamwork skills as valuable. Rusty (SD) said, “Science oly taught be the value of teamwork.”

Some of the males linked teamwork with winning. Some of the responses that were grouped into this category were: “It opened a world of discover that led to personal enthusiasm – fun learning – team victory – and fond memories,” “I have learned how teamwork can lead to success,” “Science Olympiad provides a great opportunity for students to enhance their science knowledge in a team atmosphere,” and “Science Olympiad has helped me to learn how to work with team members- each with different skills and talents- to accomplish a mutual goal.”

One female wrote about the importance of being able to bond with other girls in science. Vanessa (MI) said, “Science Olympiad allowed me to cultivate my interest in science and math – learn how to work in teams and to plan projects. As a young girl- being on the Science Olympiad with other girls created an important support group....”

Two of female respondents articulated how Science Olympiad and the team bonding made them feel like they fit in. Kari (OH) said, “It wasn't just the science, but the teamwork, the camaraderie. We enjoyed helping one another, and since very few of us were athletic, it gave us an avenue to satisfy our competitive spirit.” Emily (NY) said,

It changed my life because it was the only time in high school--and really in life--that I was able to make any significant contribution to a team I really felt a part of. Even better than our considerable success as a team was the feeling of belonging to something as an extreme nerd. Our coach made us t-shirts celebrating our nerdiness and generally stressed our sense of community above competitiveness.

Problem Solving

Students. Across the all of the respondent categories, fewer people wrote about problem solving than teamwork. Only one student, a female, wrote about problem solving. She said, “...SO has helped me with teamwork- planning and problem solving.”

College. Three college students wrote about problem solving. The responses from the one female and two males were similar. The female said, “Science Olympiad has helped me develop problem solving skills. It has helped me to grow as an observant person and always attempt to find out why something went wrong.” The responses from the males were, “Science Olympiad taught me a myriad of problem-solving skills...” and “It has given me an ability to problem solve, and to know how to troubleshoot. This has been a valuable skill to have in college. Not many of my peers have the critical thinking and problem solving ability.”

Adults. Only 13 total adults, divided between males and females, wrote about problem solving. The females wrote; “It helped me to appreciate physics as well as team problem solving,” “...it is a great way to experience different ways of thinking and problem solving...,” “I learned to seek out information from a variety of sources and use that information to solve problems on my own, in my own way,” and “...I would highly recommend Science Olympiad to any middle/high schooler who enjoys problem solving.”

Several of the males linked problem solving with careers. Michael (MI) said, “I’ve retained that love of learning, experimenting and tinkering and directed it into my career as a R&D engineer. I enjoyed breaking things enough in the SO that today I work with explosives, breaking more things.” Jacob (FL) said, “The Science Olympiad taught me valuable problem solving techniques which I currently use in my career.” Michael (ND) said, “...the lesson of Science Olympiad is that of complex problem solving.... The experience in general assisted in providing me with an understanding of problem solving that has been applied both in my workplace and throughout my education.”

The other male wrote about the experience with figuring things out and the confidence it gave him. “Science Olympiad also helped me with basic tasks like fixing things for example. It made me not afraid to pick up a tool and do things myself.”

Critical Thinking

Student. Critical thinking, like problem solving, was not referred to very often. Only two students, one of each gender wrote about thinking. Their responses were, “It

has made me think more critically.” and “It has taught me to analyze things in a different fashion....”

College. There were only five college students who made statements that revolved around critical thinking. This grouping was heavily male dominated with a 4 to 1 ratio of males to females. The only female that said anything about thinking said, “It helped me maintain my interest in science and develop a logical way of thinking.” The responses from the males were similar. They said, “They learn teamwork, discipline, and most importantly, how to truly think....A quality that is of short supply among humans,” “Science Olympiad forced me to think outside of the box,” and “It has increased my lateral thinking skills a whole lot- and helped me focus on a task and keep working on it until the job is done.”

Adults. Twelve adults wrote about critical thinking. Like the college students, this was group was heavily male dominated with a ratio of nine male respondents to three female respondents. The way that each of these people looked at thinking was different. One of the females focused directly on critical thinking, Jennifer (ND) said, “I don't think I would have ever developed the passion I have for science and critical thinking I have now had I not been involved. Truthfully- I'm not sure I would have developed as many critical thinking skills.” Another female linked her response with problem solving. She said, “it is a great way to experience different ways of thinking and problem solving.” The final female in the working category focused on thinking in relation to the

competition. Jocelyn (NY) said, “Learning to work as a team and how to think under pressure most impacted my success in college and in my career.”

Several males referred specifically to critical thinking. Chris (ND) said, “Science Olympiad greatly increased my love of science and critical thinking.” Two males spoke about thinking outside of the box. Michael (no state) said, “My ability to think outside the box started with Science Olympiad!” Two males spoke about the analytical thinking skills they developed from being part of Science Olympiad. John (CO) said, “Preparing for regional, state, and national competitions developed analytical and researching skills....” Michael (MI) said, “Many of the skills I learned training and competing in Science Olympiad (prioritizing data, analytical skills, etc.) helped me tremendously in college and in a career....”

Some of the other responses were, “Science Olympiad allowed my mind to expand in a way that I never imagined. I was able to think and find out about things that I would had not otherwise learned and discovered,” and “it just made me be a better thinker in tough situations.”

Other 21st century skills

Students. Several people mentioned 21st century related skills, abilities, and learning that did not fall into the themes of teamwork, problem solving, or thinking. All three groups, students, college students, and adults, wrote about similar 21st century skills.

Five of the male students mentioned leadership or management. Of those males that did not write about leadership, one wrote about organization and the other wrote

Several of the college students also noted how much they learned about themselves. Alicia (TX) said, “I have learned many team skills and many life lessons in Science Olympiad but most importantly I have learned about myself and all the potential I have to succeed.” Bryan (no state) said, “The intellectual and personal growth the competition instilled in me was invaluable to my success not only as a scientist- but as a human being.” Geoff (PA) said, “Through science olympiad i have realized my full potential and recognized what i am truly as a person and my mental capacity to achieve my goals.” Patrick (IN) said,

As a student- science olympiad was a hugely positive force. I barely maintained a C average in the 8th grade. As science olympiad reinforced myself image year after year I engaged myself more seriously in coursework and had nearly perfect grades....

One college student summed it up by stating,

Something that I don't think is highlighted enough about SO is that for the events you must be self-motivated, learn much of the material yourself, frame questions, and learn how to meet deadlines! All of these became important skills to me when I majored in Aerospace Engineering in college. This is but a short description of its impact....

Adults. Adult responses encompassed similar themes. One female adult wrote about being “positively competitive.” Other areas included leadership, confidence, focus, organization, time management, motivation, hard work, and developing a work ethic.

The eight males wrote about similar skills including leadership, communication, “preparing for the long haul,” dedication, “drive to succeed,” focus, perseverance, and organization.

The adults wrote about some of the same life skills that the other two subgroups wrote about. There was one female and six males that wrote about other life skills that

they felt they acquired. Brian (OH) said, “I hope that my participants enjoy competing as much as I did and that they learn both science and life skills through their involvement.”

Chris (no state) said, “I am greatly thankful to Science Olympiad for teaching me to dedicate myself to something- stick with it- achieve success in it- and enjoy doing so.”

Michael (OH) said, “Science Olympiad gave me the confidence and knowledge to pursue an education beyond high school. In addition- it helped give gave me the social skills needed to succeed in life.”

Two of the statements stood out and wrapped up all the skills in a few sentences.

It taught me everything I needed to succeed that the classroom couldn't: leadership, responsibility, budgets, schedules, communication, and most of all teamwork. It was a great creative and constructive outlet for those of us who enjoyed science based competition.

And,

Science Olympiad taught me many essential habits for success later in life including perseverance- hard work- working with others- and dealing with failure.

Quantitative Data

Tables 13, 14, and 15 disaggregate the quantitative data for the research question: What are the participants’ perceptions of Science Olympiad’s impact on their learning and use of 21st century skills? Tables 13, 14, and 15 disaggregate the minor themes within the research question. Table 13 includes the student data, Table 14 includes the college data, and Table 15 includes the adult data.

Table 13

21st Century Skills Acquired - Students

	Total	Female	Male
Total students survey respondents	188	102	86
Total 21 st Century Skills	26	14	12
Teamwork	11	7	4
Problem Solving	1	1	0
Thinking	2	1	1
Other	18	9	9

Table 14

21st Century Skills Acquired - College

	Total	Female	Male
Total college survey respondents	206	104	102
Total 21 st Century Skills	49	22	27
Teamwork	17	6	11
Problem Solving	3	1	2
Thinking	5	1	4
Other	36	19	17

Table 15

21st Century Skills Acquired - Adults

	Total	Female	Male
Total adult survey respondents	241	112	129
Total 21 st Century Skills	57	21	36
Teamwork	22	10	12
Problem Solving	9	4	5
Thinking	14	5	9
Other	31	9	22

Table 16 combines the quantitative data for the student, college, and adult categories. Raw numbers for total respondents, female respondents, and male respondents are given. Also noted are the percentages of responses against the total survey responses of N = 635 for both the overall benefits of participating in Science Olympiad as well as the minor themes that are within the category.

Table 16

21st Century Skills - Total

	Total	F	M	Percentage		
				Total	Female	Male
Total Survey Respondents	635	318	317	100%	50.1%	49.9%
Total 21 st Century Skills	132	57	75	20.8%	9.0%	11.8%
Teamwork	50	23	27	7.9%	3.6%	4.3%
Problem Solving	13	6	7	2.0%	.94%	1.1%
Thinking	21	7	14	3.3%	1.1%	2.2%
Other	85	37	48	13.4%	5.8%	7.6%

Table 17 disaggregates the percentages of females and males within each minor theme for research question 3.

Table 17

Percentage of Females and Males within the Sub-Category 21st Century Skills - Total

	Total	Females		Males	
		n	%	n	%
Total 21 st Century Skills	132	57	43.2%	75	56.8%
Teamwork	50	23	46.0%	27	54.0%
Problem Solving	13	6	46.1%	7	53.8%
Thinking	21	7	33.3%	14	66.6%
Other	85	37	43.5%	48	56.5%

Table 18 compares the number of females making statements that comprised the minor themes and compared it to the overall number of females that responded to the survey. This table compares the same data for the males.

Table 18

Percentages of Responses Disaggregated by Minor Theme and Gender for 21st Century Skills - Total

	<u>Females (N=318)</u>		<u>Males (N=317)</u>	
	n	Percentage	n	Percentage
Total 21 st Century Skills	57	17.9%	75	23.7%
Teamwork	23	7.2%	27	8.5%
Problem Solving	6	1.9%	7	2.2%
Thinking	7	2.2%	14	4.4%
Other	37	11.6%	48	15.1%

Research Question 4

What are the participants' perceptions of Science Olympiad's impact on their career choice?

The questions related to careers on the Science Olympiad survey were, "Did your participation in Science Olympiad help lead you to a career?" and "Please describe what impact Science Olympiad has had on your life/career." The first question was presented as a yes/no question. The data could not just be looked at as to whether or not the respondent checked yes or no. Some of the survey respondents checked no even though their answer to the second question, "Please describe what impact Science Olympiad has had on your life/career" clearly indicated that Science Olympiad impacted their career, or choice of college major or career in some way. Based on this, it can be assumed that the question was unclear.

The data for these research questions were analyzed quantitatively. It included counting the number of yes and no responses to the question, disaggregating the data by gender and age, and then analyzing the data qualitatively. It was necessary to disaggregate the career data in to the three subcategories of students currently participating in Science Olympiad, college students with had picked majors of study but were not in a career yet, and adults who had entered the workforce.

Students. Even though K-12 students have not yet embarked on a career, 80 of the student respondents answered yes to the question, "Did your participation in Science Olympiad help lead you to a career?" Eighty-nine students answered no and 19 students

did not give an answer. Of the 19 no response answers to this question, there was no accompanying statement in response to the second question that led the researcher to determine **that** a yes or no answer should have been given.

Of the 89 students who responded no to the question, six girls, and one boy responded to that they were thinking about a career in the sciences. Jonah (no state) said, “It increased my interest in science- particularly physics; I am considering majoring in physics or chemistry in college.” The females indicated an interest in majoring in or “going into” biology, quantum physics, marine biology, human anatomy, space studies, and aerospace engineering. One girl indicated that Science Olympiad opened up possibilities for her. She said, “Many of the events have allowed me to explore career options I may not have considered otherwise.”

Of the 89 students who responded yes to the question asking whether or not Science Olympiad led to a career, 21 females and 10 males said something that related to majoring in or working in a science or engineering field. Females indicated a desire to embark in a career in zoology, animal photography, medicine, physical therapy, forensic pathology, cell/molecular biology, meteorology, and science. Kate (MO) said, “Science Olympiad has led me to the conclusion that I want to be a meteorologist eventually. Since I'm only in eighth grade- my interests may change- but I LOVE METEOROLOGY!”

Asia (GA) said, “Science Olympiad helped me decide that I wanted a career in the medical field. I loved disease detectives.” Disease Detectives is one of the Science Olympiad events. Nicole from California indicated that she never thought of forensics as a career until Science Olympiad.

Before science olympiad, i had never even considered things like forensics a science. i tried the event because a friend asked my to. since then, it has been my goal to get a degree and work in criminal justice as a forensic scientist.

Jessica (no state) was also very excited about forensics. "... I am going to gain SO much knowledge for my future occupation!!! I am planning to be a forensic pathologist! Exciting-huh? So i am going to participate in science crime busters!!!!"

The male students indicated interest in becoming geneticists, chemists, astronomers, mechanical engineers, civil engineers, science/math teachers, and just scientists in general. Garrett (GA) credits the bridge building event for getting him interested in engineering. "Though Science Olympiad- and more directly the Bridge Building event- I have found that I want to be a civil engineer." Jeremy (no state) said, "It helped me by deciding that i want to go into the science field. I would like to be a chemist because in science olympiad we do a lot of hands on things and labs." Several other students said they were more aware of science careers, or would now consider science as a career.

College.

The college students were not yet in careers, but did for the most part pick a major. One hundred-sixty of the college students said that Science Olympiad led them to a career. Forty-one college students answered no and five gave no answer. Of the 41 no responses, seven females and five males reported going into a STEM field or learning things in Science Olympiad that helped in their selection of a major in college. Some of the college students indicated that they answered no because they did not have a career

yet, it can be surmised that some college students answered the same way for the same reason.

Some of the fields that the female college students were majoring in were chemistry, biology, teaching, environmental studies, math, and astronomy.

Ariel (IN) said that Science Olympiad was the reason that she chose her major.

She said,

My participation in Science Olympiad furthered my interest in the field of science. I have declared a major of biology because of my participation in this. It made me want to know more of what the world of science had to offer me.

The males indicated that they were majoring in areas such as, electrical engineering, analytical chemistry, software engineering, physics, and math education.

The college students who did say that Science Olympiad lead them to a career had many different reasons for their yes response. Some, like Jessica (MI), credited the events that they participated in for helping them decide on a career. "Science Olympiad is what inspired me to become an engineer. My favorite event was always Polymer Detectives- so it just made sense to major in Materials Science and Engineering." Katie (IN) felt the same way,

Science Olympiad brought me into the world of biology. Before SO I almost hated biology then I became involved in the event Life Science Process Lab, which opened my eyes to genetics. After that I participated in Designer Genes and Cell Biology and loved both of them. I hope to some day do genetic research on autism and other complex, hereditary diseases.

A female that asked to remain anonymous gave a very detailed and specific statement as to how Science Olympiad influenced her career.

SO sparked my interest in science. I had originally intended to be a music major and Science O. was something random I picked up in my junior year. I had never been particularly interested in science and had never realized I had a special talent

for science and mathematics. The ease with which excelling at SO came to me was quite a surprise.

My performance in SO most likely gained me acceptance to MIT. (I probably would not have even applied if my performance during my first year in SO hadn't given me confidence in my intellectual abilities!) It also made me interested in other science competitions, in which I had a great time :)

It moved my interests towards Oceanography/Earth Science/Chemistry. I am now a chemistry major with a minor in Earth Science.

I guess that overall SO gave me the desire and courage to follow my abilities in science. I never really thought of myself as particularly smart or geeky, and four years ago I would never have pictured myself where I am now-- at the world's foremost scientific university, with several science scholarships under my belt and an upcoming internship at a prestigious oceanography institution! Picking up that first oceanography textbook to study for SO was definitely a major turning point in my life.

Joanne (no state) credits Science Olympiad for getting her interested in science and for building her desire to get other people interested too, "I decided to get my degree in biology because Science Olympiad made me love the subject and see its purposes in the real world. Now I want to be a science educator and help other people love science-too!"

Junxiao (OH) credited the competitiveness of his Science Olympiad team with forcing him to learn many different areas of science, this in turn led to his choice of college majors.

I have yet to have a career of sorts since I just started college, but I am currently attending The Johns Hopkins University studying Biomedical Engineering. I had always had a strong interest in science, but it was my experiences in Science Olympiad that solidified my wish to pursue science in a career and for the rest of my life. Because my team was very competitive, and being selected for the states and nationals team was a competitive process as well, it really forced me and other members to diversify ourselves in all sorts of events. Thus, I did many events in different areas of science, including the ones listed above, and as a result, I was able to sample many different areas of science and determine what I was really interested in. I found a love for chemistry, mechanics, and biology,

and so I was curious about majors like Biomedical Engineering. So far, at Johns Hopkins, I really like the "BME" major, and I think this is what I will stick with while I look into going to medical school.

Andrew (IA) echoed the same sentiment.

Participating in SO helped me to sample a variety of different sciences. I credit Reach for the Stars with allowing me to see aspects of astronomy beyond just stargazing. Thanks in part to that experience- I am now in my third year of an astronomy major.

Adults. There were 182 adult alumni who credited Science Olympiad with their choice of career. Fifty-five adults answered no and four did not respond to the question, "Did your participation in Science Olympiad help lead you to a career?" Of those adults who answered no to whether or not Science Olympiad lead them to a career, nine females and 16 males in their subsequent descriptions credited Science Olympiad with their choice of career fields. All of these adults were employed in a STEM related field. The females indicated that they were engaged in the following careers: Researcher in the department of anesthesiology, electronics, research engineer, webmaster, science teacher, and systems engineer.

Many of the males who had answered no also majored or were involved in the following STEM careers: Electrician, technology consultant, chemical and biomolecular engineering (processing manager), programmer, network engineer, math teacher, research chemist, PC support specialist, science teacher, software developer, physician, computer scientist, veterinarian, and research scientist. One male said that he had already planned on his career before being involved in Science Olympiad, but that being involved in Science Olympiad made sense. He said, "participation in the Science Olympiad was a natural extension of our interests."

John (MI) did not go into a STEM field but credited Science Olympiad with the path he did follow. “Science Olympiad, particularly through the Road Scholar event, was instrumental to helping me develop my interest in geography. This, in turn, led me to pursue a career in International Relations, majoring in it at American University in Washington, DC.”

The adult workforce made similar statements to that of the college students as to what lead to their career choices. Jennifer (PA) said,

Science Olympiad helped me figure out that I liked science and technology enough to spend a lot of my free time on it. I learned how to work independently. I learned to seek out information from a variety of sources and use that information to solve problems on my own, in my own way. As a result, it gave me confidence that I could go to big university and take on a tough major like aerospace engineering. I ended up doing pretty well and now I am helping to design a new business jet. I use the fundamental skills I learned by being on the science team every day.

Kristina (MI) succinctly explained her personal Science Olympiad to career timeline.

“The geology competition (rocks/minerals) led to me taking a college class- which led to a Earth science major with a secondary ed. certificate. (thanks!!)”

Michael (MI) also credited Science Olympiad with his choice of careers.

The SO provided me an environment where inquiry and the eagerness to learn was encouraged. For the first time I saw adults and even other students supporting "being smart" -- quite a difference from my regular school day in middle school. I've retained that love of learning, experimenting and tinkering and directed it into my career as a R&D engineer. I enjoyed breaking things enough in the SO that today I work with explosives, breaking more things.

Brent (NC) credits the excitement that he felt for Science Olympiad for his choosing science as a career. “The impact of the Science Olympiad on my resulting career path is

nearly beyond words. The excitement of competing and excelling in an educational activity led me to choose science for my livelihood.”

Quantitative Data

Table 19 disaggregates the student responses to the question: Did your participation in Science Olympiad help lead you to a career? The raw numbers for yes, no, and no answer are presented as well as the percentage of the total number of students who answered in each category and the percentage breakdown by gender within each category.

Table 19

Science Olympiad Leading to a Career - Students

	Total	F	M	Percentage		
				of all students	within category who are female	within category who are male
Yes	80	41	39	42.6%	54.3%	45.7%
No	89	49	40	47.3%	51.3%	48.8%
No Answer	19	12	7	10.1%	55.1%	44.9%
Total	188	102	86	100%	54.3%	45.7%

Table 20 disaggregates the college student responses to the question “Did your participation in Science Olympiad help lead you to a career?” The raw numbers for yes, no, and no answer are presented as well as the percentage of the total number of students who answered in each category and the percentage breakdown by gender within each category.

Table 20

Science Olympiad Leading to a Career - College

	Total	F	M	Percentage		
				of all college students	within category who are female	within category who are male
Yes	160	81	79	77.7%	50.5%	49.4%
No	41	22	19	19.9%	53.7%	46.3%
No Answer	5	1	4	2.4%	20.0%	80.0%
Total	206	104	102	100%	50.5%	49.5%

Appendix A presents the number of college students who were majoring in science, math, engineering, technology, a combination of science, math, engineering, or technology, and science, math, or technology teaching. Also noted in Appendix A is the number of students who are engaged in a major that indicated that Science Olympiad led them to a career. As a result of college students checking no to the question, “Did Science Olympiad lead you to a career?”, but then writing a statement that Science

Olympiad involvement did indeed lead them to a career, both yes and no responses are included. The number of yes answers does not add to the 160 as it does in table 20 because some college students checked yes but did not go in to a STEM major.

Table 21 disaggregates the adult responses to the question “Did your participation in Science Olympiad help lead you to a career?” The raw numbers for yes, no and no answer are presented as well as the percentage of the total number of adults who answered in each category and the percentage breakdown by gender within each category.

Table 21

Science Olympiad Leading to a Career - Adults

	Total	F	M	Percentage against the total number of adults in the workforce (n=241)		
				Adults	Female	Male
Yes	182	83	99	75.5%	34.4%	41.1%
No	55	27	28	22.8%	11.2%	11.6%
No Answer	4	2	2	1.7%	.83%	.83%
Total	241	112	129	100%	46.5%	53.5%

Appendix B provides a table that disaggregates the number of adults who are engaged in a career involving science, math, engineering, technology, a combination of science, math, engineering, or technology, and science, math, or technology teaching. This appendix also notes the number of students who are engaged in a major that indicated that Science Olympiad lead them to a career. As a result of adults checking no to the question, “Did Science Olympiad lead you to a career?”, but then writing a statement that Science Olympiad involvement did indeed lead them to a career, both yes and no responses are included. The number of yes answers does not add to the 182 as it does in table 20 because some college students checked yes but did not go in to a STEM major.

Table 22 disaggregates the combination of college and adult alumni workforce responses to the question “Did your participation in Science Olympiad help lead you to a career?” The raw numbers for yes, no and no answer are presented as well as the percentage of the total number of adults who answered in each category and the percentage breakdown by gender within each category.

Table 22

Science Olympiad Leading to a Career – Combined College and Adults

	Total	F	M	Percentage		
				of total college/adults	of Females of all college/adult Females	of Males of all college/adult Males
Yes	342	164	178	76.5%	75.9%	77.1%
No	96	49	47	21.5%	22.7%	20.3%
No Answer	9	3	6	2.0%	1.4%	2.6%
Total	447	216	231			

Table 23

Table 23 compares the percentages of the females to the total number of college and adult females for the question asking if Science Olympiad led to a career. The raw numbers were compared to the total number of adult and college respondents to determine a percentage. Data was disaggregated by gender. Included are only those who said yes to the question asking if Science Olympiad led to a career. Table 23 also compares this information for the males.

Table 23

Percentage of Total College Students and Adults Engaged in a STEM Field

	Total (n=447)	Females	Males
Science	27.1%	14.1%	13.0%
Math	.45%	.22%	.22%
Engineering	18.1%	5.6%	12.5%
Technology	1.6%	.22%	1.3%
Combination	1.8%	.89%	.89%
Teaching	12.3%	7.4%	4.9%
Total	61.3%	28.4%	32.8%

Table 24 combines the responses of the college students and the adults. It disaggregates the STEM majors and careers by raw number. It breaks down the data to yes and total for leading to a career.

Table 24

Science Olympiad Leading to a Career Disaggregated by Minor theme and Gender - Combined College and Adults

	Total	Yes	Disaggregation of the total responses of yes in each subgroup	
			Females	Males
Science	132	121	52.1% (n=63)	47.9% (n=58)
Math	5	2	50.0% (n=1)	50.0% (n=1)
Engineering	86	81	30.9% (n=25)	69.1% (n=56)
Technology	16	7	14.3% (n=1)	85.7% (n=6)
Combination	9	8	50.0% (n=4)	50.0% (n=4)
Teaching	61	55	60.0% (n=33)	40.0% (n=22)
Total	309	274	46.4% (n=127)	53.6% (N=147)

Research Question 5

Is gender a factor of the participants' overall perceptions regarding Science

Olympiad? This question was imbedded in the analysis of the first four research questions and therefore is not separately analyzed.

Summarized Quantitative Data

Table 25 denotes the percentages for responses for each research question. The total percentages equal more than 100% due to the fact that survey respondents statements may have been assigned to more than one category.

Table 25

Overall Data

	Total (N =635)	Females (N = 635)	Males (N = 635)	Females (n = 318)	Males (n=317)
Overall Benefits	44.7%	24.1%	20.6%	48.1%	41.3%
STEM Learning	36.1%	19.5%	16.5%	39.0%	33.1%
21 st Century Skills	20.8%	9.0%	11.8%	17.9%	23.7%
Career Choice	76.5%	36.7%	39.8%	75.9%	77.1%
*For career choice:	(n = 447)			(n= 216)	(n=231)

Summary

In this chapter, the data was disaggregated into categories and sub-categories. The data was grouped by students, college students, and adults in order to more clearly analyze the data. Some responses were grouped into more than one category depending on how well it fit the category or sub-category. To analyze the data and address the research questions, the statements of each respondent were analyzed as a whole, rather than how it answered the specific Science Olympiad survey questions. This procedure was followed because the questions were open-ended and respondents did not limit their answers to the questions being asked.

The research questions sought to determine the participant's perceptions in terms of science learning and interest, 21st century skills and abilities, perceived influence on careers, and the overall benefits of being involved in Science Olympiad. Gender was disaggregated for each question to determine if it was a factor in perceptions. Data was acquired through the Science Olympiad survey database. It consisted of 635 usable surveys, split evenly between males and females. This study employed a mixed methods analysis. The qualitative data allowed the individual perceptions of the respondents to be highlighted and acknowledged, while the quantitative data allowed generalizations to be identified.

In Chapter V, the compiled data is reviewed and conclusions are drawn. The qualitative and quantitative data is analyzed both as separate components and as combined components to determine conclusions based on the research questions. These conclusions are the basis for suggestions for further research and for school and educational recommendations.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to analyze the perceptions of Science Olympiad participants, in terms of science learning and interest, 21st century skills and abilities, perceived influence on careers, and the overall benefits of being involved in Science Olympiad. The study also sought to determine if there were any differences of perception when gender was viewed as a factor. Various aspects of the Science Olympiad participants' perceptions were analyzed. As the sample size was very large, it was necessary to group data into themes and subthemes, or subcategories, within major categories. I looked for major and minor themes to determine the overarching perceptions within the 635 usable responses. The data was also analyzed as to the impact of Science Olympiad on future career choices.

In order to address the research questions, a mixed analysis research method was used. The survey responses were analyzed qualitatively to highlight major and minor themes and allow individual perceptions to be brought to light. Since the database of responses was so large, the data was also analyzed quantitatively to determine the frequency of various perceptions. The data was also disaggregated by gender and age grouping. This disaggregation was imbedded in the analysis of each research question.

Chapter I provided an overview and introduction to the topic of Science Olympiad. Chapter I is where the purpose of the study, the statement of the problem, the research questions, the definition of terms, and the limitations and delimitations of the study were first introduced. Chapters II highlighted the relevant research in the areas of science and STEM education, the importance of 21st century skills, the pertinent

information on extracurricular activities, and the discussion surrounding gender and STEM fields. Chapter III explained and reviewed the methodology that was used to analyze the data. Chapter IV presented the data and delineated it according to the five major research questions. The research question related to gender was imbedded within the other research questions. The data was also grouped by age category. Qualitative and quantitative data was presented in this chapter. Chapter V presents summary and conclusive statements that were derived from the analysis of the data. Suggestions for further research are also presented.

The following questions drove the research:

1. What are the participants' perceptions of the overall benefits of being on a Science Olympiad team?
2. What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?
3. What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?
4. What are the participants' perceptions of Science Olympiad's impact on their career choice?
5. Is gender a factor of the participants' overall perceptions regarding Science Olympiad?

Research Question 1

What are the participants' perceptions of the overall benefits of being on a Science Olympiad team?

There were numerous benefits stated by Science Olympiad participants. Among some of the top themes were that of having fun, enjoying the experience, just plain loving Science Olympiad, making friends, enjoying the social aspects of being on a team, liking the competitive aspect of the challenges and the prestige it brought to the individual, team, and school, and the feeling that participation in Science Olympiad was a major part of the middle school or high school experience. In total, 44.7%, which was a little less than half of the people who answered the survey, wrote about the overall benefits of their participation in Science Olympiad. This percentage was split almost evenly between females and males, with percentages of 53.9% and 46.1% respectively. The span of percentages from the most mentioned subcategory to the least mentioned subcategory within the overall benefits was just 12.6% for females and 6.9% for males.

Of the subcategories within overall benefits, the social aspects of being involved were rated the highest. Data disaggregation by gender showed that females had a slightly higher interest in the social aspects of participation than the males did. Even though the social aspects of participation were referred to more by females than males, it was the most mentioned in the male subcategories regarding overall benefits. This differential was especially noticeable in the responses of the students. Twenty-one female students compared to only eight male students wrote about their social experience. Research supports the fact that extracurricular activities are an important part of finding and

developing friends (Fredricks & Eccles, 2005). The idea of socialization should not be dismissed as unimportant in the realm of academic competitions. Peers are known to have a positive influence on other students' involvement in science (Hounsell, 2000). McGonigal and Payne in their 2007 report on Science Olympiad stated that the chance to work with friends and peers held a great interest to the students. Several of the students in this study wrote about how being part of Science Olympiad made them finally feel like they fit in.

The fun aspect of participation was the second highest mentioned overall benefit of participating in Science Olympiad. Of the 635 survey respondents, 11.2% considered their participation in Science Olympiad to be fun. This is not surprising, as few students volunteer to participate in an activity that they do not consider fun. The percentage would have even been higher had the researcher grouped "enjoyment" in this category. The researcher chose to include only responses that actually used the word fun in this category. McGee-Brown (n.d.), in a study of Science Olympiad, found that students thought their experiences were challenging and fun. This idea of Science Olympiad being fun was also echoed in the research of Abernathy and Vineyard (2001) and Hounsell (2000). Fun and science are important partners. Students' understanding of science is increased when they feel that what they are doing is fun (Moreno & Tharp, 2006). Play and fun in learning produces new neurological pathways to form (Liston, 1994 as cited in Price, 2001). The benefits of fun and learning are clear.

The notion of loving Science Olympiad as a general idea was also more prevalent among females than males. Ideas that fell into this affective category were enjoyment, loving it, liking it, thinking that it was an awesome or great experience. Again, this

subcategory was most noticeable among the student group. The college group and the adult group had almost no differential between males and females loving Science Olympiad. I believe that this skewing toward female students may have something to do with the way students seem to express their interest in areas; they easily say that they love something, but are more hard-pressed to give specifics. The adult alumni barely wrote about loving Science Olympiad at all. In my opinion, this may be because they are more clearly able to articulate specific areas of interest rather than just a blanket love for the organization.

Competition was an important part of the overall benefits of Science Olympiad for both males and females. Competition was tied with the importance of the social aspects of Science Olympiad for those males that wrote about the overall benefits and was third for females, just a little less than the references to fun. The percentage of competition references was skewed toward males as a result of the responses by male adults where competition was mentioned more than two times as much as it was mentioned by adult females. The other two age groupings did not show this differential. The college students referred to competition equally. After analyzing the data I believe that this skewing of the subcategory, competition, may have something to do with the subdivision of age in looking at the data. Some of the adults competed between five and fifteen years prior to taking the survey. Females are increasingly involved in competitive activities, and their focus may be on the competitive aspects much more than females in the past. According to the research, competitions can be beneficial in allowing students to assess their own skills (Ozturnk & Debelak, 2008). Competitive athletics are seen as beneficial and as a way to hone talents (Subotnik, Miserandino, & Olszewski-Kubilius,

N.D.). Several of the students compared the science competition to athletics and related how competing with the team brought them individual and team acknowledgement as well as school recognition and pride. Most research on competitions does not focus on the participants' motivation to compete (Udvari & Schneider, 2000). Those that did mention competition liked the competitive aspects of being on the team and going to the tournaments.

The perception that Science Olympiad had a major impact on their life was noted by 46 (7.2%) of the respondents. Overall, this was the lowest percentage in the subcategories of overall benefits, but it was not the lowest for the college students or the adults. It is understandable that fewer students would mention this theme as they were less immersed in the organization and are not looking back on it after other life experiences as are the college students and adults. This affective aspect of Science Olympiad was very important to those that wrote about it. The perception that Science Olympiad was the best thing the respondents ever did with their life or that it changed their life in a positive and meaningful way is an important part of how Science Olympiad should be viewed by outsiders. Any organization that can garner such positive passionate feelings is worthwhile.

Research Question 2

What are the participants' perceptions of Science Olympiad's impact on their learning and interest of science and other STEM related concepts and skills?

It was difficult from the way that this survey was written by the Science Olympiad organization to definitively determine if the participants gained any greater knowledge or understanding of science. The sub-categorization of themes allowed the researcher to highlight areas within the science and STEM fields that the participants focused on in their responses.

Thirty-six percent of the 635 who completed the survey focused on the science and STEM areas. Of all of the females to respond to the survey, 39% focused on some aspect of science and STEM. The males were closely aligned with this percentage, with 33.1% of them focusing on science and STEM learning and interest. College students and adults referred to the fact that science is interesting more than any other facet of science and the STEM areas. Students focused more heavily on specific areas of science rather than whether or not they found it interesting.

Of the 16 students who wrote about a specific topic, physics and engineering were the least prevalent topic. One female student and three male students wrote about physics. Although college females heavily focused on biology, there was discussion of chemistry and engineering. College males first introduced the topics of math and computer science. They also concentrated heavily on engineering areas. There is a perception that the physical science and engineering fields are for males (Adams, 1996) and less females are engaged in these areas than the biological sciences (Blickenstaff,

2005). As opposed to what research says about females in engineering and the physical sciences, the female adult alumni group references were geared toward chemistry, physics, and engineering. The male adults also focused on chemistry, physics, and engineering. It is possible that the students were not as focused on the type of science that comprised an event. For example building a robot might be considered fun, but not necessarily an engineering task. This area would benefit from further study.

A minor theme within the acquiring of STEM knowledge was that of actually doing the work of science, participating in labs, or doing hands-on activities. The National Research Council's (1996), National Science Education Standards supports this idea of "doing" science and having hands-on, minds-on experiences. Several of the respondents spoke about the chance to get out of the textbook and classroom and really experience science and engineering. These respondents liked the practicality of what they were learning. The statements highlighted how involvement in Science Olympiad let these participants experience science in a way that let them experience what "doing" science was really like. They felt that they gained an understanding of the real world of science and the application of science that they did not get from reading a textbook. It would be interesting to ask these students to draw a picture of a scientist. It is doubtful that all of their pictures would be of white men in a lab coat (Finson, 2002). This subcategory highlights that students enjoyed being immersed in science and engineering and showed what the regular classroom was not doing for them. The perception from these respondents was that the regular classroom was not giving them what they needed. This was consistent with the research that said that science curricula in the United States tends to be superficial, fragmented and covers a range of topics with little emphasis on

conceptual understanding (Vitale & Romance, 2006). Dewey made the same observation about the curriculum in the early 1900's (Drayton & Falk, 2002). The fact that these participants were less interested in learning from a textbook in a classroom than actually engaging in science is supported by research. This type of rote learning and memorization actually inhibits brain development (Campbell, 2008). Students need to be focused less on textbook learning and more on inquiry learning (Moreno & Tharp, 2006) Jorgenson and Vanosdall (2002) note that students engaged in inquiry do better than those who learned in a text-focused way.

The minor theme of science as an overall area, referred not to a specific subject or area, but to science and engineering as overall fields of study. The student group focused on how much more they learned about science and how they were able to use that knowledge in their regular classes. The Programme for International Student Assessment (PISA, 2006) found that 67% of students liked learning science. The college students and adult alumni focused on their perceptions of learning more science and getting the chance to experience a diversity of STEM fields. A strong background in core content knowledge is important because it allows for the ability to eventually analyze and innovate (Jerald, 2009). Piaget (as cited in Campbell, 2008) supports the fact that children want to learn. It is clear from the statements of the participants that they were eager and excited to learn something new.

The last minor theme for this research question was the affective feelings that participants developed toward science and the STEM fields. Statements that were specifically about science and other STEM fields and not about Science Olympiad were included in this sub-theme. Research supports the idea that science and math

competitions increase student interest in these subject areas (Christie, 2008). All of the groups, students, college students, and adults, wrote about loving science and having fun with the science and engineering aspect of being involved in Science Olympiad. This subcategory of science and STEM learning is important. People's attitude toward science makes a difference in their desire to take additional science courses. Approximately, 25% percent of all survey respondents made a statement saying that they thought science was interesting, that they liked it, loved it, or thought it was important.

Research Question 3

What are the participants' perceptions of Science Olympiad's impact on their learning and use of 21st century skills?

The focus of this research question was to look for perceptions of learning and use of teamwork, problem solving, and critical thinking skills. These are some of the areas that the Science Olympiad organization purports as part of their mission and goals (website of Science Olympiad, n.d.). Research supports the need to acquire these type of skills (Stohr-Hunt, 1996). The range of 21st century skills are as varied, as are the responses from the participants, therefore a subcategory of other referenced skills is included.

Participants did not refer to 21st century skills as much as to science and other STEM learning. Only a fifth of all of the respondents to the survey made a statement that fell into the 21st century skill category. Statements about 21st century skills skewed slightly toward the males, with percentages of 23.7% for males and 17.9% for females.

The percentages of responses that were grouped under each subcategory skewed toward the males, although only slightly. Further research would have to be conducted to see why this occurred. It would be interesting and beneficial to determine if the responses had something to do with the type of events the respondent participated in during their time on a Science Olympiad team. Science Olympiad has a variety of events, some that involve engineering and by default problem solving.

McGee-Brown (n.d.) stated that Science Olympiad was a model of collaboration and competition. Additionally, Jerald (2009) stated that complex communication is working with others both to gain information and to disseminate it. Fifty people, or 7.9%, of respondents in this study, wrote about teamwork. Students noted that Science Olympiad specifically helped them with teamwork. The college students also wrote about teamwork. Some of the college respondents focused on the team bonding experience, rather than the specific skill of teamwork. Statements about teamwork revolved around the added benefits of working with a team which included sharing new ideas and engaging in debates that a person would not have been a part of if they had worked alone. Working females saw teamwork as a specific skill while many of the working males linked teamwork with winning. They saw their participation on the team, and working with others as part of the team as fostering group success and winning. One female specifically focused on the chance to bond with other females who were interested in STEM areas. Teamwork is considered an important aspect of participating in Science Olympiad according to students and school personnel (Hounsell, 2000). The organization of each event allows partner groups. This structure increases the potential

for student understanding, as students can often learn from each other (Moreno & Tharp, 2006).

Far fewer participants referred to the skills of problem solving. In fact only one female student and one female and two male college students even mentioned it. The number of alumni who referenced problem solving was also minimal. Only 9 of 241 adults referred to problem solving. These quantitative results were interesting considering the number of alumni who focused on engineering in various statements. Some of the adult males who wrote about problem solving linked it with their career choice. They noted how much they enjoyed problem solving. They also said that the problem solving that they learned in Science Olympiad was useful in their careers. A study on Science Olympiad by Abernathy and Vineyard (2001) stated that participants used problem solving skills and that problem solving was a major part of being successful in Science Olympiad (Hounsell, 2000). It is my belief that had the survey asked questions specifically about problem solving that the response would be higher in this category. In other studies, parents and coaches specifically mentioned seeing problem solving and critical thinking improving for team participants (McGee-Brown, n.d.; McGee-Brown, Martin, Monsasaas, & Stomber, 2003).

Critical thinking and thinking in general was also not referred very often by the survey participants. Only two students and five college students wrote about their engagement in higher-level thinking. Fourteen adults also wrote about thinking. The responses that referred to thinking were heavily male dominated in both the college and adult alumni categories. Darling-Hammond (2007) stated that the PISA and NAEP show that students in the United States are not well versed in problem solving and critical

thinking. It was interesting that so few respondents wrote about these areas. It cannot be determined from this study if this was from a lack of actually engaging in problem solving and critical thinking or if the language that surrounded this area was not in the forefront of American's minds and therefore was not included in the respondents' individual statements.

There were a variety of other 21st century related skills that were referred to in the survey. "Leadership opportunities" was a prevalent theme, especially among those participants who got to serve as the team leader or captain of their team. Male students wrote about leadership, but female students did not. More exploration should be conducted to see if the boys got chosen as team leader more often, and if so, why. Harskamp et al. (2008) stated that males often take the lead in groups with females and that females do better in all female groups than in mixed groups. There was not enough information within this data to determine if this was true for Science Olympiad groups.

Other areas mentioned by the students were motivation, discipline, determination, and staying on task. They said that they learned how to manage their time. The college students' responses included a wide range of responses that were categorized under 21st century skills. Many of the college students wrote about how their participation in Science Olympiad helped them learn study skills. This was no doubt because of the need for team members to study independently or with a partner. Although Science Olympiad coaches guide students, there is far less direct instruction than in a classroom setting. The adults wrote about most of the same areas as the other two age groups.

Research Question 4

What are the participants' perceptions of Science Olympiad's impact on their career choice?

This research question analyzed data regarding careers. The Science Olympiad organization stated that one goal was, "To attract more students particularly females and minorities to professional and technical careers in science, technology and science teaching" (website of Science Olympiad, n.d.). PISA (2006) reported that only 37% of students surveyed were interested in a career in science. Mahoney, Cairns, and Farmer (2003) found that participation in extracurricular activities lead to an increase in educational aspirations and positive plans for the future.

Seventy-eight percent of all college students and adults said that Science Olympiad did in fact lead them to a career and that 61.3% were either majoring in or working in a STEM field as a result of participation in Science Olympiad. Children who have had positive experiences in childhood with science and the STEM fields are subsequently interested in these fields as a career (Tindall & Hamil 2004). The quantitative data supported the fact that Science Olympiad was obviously a positive experience for the participants.

The percentage of respondents engaged in a STEM career only dropped to 49.1% when teaching was removed from the data. Teaching science, math, technology, or engineering was included as the researcher felt that this was engagement in a STEM field even though the primary career of teaching was not. It is very clear from the analysis of the data that participation in Science Olympiad had an impact on the chosen careers of

those that were on a team. The student group was not included in the quantitative total calculations due to the fact that they were not in a career nor had they declared a major course of study that would lead them to a career. Even so, some students checked an answer of “yes” when asked if Science Olympiad led them to a career. This data was included in Chapter IV, but because of the specificity of the question on the survey, the researcher did not draw conclusions about the students’ responses.

The phrasing of the question by the Science Olympiad organization was worded in such a way that respondents may not have been sure of whether to answer yes or no in some instances. There were several respondents who checked no but then proceeded to explain how Science Olympiad did in fact have a major impact on their career decisions. It seemed as if some of these respondents that fell into this grouping thought that they were suppose to check yes only if the Science Olympiad organization was in some way responsible for providing them a job or helping them to a secure a job. I believe that a revision of the wording of the question is needed and that the percentage of yes answers would actually be higher. There were 34 people who responded no to the question that were engaged in a STEM career. There were also several people who answered yes that Science Olympiad did lead them to a career, but that career was not in a STEM field. These respondents credited certain parts of their Science Olympiad experience for leading them to the career they chose.

The percentage of college students and adults who said that Science Olympiad led them to their career was virtually the same; 77.7% and 75.5% respectively. When the data was disaggregated by gender, the differences in career choices were more evident. The number of males and females who pursued a career in science was very close; a little

over half of those who went into science were females. The percentage of males and females that went into math was exactly the same, although there were only two people who responded yes saying that Science Olympiad was what led them to a career in math. The same was true of those respondents who indicated some combination of majors or careers. The subcategory showed a 50% male and 50% female split. There was a considerable disparity between males and females who pursued engineering careers. Of the total of 81 respondents who said that Science Olympiad led them to a career, 30.9% were females and 69.1% were males. The current research data on engineering careers and gender disaggregation says that females are granted only 18% of the awarded engineering degrees (Tindall & Hamil, 2004). Although there was a large disparity between males and females pursuing engineering careers, the percentage was much higher for females going into engineering than other research has found.

There was also a considerable disparity of males and females going into a technology field for a career. These numbers were misleading as there were so few people who actually said they were engaged in a technology field. Very few Science Olympiad events focus on technology as it relates to computers. It would be interesting to determine if this was one of the reasons that there were so few respondents who were involved with the competition that went into a technology field. There was not enough information in the analyzed data to determine if the minimal number of technology events contributed to the skewing of the data. Science, math, and technology teaching was included in the data on careers even though it is not a true STEM career. There were several people who indicated that they chose to become a science teacher because of their love of science that they got from Science Olympiad. They also said that they

wanted to bring Science Olympiad to others. Several respondents also referred to the close relationship they formed with their coaches and that seeing their teachers in a different light made them want to become teachers. **Fredricks and Eccles (2005)** said the fact that students having the chance to work with adults is part of the importance of extracurricular activities. Only teachers who indicated that they taught science, technology, engineering, or math were included in the teaching category.

Of the respondents who credited Science Olympiad with leading them to a career, the majority pursued a non-STEM related career. This data may be skewed, as the researcher often had to determine a respondent's college major or career based on the statements they made if they did not state it explicitly.

It is clear that Science Olympiad impacted the future careers of those who were involved.

Research Question 5

Is gender a factor of the participants' overall perceptions regarding Science Olympiad?

Although the question regarding the impact of gender was imbedded in each of the first four research questions, it is important to highlight some overall findings in regard to gender and Science Olympiad. The usable survey responses showed a nearly perfect split of females and males, $n=318$ and $n=317$ respectively. Even though some responses in the original survey database were removed from the final analysis due to inappropriate or joke statements, this split of males and females was very interesting. Research in general states that females are less engaged in science, engineering, and other

STEM activities. Analyzed data from the Abernathy and Vineyard (2001) study of 453 Science Olympiad participants showed a higher percentage of male involvement. The analysis of this researcher's data does not uphold the Abernathy and Vineyard findings. McGee-Brown (n.d.) found in her research that participation in Science Olympiad helped students believe that girls and boys were equally good in science. In this survey, no one mentioned a feeling either way about the intellectual science abilities of boys or girls.

Summary of Findings

The goals of the Science Olympiad organization include increasing the understanding and interest in science and engineering, learning teamwork, problem solving, and thinking, and increasing the number of females engaged in science. Participants wrote about all of these areas to varying degrees. The survey by the Science Olympiad organization asked a range of questions from the very specific, "Did your participation in Science Olympiad help lead you to a career?" to the very open ended, "Do you have any additional information or comments you would like to share?" The researcher could not predict where the data would lead or what information the survey would yield. Since the database was large, the researcher chose to not only look at the qualitative data, but also chose to quantify the data in order to determine if there were any generalizable patterns. The qualitative data painted a much more positive picture than the quantitative data depicted.

The two questions regarding career choice were included in this study as a specific research question. The data from these two survey questions yielded the greatest amount of quantitative data and showed the clearest impact of Science Olympiad on the participants. The remaining four research questions were not specifically asked in the

Science Olympiad survey and hence it was difficult to definitively make conclusive statements based on the data. The researcher took all of the qualitative answers to the posed survey questions and mined the data for themes and major and minor categories. The quantitative data derived from the categorization of the respondents' statements did not show a clear enough pattern when compared to the qualitative data. The researcher cannot make a definitive statement regarding the impact of Science Olympiad on Overall Benefits, Science and STEM learning and interest, or 21st century skills, based on the quantitative data. All of the results for these research questions yielded a less than 50% reference rate. The quantitative data just did not capture the significance in each researched category that the qualitative anecdotal evidence showed. It was clear from both the qualitative and the quantitative data that Science Olympiad had an impact on the participants' career choices. Both the qualitative data and the quantitative data supported that conclusion.

The qualitative data showed that Science Olympiad has had an impact on individual participants in terms of overall benefits, science and STEM learning and interest, and 21st century skills. The anecdotal evidence was overwhelmingly positive and highlighted some of the purported goals of Science Olympiad. What is clear is that Science Olympiad made a difference to those who chose to answer the survey. The pure number of responses from college students and adults showed the long lasting effect involvement had for the respondent.

Recommendations for Research, Practice, and Policy

Based on the findings of this research, additional areas for study are recommended. There are so many advocates and sponsors for Science Olympiad that it is important that more specific and definitive quantitative conclusions be drawn. The researcher encourages further research on this organization. There are also recommendations for school and educational organizations based on the information attained from this study.

Recommendations for Further Research

1. Replicate this study using the same database to determine if the emerging themes are evident to another researcher.
2. Conduct a similar study using other competitive STEM competitions to see if the same perceptions and themes emerge as did with Science Olympiad.
3. Design a study that specifically asks the research questions addressed in this study. Determine if the results are the same as this study.
4. Design a pre-post test quantitative study to determine the impact of Science Olympiad before and after involvement.
5. Design a study that analyzes the impact that the coaches have on the perceptions of the participants.
6. Design a study to determine the type of teachers that coach teams and how their involvement with Science Olympiad influences their classroom instruction.
7. Use the same Science Olympiad database to determine if the number of years that participants were involved effect participants' perceptions.

8. Use the same Science Olympiad database to determine if the level of competition (regional, state, national) effect participants' perceptions.
9. Design a study reanalyzing the same data to determine if the events that the participants competed in impacted their perceptions. Also, disaggregate the data by gender to determine if there is a difference in the type of events males and females compete in.
10. Design a pre and post test to analyze the quantitative impact of Science Olympiad on knowledge in the STEM areas.
11. Many of the college and adult respondents indicated that they were still involved in Science Olympiad or would like to be. It would be interesting to determine what keeps these alumni coming back even after their years on the competitive team have ended.
12. A study should be done to determine which of the events are most beneficial to students' acquiring of STEM concepts and 21st century skills. Inquiry involves students asking their own questions as well as engaging in others' questions. It would be interesting to determine aside from the engineering events, which other events offer true inquiry and problem solving.
13. Several respondents wrote about the bonds they formed with their coaches. This echoes the research by Juliana and Andrews (2005) who found that teachers who create a passionate learning atmosphere are collaborative co-learners with their students. Students have a chance to direct their own learning. This is very similar to the practice of Science Olympiad where there are numerous events going on and students are ultimately

responsible for attaining the information they need. It would be interesting to focus specifically on the student/coach relationship.

District and Educational Recommendations

1. Develop and encourage participation in Science Olympiad. Support students and teachers who are interested in starting Science Olympiad teams or who are already involved in the organization.

2. Districts should use this research and other research on Science Olympiad to determine which of the components they can put in place in their schools to positively impact regular classroom instruction.

3. Several of the respondents spoke about liking the chance to learn in a way that did not involve solely studying from a textbook. They felt that they got real experience in the fields of science and engineering and that it was more significant than what was happening in their classrooms. The regular classroom is obviously not fulfilling the needs of those students who are intensely interested in science and engineering. Districts and educational leaders should use the anecdotal data provided in this study as a basis for looking at their own curriculum. More inquiry and hands-on learning should be taking place in the school classrooms.

4. Females do not shy away from the areas of chemistry, physics, and engineering. Schools need to take cues from the organization of Science Olympiad teams and look at ways to make the physical sciences and engineering areas more accessible and attractive to females.

5. It is clear from the data that students enjoy learning. They like both collaboration and competition. Intrinsic and extrinsic rewards keep students motivated. Schools need to balance these factors in their own classrooms. A student on the wiki site, www.scioly.org, wrote the following on a posting, “School is just the 7 hours before Science Olympiad.” Schools need to determine how the school day can be just as exciting as extracurricular activities. Important areas for respondents were, working with peers, having fun, learning a lot, and engaging in “hands-on” science. Schools need to incorporate this type of learning into their science classes. Research by Freedman (1997) found that attitude regarding science influences achievement. Change in practice may include, more choice in learning, learning in groups, opportunities to make decisions, or simply making learning more fun.

6. The National Science Education Standards (National Research Council, 1996) stated that individual classrooms cannot provide a complete science education and that schools should reach out to the greater community to develop a more comprehensive science education. Schools should look to organizations such as Science Olympiad to get students engaged in science and engineering.

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Appendix A

Science Olympiad Leading to a Career - College

Appendix A

Science Olympiad Leading to a Career - College

	Total	F	M
Science			
Yes	87	50	37
No	6	4	2
Total	93	54	39
Math			
Yes	2	1	1
No	2	1	1
Total	4	2	2
Engineering			
Yes	27	8	19
No	1	0	1
Total	28	8	20
Technology			
Yes	1	0	1
No	0	0	0
Total	1	0	1
Combination			
Yes	8	4	4
No	0	0	0
Total	8	4	4
Teaching			
Yes	2	1	1
No	0	0	0
Total	2	1	1

Appendix B

Science Olympiad Leading to a Career – Adults

Appendix B

Science Olympiad Leading to a Career - Adults

	Total	F	M
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Science			
Yes	34	13	21
No	5	2	3
Total	39	15	24
Math			
Yes	0	0	0
No	1	0	1
Total	1	0	1
Engineering			
Yes	54	17	37
No	4	2	2
Total	58	19	39
Technology			
Yes	6	1	5
No	9	2	7
Total	15	3	12
Combination			
Yes	0	0	0
No	1	0	1
Total	1	0	1
Teaching			
Yes	53	32	21
No	5	3	2
Total	59	36	23
(includes 1 no answer)			
