

THE IMPACT OF A CITIZEN SCIENCE PROGRAM ON STUDENT
ACHIEVEMENT AND MOTIVATION: A SOCIAL COGNITIVE CAREER
PERSPECTIVE

by

Suzanne E. Hiller
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Education

Committee:

_____ Chair

_____ Program Director

_____ Dean, College of Education and Human
Development

Date: _____ Fall Semester 2012
George Mason University
Fairfax, VA

The Impact of a Citizen Science Program on Student Achievement and Motivation: A
Social Cognitive Career Perspective

A dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy at George Mason University

by

Suzanne E. Hiller
Master of Arts
Loyola College, 1995
Bachelor of Arts
University of Mary Washington, 1988

Dissertation Director: Anastasia Kitsantas, Professor
Department of Education

Fall Semester 2012
George Mason University
Fairfax, VA



This work is licensed under a [creative commons attribution-noncommercial 3.0 unported license](https://creativecommons.org/licenses/by-nc/3.0/).

DEDICATION

This work is dedicated to my parents,
Lieutenant Colonel Herbert L. Hiller and Elinor C. Hiller

ACKNOWLEDGEMENTS

Throughout my teaching career, I have found that children flourish when instruction develops a sense of competence. Inversely, programs which focus on memorization without authentic application erode student confidence and motivation. Collaborative opportunities between scientists and students are a meaningful way to bolster student achievement.

My dissertation committee has given me the skills to transcend these beliefs about developing student science performance into a tangible product. I would like to thank Dr. Kitsantas for teaching me about educational psychology constructs and quantitative methods so that I could express my ideas clearly. Dr. Kitsantas' background in self-regulation has had an immense impact on the way I teach, learn, and conduct research. In particular, I greatly appreciate her guidance in terms of merging methods and concepts in my writing and through the dissertation process.

Dr. Peters Burton has been instrumental in developing my understanding of current science policies and practices. The opportunity to work with Dr. Peters Burton as a Graduate Research Assistant provided a strong background in science education literature, methods, and conference and publication experience. Her willingness to include me in research studies has been a key factor in my ability to develop this dissertation.

Dr. Reybold has been an inspirational support throughout the doctoral program. Her generosity in time, knowledge, and encouragement has transformed me into a researcher. She has guided me through the steps involved in methods, writing, conferences, and publication submissions. Most importantly, she has taught me the importance of ethical boundaries designed to protect participants above all other aspects of research.

The faculty in the College of Education and Human Development has been exemplary, and the knowledge I have gained has been influential in shaping this study. I would like to thank Dr. Buehl, Dr. Dimitrov, Dr. Galluzzo, Dr. Maxwell, and Dr. Sheridan for all of their efforts throughout the doctoral program.

I received a great deal of encouragement and support from my family, friends, neighbors, fellow doctoral students, and work colleagues. This help came in the form of positive feedback, technological assistance, coverage to attend classes, and review of my

work. I would especially like to recognize my son Jake for inspiring me to enter the doctoral program and for his insights on how children learn.

This dissertation is the result of dedication on the part of the board of supervisors, administrators, teachers, and field experts who invited me into the realm of horseshoe crab citizen science programs. These individuals worked with me to conduct data collection, instruct students, and coordinate the logistics of an overnight field experience. It has been a pleasure to be part of this community. I would like to thank the participants who were willing to try a new experience and provide information for this writing.

Finally, I would like to recognize the children who have been my students for the last two decades. The lessons I have learned from them about effective math and science practices, competence, and motivation have been the underlying foundation of this dissertation.

TABLE OF CONTENTS

	Page
List of Tables	ix
List of Figures	x
Abstract	xi
Chapter 1	1
Introduction.....	1
Background of the Problem.....	1
Statement of the Problem	7
Purpose of the Study	10
Intervention	12
Significance of the Study	15
Key Terms	17
Literature Review.....	19
The Relationship among Self-Efficacy, Interest, Outcome Expectations, and Choice Goals.....	21
Holland Themes.....	21
Self-Efficacy and Interest.....	21
Self-Efficacy, Interest, and Choice Goals.....	24
Self-Efficacy, Interest, Choice Goals, and Outcome Expectations.....	27
Social Cognitive Career Theory and Informal Natural Science Learning Settings	34
Self-Efficacy and Environmental Attitudes.....	34
Citizen Science and Scientific Observations.....	36
Citizen Science, Science Literacy, and Content Knowledge.....	37
Citizen Science, Interest, and Motivation.....	41
Citizen Science and Social Cognitive Career Theory.....	43
Gender Differences and Vocational Science Interest.....	48
Research Questions	52

Method	53
Participants and Setting.....	54
Research Design.....	54
Intervention	57
Quality and Ethics	58
Data Collection Instruments.....	61
Design and Procedure.....	67
Data Analysis	67
Quantitative Analysis	69
Qualitative Analysis	70
Validity.....	73
Results.....	79
Correlational Analyses	79
Descriptive Statistics.....	83
Paired Samples t-test Analyses	91
Factorial Analyses.....	93
Path Analysis.....	97
Qualitative Results	99
Science Skills, Learning, and Fun	104
Training and Collaboration.....	111
Future Careers.....	119
Summary of Results	121
Discussion.....	126
Discussion of Results	128
Implications for Instructional Practice	140
Limitations	144
Recommendations for Future Research	147
Measures	151
Semi-Structured Interview Format	160

Event Measure	161
Open Coding Descriptive Labels	162
Human Subjects Review Board Approval	165
Informed Consent and Minor Assent Forms for Treatment Group	166
Informed Consent and Minor Assent Forms for Comparison Group	168
References	171

LIST OF TABLES

Table	Page
Table 1 <i>Factor Loadings for Exploratory Factor Analysis of the Citizen Science Self-Efficacy Scale (Hiller, 2012b)</i>	63
Table 2 <i>Factor Loadings for Exploratory Factor Analysis of Citizen Science Outcome Expectations Scale (Hiller, 2012c)</i>	64
Table 3 <i>Pearson Correlations among Self-Efficacy, Task Interest, Outcome Expectations, Career Goals, and Academic Achievement</i>	81
Table 4 <i>Means and Standard Deviations for Academic Achievement and Self-Efficacy for the population</i>	84
Table 5 <i>Means and Standard Deviations for Task Interest, Outcome Expectations, and Career Goals for the Population</i>	85
Table 6 <i>Means, Standard Deviations, and Effect Sizes for Academic Achievement and Self-Efficacy for Treatment and Comparison Groups</i>	87
Table 7 <i>Means Standard Deviations, and Effect Sizes for Task Interest, Outcome Expectations, and Career Goals for Treatment and Comparison Groups</i>	88
Table 8 <i>Means, Standard Deviations, and Effect Sizes for Academic Achievement, and Self-Efficacy for Gender</i>	90
Table 9 <i>Means Standard Deviations, and Effect Sizes for Task Interest, Outcome Expectations, and Career Goals for Gender</i>	91
Table 10 <i>Paired Samples t-Test Results for Academic Achievement, Sources of Science Self-Efficacy and Citizen Science Self-Efficacy</i>	93
Table 11 <i>Outcomes of Qualitative Data Source</i>	104
Table 12 <i>Outcomes of Event Measure</i>	108

LIST OF FIGURES

Figure	Page
<i>Figure 1.</i> Conceptual graphic of social cognitive career theory underlying a citizen science context.....	9
<i>Figure 2</i> Citizen science research design conceptual map.	11
<i>Figure 3.</i> Intervention sequence.	14
<i>Figure 4.</i> Research design sequence.....	73
<i>Figure 5.</i> Validity matrix	76
<i>Figure 6.</i> Model for the relationship between the five constructs for the population	99
<i>Figure 7.</i> Theme development during the axial phase.....	102
<i>Figure 8.</i> Methods alignment matrix	124
<i>Figure 9.</i> Top view of horseshoe crab by Jackson, A. Copyright, 2011.	155
<i>Figure 10.</i> Bottom view of horseshoe crab by Jackson, A. Copyright, 2011.....	156
<i>Figure 11.</i> Top view of horseshoe crab by Jackson, A. Copyright, 2011.	157
<i>Figure 12.</i> Horseshoe crab gender identification by Stubbolo, G. Copyright, 2012. Reprinted with permission.	157
<i>Figure 13.</i> Spawning horseshoe crabs by Jackson, A. Copyright, 2011.	158

ABSTRACT

THE IMPACT OF A CITIZEN SCIENCE PROGRAM ON STUDENT ACHIEVEMENT AND MOTIVATION: A SOCIAL COGNITIVE CAREER PERSPECTIVE

Suzanne E. Hiller, Ph.D.

George Mason University, 2012

Dissertation Director: Dr. Anastasia Kitsantas

Citizen science programs are joint efforts between hobbyists and professional scientists designed to collect data to support scientific research. Through these programs, biologists study species population trends while citizen scientists improve their content knowledge and science skills. The purpose of the present mixed method quasi-experimental study was to examine how involvement in a horseshoe crab citizen science intervention affected middle school student academic achievement and career motivation within a social cognitive career framework. Eighty six ($n = 86$) eighth graders from two schools were assigned into either a treatment or comparison group. Individuals from the treatment school received instruction from field experts on site and collected data for a biological researcher and a mock survey. The comparison group studied ecological niches within the same geographical area during class instruction; however, students did not conduct field research. All students responded to a series of surveys and content measures related

to self-efficacy, interest, outcome expectations, choice goals, and academic achievement. Further, members of the treatment group participated in qualitative interviews to examine perceptions of their scientific observation skills and career influences. Findings supported the hypothesis that the treatment group would outperform the comparison group on all measures with the exception of choice goals. Path analysis results indicated that the interaction among self-efficacy, interest, content knowledge, and outcome expectations directly and indirectly influenced choice goals. In terms of gender, results confirmed the hypothesis that there would be no gender differences based on self-efficacy, outcome expectations, and choice goals although treatment males outperformed females on academic achievement. In addition, qualitative analysis corresponded with these findings by examining the influence this type of intervention had on student performance and career interests. The implications of this study are to highlight the benefits of collaborative opportunities with field experts during outdoor experiences on student academic and career path development.

Keywords: choice goals, citizen science, interest, outcome expectations, scientific observation skills, self-efficacy, social cognitive career theory

CHAPTER 1

INTRODUCTION

The purpose of this study was to examine the effect of a horseshoe crab citizen science program on middle school student academic achievement and career motivation. Specifically, this research study centered on the impact of the intervention from a social cognitive career theory perspective including self-efficacy, task interest, outcome expectations, and choice goals.

Background of the Problem

Learning in a natural environment affords sensory experiences distinct from a traditional classroom setting. As one naturalist stated,

It's about interface with the resource... There are many limitations on the input of sensory stimuli in the classroom. The ability to smell, touch, hear, even taste elemental aspects of nature can only be replicated indoors in poor fashion. And how would you observe the interactions of living things in the classroom? Through a video? Out the window? (Hiller & Reybold, 2012, p. 8).

The North American Association for Environmental Education (2008) promotes the development of state environmental literacy plans, as research indicates students working in environmental contexts outperform students in formal settings on

performance assessments. Although instruction in informal natural science settings has been shown to influence problem solving skills, affect, and cognition, and motivational influences in stewardship (Bierle & Singletary, 2008; Cachelin, Paisley, & Blanchard, 2009; Meinhold & Malkus, 2005) few studies have focused on the influence of outdoor education on the constructs of self-efficacy, interest, outcome expectations, and choice goals in relationship to academic achievement and career paths.

The term motivation refers to an interconnection among affect, cognition, beliefs, and contextual settings which influence an individual's behavior (Perry, Turner, & Meyer, 2009). For adolescent students, motivation is a key determinant related to educational and occupational choices. This time frame is the basis for developing identity, motivation, and a strong sense of competence which in turn supports beliefs, values, and goals (Wigfield & Wagner, 2007). Intrinsic interest is an underpinning of motivation in which an individual has a predisposition for an activity resulting from continued exposure and positive affect. Interest in a particular skill over an extended period of time supports growth in terms of affective states, cognitive development, and motivation (Hidi & Ainley, 2009). To develop domain specific competency, individuals apply mastery-goal strategies stemming from intrinsic motivation to develop their personal knowledge (Kitsantas & Dabbagh, 2010).

Analyzing the relationship between student self-efficacy, academic achievement, intrinsic interest, and motivation relates to understanding how to transition the novice learner to expert status (Zimmerman, 2011). As developing an individual's scientific observation skills stems from modeling of field experts, considerations of the impact of

self-efficacy, interest, outcome expectations, and goal setting in an environmental studies context are viable topics (Eberbach & Crowley, 2009; Hiller, 2012a; Sutton, 2009).

Citizen science, an experience in which individuals follow a protocol to collect data on organisms for scientific analysis, influences children's self-efficacy and science literacy (Sutton, 2009). Further, citizen science has been shown to influence student's mastery experiences, content knowledge, self-efficacy for science process skills, interest, and career motivation (Chawla & Cushing, 2007; Hiller, 2012a; Tomasek, 2006; Trumbull, Bonney, & Grudens-Schuck, 2005). These studies highlight the role of self-efficacy, motivation, and achievement within environmental education literature. Moreover, motivation in terms of conservation efforts and responsibility beliefs has been attributed to high levels of self-efficacy (Meinhold & Malkus, 2005; Sutton, 2009).

Individuals with raised intrinsic interest and self-efficacy are more likely to engage in career related goal setting (Bonitz, Larson, & Armstrong, 2010). Strong levels of motivation and self-perceptions influence goal setting and career planning (Patrick, Care, & Ainley, 2010) The intertwined relationship between academic performance, self-efficacy, interest, outcome expectations, and goal setting has been documented in literature related to occupational training (Lent, Lopez, Lopez, & Sheu, 2008; Rogers & Creed, 2011). This construct interaction is relevant to field work and addresses current vocational projections which indicate that students do not have the training for future environmentally oriented occupations.

Professional career trends indicate that environmental occupations are part of a growing field with an expected 19% increase resulting in over 106,000 positions by 2020

(U. S. Department of Labor, 2012b). Public demands to monitor the state of the environment based on human behavior will spur vocational growth. In addition, environmental occupations will center on developing action plans to protect ecosystems (Bureau of Labor Statistics). In addition, out of the 30 fastest growing occupations within this time period, eleven encompass health care fields including medical researchers (U. S. Department of Labor, 2012a).

In contrast to pressing demands within the work force, the results of the 2009 Program for International Student Assessment (PISA) identified 9% of students worldwide demonstrating advanced proficiency in science and 22 countries outperformed the United States (Organisation for Economic Co-operation and Development, 2010). In addition, 70% of eighth graders were not able to demonstrate proficiency in science on the 2009 National Assessment for Education Progress (National Science Board, 2012). Despite reports which indicate American students are lagging behind their international counterparts, 20.6 million American students in 2021 will enroll in collegiate programs. (Institute of Education Sciences, 2012)

In the future, a specifically trained work force will analyze natural conditions to protect the environment. As such, individuals participating in professional science occupations require high levels of expertise (Eberbach & Crowley, 2005). Modeling has been found to be an essential component in an individual's development from beginner to advanced levels (Kitsantas, Zimmerman, & Cleary, 2000). Experts in various fields transfer knowledge by their behavior and are instrumental in the process of emulation (Bandura, 1997). From a social cognitive theory perspective, there is a strong relationship

between the individual, behavior, and environment (Zimmerman, 2000) In order to heighten levels of skill development individuals gain expertise with the opportunity to work with someone more experienced (Kitsantas, Zimmerman, & Cleary). This mentoring relationship is of particular importance in the field of informal natural science learning settings in which skill development requires refined observation skills (Cartwright, 1989; Eberbach & Crowley, 2009).

Guided by specific strategies, self-regulation is an underpinning of an individual's ability to achieve an academic goal and derives from self-regulated strategies, self-efficacy beliefs, and a drive to reach academic goals (Zimmerman, 1989). Self-efficacy is the perception an individual has about their capability to master skills in a specific domain (Bandura, 1997). From the perspective of social cognition, motivation stems from consequences of behavior (Zimmerman). As such self-efficacy influences human behavior and is the underlying basis for the triadic reciprocity between the person, environment, and behavior (Zimmerman, 2000).

The foundation for social cognitive theory, self-efficacy steers the process of self-awareness through cycles involving forethought, performance, and self-reflection (Zimmerman, 2000). The forethought phase is a precursor to knowledge acquisition and enhances future learning through task analysis and self-motivational beliefs. Self-control and self-observation steer the subsequent phase of performance, whereas the self-reflection phase entails self-evaluation and self-judgments (Zimmerman & Schunk, 2003)

In addition, social cognitive theory centers on the need for modeling in order for students to acquire the capacity to self-regulate. Enactive mastery in which students

develop skills through modeling is essential for developing self-efficacy. During self-regulation stages, students learn to self-regulate by setting process oriented goals and through a variety of strategies to monitor progress such as self-evaluation, planning, requesting help, keeping records, seeking social assistance, and reviewing records (Zimmerman, 1989, 2011).

Social cognitive career theory applies the focus on the relationship between an individual, context, and behavior within the framework of career planning (Lent, Lopez, Lopez, & Sheu, 2008). Lent, Brown, and Hackett (1994) developed this orientation on career development as an extension of social cognitive theory. In terms of career counseling, social cognitive career researchers target occupational choices, barriers to participate in vocations, and modifying an individual's self-efficacy beliefs (Savickas & Lent, 1994). Specifically, these studies focus on the interplay between self-efficacy, interest, outcome expectations, choice goals, academic achievement, barriers, and social supports as a crucial component of career planning (Fouad, Smith, & Zao, 2002; Lent & Brown, 2006; Lent, Lopez & Bieschke, 1991; Nauta, Kahn, Angell, & Cantarelli, 2002; Rogers & Creed, 2011; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). In addition, further considerations within this framework include culture, gender, biological influences, and critical life events as mediating factors (Savickas & Lent).

Complex interactions of self-efficacy, interest, outcome expectations, choice goals, and social capital have been found to positively impact student achievement and career planning within many cultural contexts and in different subject domains particularly in math and science related fields (Fouad, Smith, & Zao, 2002; Lent, Paixão,

Silva, & Leitão, 2010; Sheu, Lent, Brown, Miller, Hennessy, & Duffy). In particular, self-efficacy and interest have been shown to have a strong influence in a variety of contexts (Lent, Brown, & Sheu, 2010; Lent, Brown, Tracey, Soresi, & Nota, 2006; Nauta, Kahn, Angell, & Cantarelli, 2002).

In contrast to social cognitive career research, the majority of adolescent studies related to outdoor contexts center on self-efficacy and stewardship. Researchers have found a positive relationship between adolescents responsibility beliefs, self-efficacy and pro environmental behavior (Meinhold & Malkus, 2005). In addition, individual's self-efficacy and beliefs about their capability to impact global warming have been correlated. Researchers found that children participating in environmental organizations have greater awareness, self-efficacy, and a sense of responsibility as compared to their counterparts (Devine-Wright, Devine-Wright, & Fleming, 2004). Citizen science programs create divergent learning opportunities which influence student content knowledge, interest, and science literacy (Sutton, 2009; Tomasek, 2006; Trumbull, Bonney, Grudens-Schuck, 2005). Nevertheless, limited research centers on the influence of learning in informal natural science learning settings within a social cognitive career theory framework aimed at career development.

Statement of the Problem

Although social cognitive career theory has focused on construct interaction within formal school settings, there is a gap in terms of career planning development situated in informal natural science learning settings. Citizen science is one medium which provides a back drop for exploring vocational paths. During citizen science

experiences, individuals collect data which is used in data analysis by professional scientists (Bombaugh, 2000). Essential to viable data collection, field experts train volunteers in pre-established protocol (Snäll, Kindvall, Nilsson, & Pärt, 2011). For middle school students, training which focuses on consistent data collection techniques, provides students access to field expert modeling in scientific observations. In other words, citizen science programs provide a scaffold for individuals, potentially offering an avenue to influence career planning and developing stronger skill sets. This type of modeling is essential in observation learning and is the first step in a four step processes outlined by Bandura (1997) which encompasses attention, retention, production, and motivational processes. In addition to enhancing the content knowledge of volunteers (Harrison, Underhill, & Barnard, 2008), the results of a horseshoe crab citizen science program indicated that this collaborative activity influences intrinsic interest, self-efficacy for observation skills, mastery experiences, and a sense of competence (Hiller, 2012a).

Figure 1 shows the interconnection among self-efficacy, interest, outcome expectations, choice goals, and academic achievement within an informal natural science learning opportunity based in social cognitive career theory. The foundation of this theory is what Zimmerman (2000) refers to as the triadic relationship between self, environment, and motivation within a career development framework. Self-efficacy, interest, outcome expectations, choice goals, and academic achievement interrelate and influence career planning and vocational trajectories (Patrick, Care, & Ainley, 2010). The interaction between these constructs within an informal natural science learning setting

and an underlying social cognitive career theory foundation positively influences career decisions. Within the graphical representation, the person, environment, and behavior form a foundation within a citizen science context. The constructs of self-efficacy, interest, outcome expectations, choice goals, and academic achievement interact to form a wheel. The spokes of the wheel intersect in the center influencing career planning.

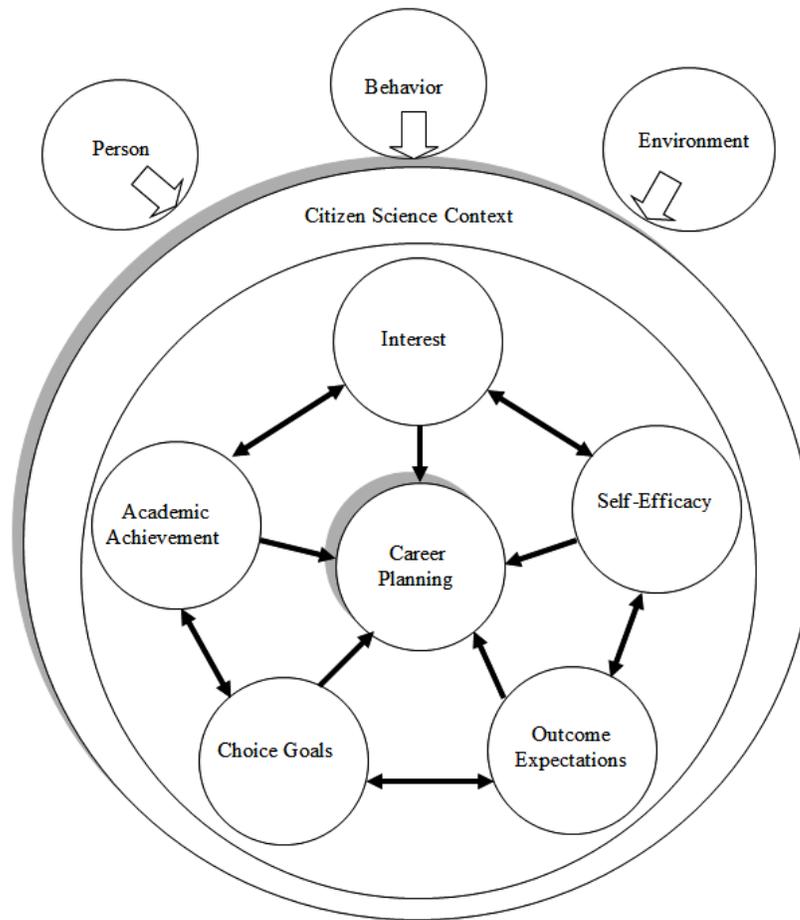


Figure 1. Conceptual graphic of social cognitive career theory underlying a citizen science context.

Purpose of the Study

The purpose of the study was to examine the effect of a citizen science intervention program on middle school student self-efficacy, intrinsic interest, outcome expectations, choice goals, and academic achievement in terms of career planning. The format of the study was quasi experimental and targeted eighth grade students. The treatment group consisted of 45 participants ($n = 45$) receiving protocol training to participate in horseshoe crab data collection for a professional scientist. The comparison group ($n = 41$), located at a different school within the same district, did not participate in the intervention. The student experience for the comparison group and treatment group involved class instruction on the same coastal system as prescribed by state guidelines. The instructor of the comparison group received training from the instructor of the treatment group in citizen science horseshoe crab programs. Both groups viewed a PowerPoint on horseshoe crabs designed by a field expert. Students had similar backgrounds in local ecological interactions although the comparison group did not have the outdoor experience or direct instruction from a field expert. The independent variables for this study included gender and treatment versus comparison groups. It was hypothesized that there would be main effects in self-efficacy, interest, outcome expectations, choice goals, and academic achievement between the treatment and comparison group in favor of the treatment group. Further, an expectation was that there would be no gender differences on these variables. A conceptual map of the research design modeled after Maxwell (2005) appears in Figure 2. In his research model, Maxwell espouses the use of interconnected rather than sequential design components.

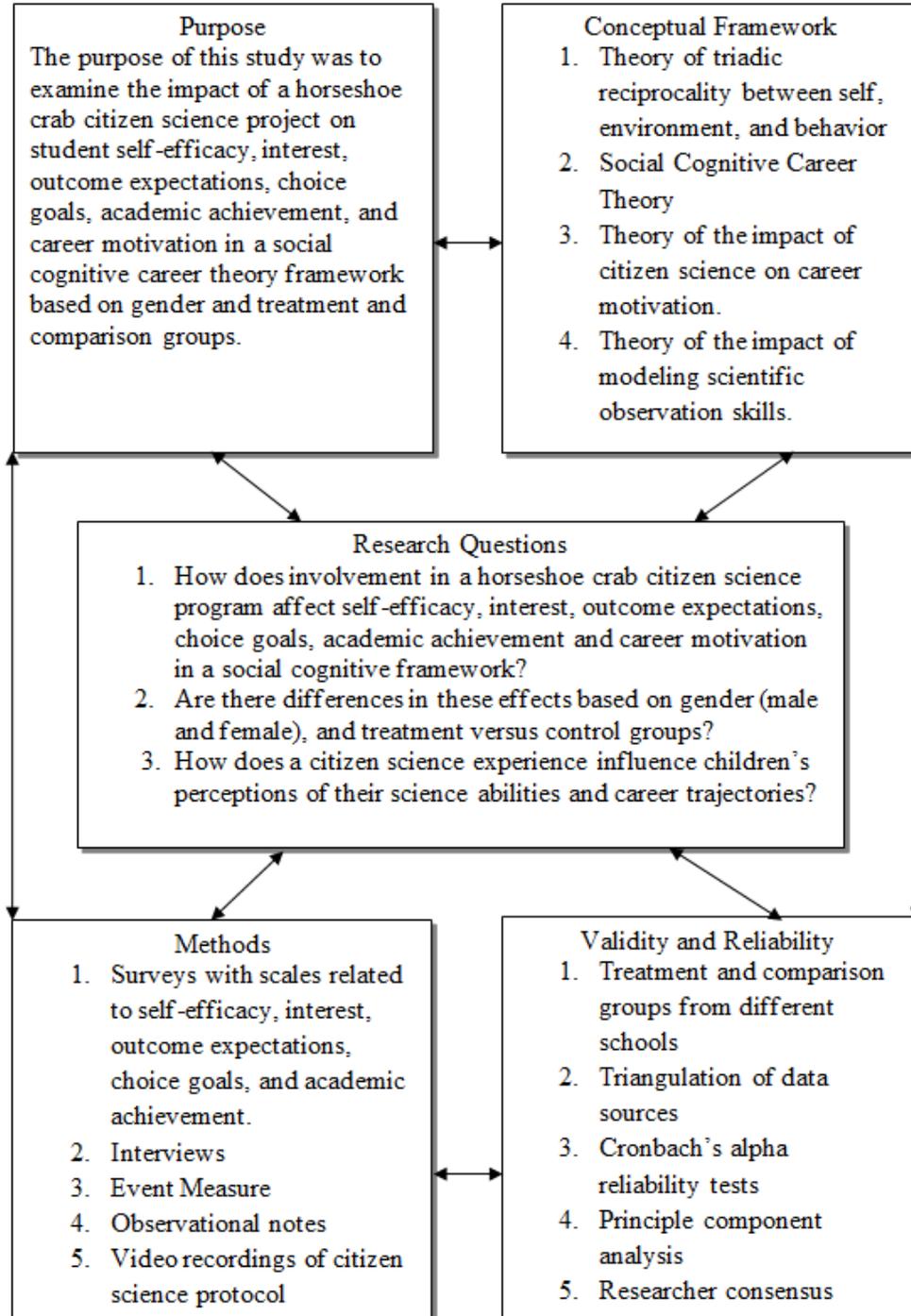


Figure 2 Citizen science research design conceptual map.

Intervention

The intervention involved a series of training events, data collection of horseshoe crabs, and formal presentations by field experts. In the morning, students attended a field expert presentation on horseshoe crab life cycles, form and function, systems and interactions, and data collection techniques. Students conducted a lab to examine how Limulus amoebocyte lysate (LAL), a reagent derived from horseshoe crab blood, detects the presence of bacteria. Following this training, participants in the treatment group visited a local naturalist center to reinforce previously learned skills by viewing exhibits and informally speaking with field experts. The following description of the intervention reflects a quality check as an in depth description of the protocol training and student data collection highlights the nuances, social context meaning, and processes of the activity (Patton, 2002) for a richer understanding of the field of citizen science.

In the afternoon, participants met with three field experts to receive protocol training for data collection on measuring the interocular distance, determining gender, and identifying relative age. As students entered the beach, the image which emerged was thousands of horseshoe crabs at the water's edge in both directions to the horizon. The noise level was striking with the sounds of choppy water and off shore birds hunting for buried horseshoe crab eggs. Within this space, students approached the field experts tentatively. One of the trainers greeted the students by saying, "We've got some serious science to do. Come up close. Come around."

In order to prepare students for data collection, the field experts guided them through survey protocol. Initially, students clasped their hands or pointed towards the

horseshoe crabs. As field experts led the training, students exhibiting their knowledge by adding to the discussion, “No. The darker they are the older they are.”

After the initial sequence, students carefully picked up and moved horseshoe crabs away from the water. As they determined the interocular distance with a tape measure, the field experts monitored their technique and confirmed accurate measurements. Each of the two days, participants worked in teams of two to three individuals to collect and record the relevant data for the professional biologist who is studying horseshoe crab speciation or to participate in a mock survey. Students developed strategies for working as partners. Typically, one team member would position the horseshoe crab away from the tide and reference the compound eyes with their fingers. The second partner would bend down and place the tape measure between the eyes. Both partners would confirm the measurement before recording. As students became more comfortable, teams began comparing horseshoe crabs. One student held a horseshoe crab up to peers and said, “I think I got a lively one!”

Due to the high tide schedule, students participated in one of these two activities based on teacher selection. Students collecting data for the mock survey learned to pace off correctly and how to drop a one square meter PVC pipe frame in order to collect data. This work posed unique challenges in that a large volume of horseshoe crabs was within the frame. The combination of incoming waves with layers of horseshoe crabs on top of each other made identifying gender challenging. The field expert modeled how to work with the waves to count the horseshoe crabs. “How many females?” the trainer asked.

“One!” responded a student. “No, I see another one,” he answered. Students learned to feel the arches of the male horseshoe crabs and the bottom to find the females buried.

Students spent approximately one and a half hours collecting data. Following the activity, participants compiled data. The instructor discussed the implications of data collection to assist a biologist in examining speciation along the northeast coast of the United States. In all, participants interacted with five field experts during the experience. Figure 3 shows the sequence of activities during the intervention.

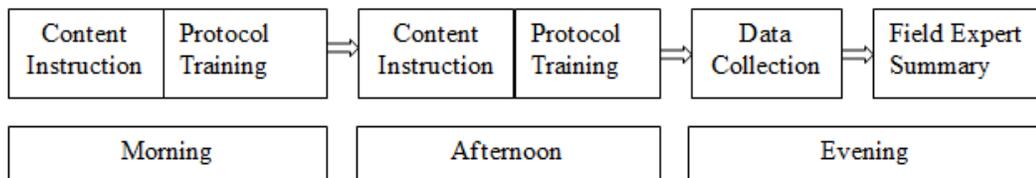


Figure 3. Intervention sequence.

A mixed method quasi experimental design captured the effect of the citizen science intervention on self-efficacy, interest, goals, outcome expectations, academic achievement, and career motivation. Based on previous studies related to social cognitive career theory and citizen science programs, the supposition underlying the present dissertation is that citizen science projects have the potential to influence career related constructs. Specifically, results from a citizen science pilot study found correlations among self-efficacy and task interest. Further, statistically significant mastery experiences on pre and post measures may have implications for academic achievement

(Hiller, 2012a). Of the four sources of science self-efficacy, mastery experience is most closely associated with achievement (Britner & Pajares, 2009). Qualitative findings from the same pilot study indicated that the experience influenced students' perceptions of their science abilities and possible career paths (Hiller). Incorporating choice goal and outcome expectation measures further illuminated the effect of this intervention on career planning.

Significance of the Study

A distinction of the present study is that it applies the tenets of social cognitive career theory within an informal natural science learning setting. Three other elements which contribute to an understanding of the influences of natural science learning settings is the focus on self-efficacy for scientific observation skills and the influence of outdoor learning on academic achievement and career motivation. Much of the literature related to career paths focuses on math and science instruction within traditional classroom settings (Fouad, Smith, & Zao, 2002). This work examines the impact of a field based intervention on self-efficacy, interest, choice goals, and outcome expectations, and the influence of these constructs on academic achievement and career motivation.

A main feature of this study which contributes to the general body of knowledge is the focus on self-efficacy for scientific observation skills. The Citizen Science Self-Efficacy Scale, a measure developed to assess self-efficacy for scientific observation skills (Hiller, 2012b) was incorporated within a social cognitive career theory. Science process skills related to observation are the critical component in terms of scientific data collection (Cartwright, 1989; Eberbach & Crowley, 2009; Hiller & Reybold, 2011). This

study examined the impact of an intervention on student self-efficacy for developing a higher level of field work skills. Further, an event measure confirmed by field experts corroborated with this scale in terms of assessing student accuracy in data collection.

Generally studies related to informal natural science learning settings highlight themes related to affect, cognition, problem solving, self-efficacy, and responsibility beliefs (Bierle & Singletary, 2008; Cachelin, Paisley, & Blanchard, 2009; Meinhold & Malkus, 2005). This study differs in that the focus was on academic achievement within the context of career motivation constructs including self-efficacy, interest, choice goals, and outcome expectations. With the increasing demand for professionals in scientific fields related to the environment within the next decade, this study examined the benefits of outdoor activities which provide students the opportunity to observe field expert models and to collect data for professional scientific databases. The Citizen Science Self-Efficacy Scale (Hiller) related to observation skills was a new application combining the literature from best practices in environmental education instruction (Eberbach & Crowley, 2009; Hiller & Reybold, 2011) and the influences of self-efficacy, interest, outcome expectations, choice goals, and academic achievement on career planning. A second new measure, the Citizen Science Outcomes Expectations Scale (Hiller, 2012c) relates outcome expectations within the outdoor context. The aim of this research was to extend current understanding of these interactive influences within an informal natural science learning setting.

Key Terms

Key terms within the context of this study include social cognitive career theory, self-efficacy, sources of self-efficacy, interest, choice goals, outcome expectations, citizen science, scientific observation skills, participants, and content knowledge. Social cognitive career theory emphasizes the interaction of the individual, environment and behavior specifically in terms of career motivation. Originally developed by Lent, Brown, & Hackett (1994), social cognitive career theory extends Bandura's (1997) posits related to the interaction of the individual, environment, and behavior. Social cognitive career theorists consider self-efficacy, interest, outcome expectations, choice goals, barriers, supports, and biological factors with the framework of career motivation (Lent, Lopez, Lopez, & Sheu, 2008; Patrick, Care, & Ainley, 2011; Rogers & Creed, 2011)

Self-efficacy is a central component within social cognitive career theory and relates to an individual's perception about their capability in a specific domain (Bandura, 1997). Four underlying aspects which steer an individual's self-efficacy include mastery experiences, vicarious experiences, social persuasion, and affective states (Britner & Pajares, 2006).

Interest, outcome expectations and choice goals have been found to be closely linked to self-efficacy (Lent, Lopez, Lopez, & Sheu, 2007; Navarro, Flores, & Worthington, 2007). Interest stems from multiple experiences which foster motivation to pursue an activity (Hidi & Ainley, 2009). Choice goals center on behavior which assists individuals in accomplishing mastery of a task (Lent, Lopez, Lopez, & Sheu, 2007)

whereas outcome expectations relates to an individual's assessment of their capability to be successful in an activity (Schunk & Pajares, 2005)

Citizen science is a type of program in which volunteers are included in data collection to support professional scientific research. Through activities such as measuring, counting, and identifying members of a species population, volunteers aid professional scientists in studying population patterns more fully (Snäll, Kindvall, Nilsson, & Pärt, 2011).

For this study, participants included students from both the treatment and comparison group. The students were between 13 and 14 years old and take eighth grade science as part of their school requirements.

Content knowledge refers to a general understanding of a specific area of study (Peters, 2009). Within the context of this study, content knowledge refers to overall understanding related to horseshoe crab anatomical structure, life cycles, and interaction within ecological systems. Learning in the outdoors has been shown to increase participants content knowledge particularly with the influence of field expert modeling (Brossard, Lewenstein, & Bonney, 2005; Cachelin, Paisley, & Blanchard, 2009; Sutton, 2009). Citizen science programs potentially mirror the framework of social cognitive career theory as mastery experiences develop through field training. The merging of a social cognitive career theory perspective with informal natural science learning settings during citizen science activities, affords new opportunities in understanding children's career development.

CHAPTER 2

LITERATURE REVIEW

Children who learn in informal natural science learning settings surpass their counterparts in science literacy (North American Association for Environmental Education, 2008). Citizen science opportunities which encompass the role of volunteers in scientific research studies (Snäll, Kindvall, Nilsson, & Pärt, 2011) extend the positive aspects of outdoor learning. For students, a benefit of this type of program is the perception that their contributions have value in the scientific community (Sutton, 2009). In addition, citizen science programs impact content knowledge growth, expose individuals to potential career choices, and increase self-efficacy in science related domains (Bombaugh, 2000; Brossard, Lewenstein, & Bonney, 2005; Chawla & Cushing, 2007; Trumbull, Bonney, & Grudens-Schuck, 2005). Moreover, within the context of a middle school citizen science program, self-efficacy for classification and measurement skills correlated with mastery experiences, a predominant source of academic achievement (Hiller, 2012a).

Citizen science opportunities correspond with the tenets of social cognitive career theory in terms of developing self-efficacy, interest, and career motivation. For students, strong self-efficacy and interest in a specific field, steers career planning (Bonitz, Larson,

& Armstrong, 2010; Howard, Ferrari, Nota, Solberg, & Soresi, 2009; Lent, Brown, & Sheu, 2010; Nauta, Kahn, Angell, & Cantarelli, 2002). The relationship between self-efficacy, an individual's perceptions about their capabilities in a specific domain (Bandura, 1997), and interest has been a prevalent theme in vocational literature.

Social cognitive theory serves as a foundation for research related to career paths. The primary precept encompasses the dynamics between an individual, environment and behavior within a specific context (Zimmerman & Schunk, 2003). Social cognitive career theory extends this focus by considering the triadic relationship in terms of career development. This interaction influences career planning and overall performance (Lent, Lopez, Lopez, & Sheu, 2008). Within this framework, the aim of researchers is to highlight the complex connections between self-efficacy and interest with other factors such as outcome expectations, choice goals, academic achievement, social supports, and barriers (Lent, Lopez, Lopez, & Sheu ; Patrick, Care, & Ainley, 2011; Rogers & Creed, 2011). The benefit of social cognitive career models is that the effect of interventions may be examined through the relationship of a variety of constructs (Fouad, Smith, & Zao, 2002). However, a deficiency in career literature is the consideration of these constructs within informal natural science learning settings.

The Relationship among Self-Efficacy, Interest, Outcome Expectations, and Choice Goals

Holland Themes. Generally, social cognitive career theorists manipulate the variables of self-efficacy, interest, outcome expectations, and choice goals in relationship to additional factors such as academic achievement, social supports, and barriers based on specific vocational fields or subject matter (Holland, 1997). A commonality among many studies is the use of Holland themes in conjunction with a variety of constructs (Lent, Paixão, Silva, & Leitão, 2010; Nauta, Kahn, Angell, & Cantarelli, 2002; Patrick, Care, & Ainley, 2011; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). Based on a classification system of vocational interests, the Holland themes are realistic, investigative, artistic, enterprising, and conventional (Holland). Of these six categories, the investigative theme corresponds with math and science fields and is the most common focus of social cognitive career theory literature (Fouad, Smith, & Zao, 2002).

Self-Efficacy and interest. Although there are several factors considered in social cognitive career theory models such as interest, outcome expectations, choice goals, social supports, and barriers, self-efficacy is generally an integral aspect of career planning studies due to the strong influence on human behavior particularly in terms of reaching academic goals (Zimmerman, 1989). Self-efficacy is often contingent on expert modeling as students develop mastery experiences, a primary source of self-efficacy (Bandura, 1997; Zimmerman). For this reason, citizen science programs which require

field expert modeling to establish data collection protocol, serve as a platform to potentially shape individuals' self-efficacy in the sciences.

According to Bandura (1997), there are four main predictors of self-efficacy: mastery, vicarious, and persuasive experiences, and physiological reactions. Mastery experiences relate to developing high levels of expertise within a specific domain. Of these indicators, mastery experiences are particularly predictive of student achievement (Britner & Pajares, 2006). Vicarious experiences steer perceptions of competency by comparing an individual's efforts to peers, adults, and other influences. Modeling is instrumental in the formation of vicarious perceptions. Social persuasion focuses on self-perceptions based on cues from other individuals. Positive feedback from influential peers, adults, and family members can instill greater self-efficacy. The fourth source of self-efficacy relates to physiological and affective states. Self-efficacy can be improved by lessening stress and negative stimuli (Bandura).

Within outdoor science contexts, students with high self-efficacy demonstrated increased behavior towards conservation efforts, heightened interest, and improved results related to mastery experiences (Devine-Wright, Devine-Wright, & Fleming, 2004; Hiller, 2012a; Meinhold & Malkus, 2005; Sutton, 2009). Further correlations have been found between mastery and vicarious experiences, social persuasion, and physiological factors. Most significantly, only mastery experiences have been found to be a predictor of science self-efficacy (Britner & Pajares, 2006).

Intrinsic interest is an underpinning of self-efficacy and motivation in which an individual has a predisposition for an activity resulting from continued exposure and

positive affect. As a result, intrinsic interest serves as a mediator between self-regulatory strategies (Hidi & Ainley, 2009). Individuals motivated to develop competency in a particular domain perform based on mastery-goal strategies to develop their personal knowledge base (Kitsantas & Dabbagh, 2010). Within math and science contexts, interest has been associated with self-efficacy, outcome expectations, and choice goals for middle school students (Navarro, Flores, & Worthington, 2007).

The relationship between self-efficacy and interest has been central to vocational education research (Bonitz, Larson, & Armstrong, 2010; Patrick, Care, & Ainley, 2011). Generally, studies identify the direct and indirect effects between these constructs and other factors. Research which distinguishes the two constructs separately rather than in tandem produce better model fits using structural equation modeling; a common method in social cognitive career theory literature (Lent, Brown, & Sheu, 2010).

A primary consideration between self-efficacy and interest is whether their influence is a unidirectional influence or whether there is a dual relationship (Bonitz, Larson, & Armstrong). Nauta, Kahn, Angell, and Cantarelli (2002) addressed this concern by researching whether self-efficacy is a precursor of interest. One hundred twenty four participants ($n = 124$), 22 male, and 82 female, from a Midwestern university completed the study.

Data collection occurred with the use of a General Occupational Theme Score based on Holland's (1994) six vocational themes of realistic, investigative, artistic, social, enterprising, and conventional. A repeated measures self-efficacy scale (Harmon, Borgen, Berreth, & King, 1996) aligned individual's self-perceptions with the six

occupational themes. A structural equation modeling approach provided an analysis of the relationship between constructs over time (Nauta, Kahn, Angell, & Cantarelli, 2002).

Results indicated that there was a reciprocal relationship between interest and self-efficacy. Path analysis showed a stronger effect between self-efficacy to interest rather than interest as the antecedent. The findings of this research support that although there are strong direct effects from self-efficacy to interest, there is a reciprocal influence, particularly in a motivational context (Nauta, Kahn, Angell, & Cantarelli, 2002).

Self-Efficacy, interest, and choice goals. Individuals with strong self-efficacy are more likely to set challenging goals for themselves (Bandura, 1997). Choice goals relates to an individual's intentions in selecting a course of action or persisting in an endeavor (Lent, Lopez, Lopez, & Sheu, 2007). Goal setting, associated with specific behavioral intentions, enhances the likelihood of reaching desired outcomes (Lent & Hackett, 1994). Self-efficacy influences goal setting standards, commitment levels, self-regulation strategies to achieve goals, and effort (Bandura). Goal setting is interdependent with career decisions (Rogers & Creed, 2011). Self-efficacy, interest, and outcome expectations steer choice goals and as such influence career planning (Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010).

Some literature extends the relationship between self-efficacy and interest to include choice goals as influential constructs in educational pathways. One such work conducted by Bonitz, Larson, and Armstrong (2010), studied the impact of interest on self-efficacy and choice goals. The researchers utilized a sequence of experimental designs with 189 participants ($n = 189$) including 112 women and 68 men and

manipulated the variable of work values in order to determine causal links between interest and self-efficacy (Bonitz, Larson, & Armstrong).

Bonitz, Larson, and Armstrong (2010) subdivided participants by interest levels based on results from a pilot study. The main study included one hundred eighty participants ($n = 180$). These individuals were contacted based on the completion of Basic Interest Marker (Liao, Armstrong, & Rounds, 2008), in the pilot study. This measure analyzed individuals' vocational interests. Respondents indicated their level of preference to participate in activities related to information technology, sales, and teaching. Based on the Basic Interest Marker (Liao, Armstrong, & Rounds), participants were grouped into three categories: high, medium, and low. Another measure used in the pilot study to determine participant selection was a work values scale which assessed the level of importance attributed to the characteristics of achievement, independence, and creativity. The main study stemmed from a job description measure examining interest for information technology, sales, and teaching. Questions across domains were consistent; however, work value statements were manipulated to account for two tiers of vocational interest. The three independent variables in the study included preexisting interest, gender, and work value congruency. Dependent variables included job description ratings, confidence, and choice goals. Analysis of variance analyzed data using a 3(pre-existing activity based interest) X 2 (gender) X 2(value congruency) matrix (Bonitz, Larson, & Armstrong, 2010).

The findings indicated that men and women differed on job interest, confidence and work values in terms of technology in favor of men. The results for teaching

indicated that there was a statistically significant difference in interest and confidence for teaching with women outperforming males. There were no main effects for interest, confidence, or choice ratings for sales. In addition, changing work values for three occupations affected interest levels. Job description statements alternated between the work values of pay, job security, hours, and location. Researchers concluded that variations in work values influenced interest and choice goals. In turn, levels of interest influenced participant confidence in their capability to perform occupational tasks (Bonitz, Larson, & Armstrong, 2010).

In order to examine the relationship between vocational interest, self-efficacy, and academic achievement in terms of educational choices, a study situated in Australia focused on career paths of 14 and 15 year old students. The participants were 68 boys and 108 girls who completed a self-report survey. The measures in the study included a vocational interest and self-efficacy instrument developed by Holland (1994). Items appeared in three sub sections: activities, competencies, and occupational preferences and corresponded with specific vocational Holland themes. Of the six themes, the investigative theme closely aligned with chemistry, mathematics, physics, and biology. Additional measures included an academic achievement score based on average grades for each subject students attended. The pathway choice measure was a ranking of subject preferences. Researchers subdivided these rankings based on the six vocational themes (Patrick, Care, & Ainley, 2011).

Using logistic regression analysis, results indicated that vocational interest, self-efficacy, and academic achievement were predictors for the educational pathways of high

school students. Further, for students identified by the math and science oriented investigative theme, self-efficacy and academic achievement were the strongest predictors of subject choices. Although interest was a significant predictor of career choices individually, its influence was minimized when considered jointly with other variables. Researchers found that in terms of investigative students, intrinsic interest was not significant in the multivariate model which indicates that interest has an indirect effect via self-efficacy. Despite the complex relationship between the three constructs of vocational interest, self-efficacy, and academic achievement on choice goals, the results of this study supported the hypothesis that all three constructs influence career pathways (Patrick, Care, & Ainley, 2011).

Self-Efficacy, interest, choice goals, and outcome expectations. Outcome expectations is a term which refers to judgments an individual makes about the consequences of behavior and the likelihood that they will be successful at a given task (Schunk & Pajares, 2005). These decisions link to an individual's beliefs about their capability to be successful in a task (Bandura, 1997). Positive and negative expectations can influence approach motivation and avoidance motivation or there may be neutral responses to a perceived consequence (Lent & Brown, 2006). Sensory experiences are central to developing these expectations (Bandura). In addition, self-efficacy influences positive outcome expectations (Lent, Lopez, Lopez, & Sheu, 2007), and jointly assists in the prediction of behavior (Lent, Lopez, & Bieschke, 1991).

Specifically within science oriented fields, students with high academic self-efficacy and outcome expectations have been shown to persevere in collegiate programs

centering on biological sciences and engineering. This combination is particularly effective for students who tend to be underrepresented in the science and technology fields from Asian countries such as Vietnam and Cambodia (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010).

Rogers and Creed (2011) considered the interaction among self-efficacy, outcome expectations, goals, supports, and personality. Of these constructs, self-efficacy and goals were the greatest predictors of career paths. The study focused on a repeated wave measure implemented in two Australian suburban high schools. Three hundred forty-four females and 287 males responded to both self-report surveys ($n = 631$). In order to assess career planning and exploration, researchers administered two subscales of the Career Development Inventory (Lokan, 1984). Using a Likert-type scale, questions focused on planning for future careers. To measure self-efficacy, researchers applied the short form of the Career Decision-Making Self-efficacy Scale (Betz, Klein, & Taylor, 1996). A third measure, developed by Betz and Voyten (1997), centered on career outcome expectations. The aim of the measurement items was to assess student value of educational career options. The Career Goals scale developed by Mu (1998) examined individuals' vocational goals. In order to examine career supports, participants took the Career Influence Inventory developed by Fisher & Stafford (1999). A personality trait measure identified trait influences and career decisions (Rogers & Creed). These traits ranged from neuroticism, extraversion, agreeableness, conscientiousness, and willingness to try new experiences from the NEO Five-Factor Inventory (Costa & McCrae, 1989).

Multiple regression analyses based on grade levels 10 through 12 identified the most influential aspects of career development as self-efficacy and goal setting. These results were consistent regardless of grade level. Personality had a minimal influence on career choices as well as work influences. Contrary to social cognitive career theory, outcome expectations did not play a role in career planning and exploration. The results of this study illuminated the dominant role of self-efficacy and choice goals in career planning (Rogers & Creed, 2011).

In other studies, self-efficacy, interest, choice goals, and outcome expectations were mutually influential and predictive of academic achievement (Lent, Lopez, Lopez, & Sheu, 2008; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). In order to establish this interaction within a variety of contexts and cultural backdrops, a great deal of social cognitive career theory literature analyzes the relationship of constructs through the use of a structural equation modeling approach. One such study included 1208 computer science majors who participated in a research studying analyzing the relationship of outcome expectations and self-efficacy on major choice goals with interest as a possible mediator. Further, researchers examined the influence of social supports and barriers on major choice goals. Seventy percent of the participants were male and 30% were female. The racial/ethnic distribution of the participants was 42% African American, 39% European American, and 6% Asian American, 5% Hispanic. The participants' majors ranged from computer science, computer engineering, information technology, or variations of these disciplines (Lent, Lopez, Lopez, & Sheu).

Individuals completed an on-line survey with scales measuring self-efficacy, outcome expectations, interests, major choice goals, social supports, and barriers. Social supports and barriers influenced choice goals via self-efficacy both directly and indirectly. In opposition to the hypothesis, outcome expectations did not have direct or indirect effects to interest or goals. Researchers concluded that focusing on improved support and limited barriers may enhance an individual's capability to work towards goals and develop higher self-efficacy (Lent, Lopez, Lopez, & Sheu, 2008).

A variety of studies have attempted to illuminate the role of outcome expectations in conjunction with self-efficacy and choice goals (Navarro, Flores, & Worthington, 2007; Rogers & Creed, 2011; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). In a meta-analysis of social cognitive career works, researchers studied an array of choice goal models which accounted for the six Holland themes. In addition, researchers hypothesized that outcome expectations and self-efficacy would indirectly influence choice goals with interest as a mediator. Another consideration in the model design was social supports and barriers as choice goal influences (Sheu, Lent, Brown, Miller, Hennessy, & Duffy).

Data collection stemmed from research studies conducted between September 1981 and December 2008 which incorporated social cognitive career theory and predictors of choice goals. The criteria for study selection was research with choice goals as a dependent variable, and at least one other variable such as self-efficacy, outcome expectations, interests, supports, and barriers. In addition the studies classified the

dependent variables along the Holland themes, and included a content specific measure (Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010).

Forty-five samples met the criteria and included college students, adults, and teens (71%, 20%, and 9% respectively). Results of the model comparisons across the six Holland themes indicated that for realistic, investigative, and enterprising themes, social supports and barriers directly and indirectly influenced choice goals but not at the same magnitude for each theme. The model indicated that the relationship demonstrated between self-efficacy and outcome expectations on choice goals via interest was relevant for the three non-math/science themes of artistic, social, and conventional (Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010).

As much of the writing related to social cognitive career models targets math and science, Fouad, Smith, and Zao (2002) focused on assessing the relationship between self-efficacy, interest, outcome expectations, and choice goals in multiple subject areas. Nine hundred thirty-two students from a Midwest college completed 16 scales designed to measure career constructs across the subject areas of art, social studies, math and science and English to examine potential differences per subject area. Additionally, researchers examined potential gender differences in the relationship of these constructs per domain (Fouad, Smith, & Zao).

Results derived from a structural equation modeling approach indicated that there was a good model fit across the domains between the relationship between self-efficacy and outcome expectations with interest as a mediator between choice goals. Researchers noted a stronger relationship between grade point average and math and science self-

efficacy. This finding corresponded with previous reports on the effect of mastery performance and self-efficacy and math and science related domains. The direct effects between outcome expectations and choice goals were not as significant as in other subject areas. Gender differences did not exist among any of the connections. Results of this study supported a social cognitive career model across subject areas (Fouad, Smith, & Zao, 2002).

Navarro, Flores, and Worthington (2007) extended the social cognitive career theory model in the domain of math and science illuminated choice intentions of middle school Mexican American students. Four hundred twenty-six Mexican American students participated in a series of measures including demographics, a task interest scale, a social support scale known as the Child and Adolescent Social Support Scale (Malecki, Demaray, & Elliott, 2000), math and science performance accomplishments based on math and science grades, the Math and Science Self-Efficacy Scale (Fouad, Smith, & Enochs, 1997), and the Math and Science Intentions and Goals Scale (Fouad, Smith, & Enochs).

Using structural equation modeling researchers found the social cognitive career theory model to be a good fit for both genders and found no gender differences in the relationship of constructs. Results indicated that a combination of self-efficacy, interests, and outcome expectations influenced goal intentions in math and science domains regardless of gender, social support, or cultural identity (Navarro, Flores, & Worthington, 2007).

An extension of these findings was a study on the constructs of self-efficacy, interest, outcome expectations, and choice goals across vocational fields with Portuguese high school students. Six hundred students preparing for advanced studies in fields such as engineering and architecture participated in a series of measures targeting self-efficacy, interest, outcome expectations, occupational influences, social supports, and barriers. These constructs related to specific career influences with items classified into 42 occupations with seven representing each of the Holland themes. Of the participants, 55% were female and 45% were male (Lent, Paixão, Silva, & Leitão, 2010).

Data analysis progressed from structural equation modeling in which the relationship between self-efficacy and outcome expectations impacted occupational considerations with interest as a possible mediator. In addition, researchers considered the influence of social supports and social barriers on occupational selections for each of the six Holland themes (Lent, Paixão, Silva, & Leitão, 2010)

Lent, Paixão, Silva, and Leitão (2010) posited that self-efficacy and outcome expectations predicted interest regardless of the six Holland themes. Further, there was a strong relationship between self-efficacy and outcome expectancies in all occupational categories. The conclusion drawn was that when an individual has a strong belief in their capabilities in a specific domain, and they perceive favorable results for their efforts, interest for developing the skill is greater. Social support and barriers had indirect effects on occupational considerations. Findings from this study corresponded with previous work on social cognitive career theory in that there was a strong relationship between

self-efficacy, interest, outcome expectancies, and choice goals (Lent, Paixão, Silva, & Leitão).

Collectively, the body of work related to social cognitive career theory demonstrates the interconnection between self-efficacy, interest, outcome expectations, choice goals, and academic achievement as applicable to the field of vocational planning. Despite varying settings, cultural and biological influences, and research frameworks, the interplay between these constructs has been replicated consistently. As a result, a viable extension to these studies is the impact of informal natural science learning within a social cognitive career theory perspective.

Social Cognitive Career Theory and Informal Natural Science Learning Settings

Self-Efficacy and Environmental Attitudes. Within the environmental education literature, there has been a variety of studies which examine the impact of informal learning activities on self-efficacy and affect. Bandura (1997) cites affect as a component of physiological states, one of the sources of self-efficacy. Affect, a component of mood, influences an individual's self-efficacy in specific contexts. As self-efficacy relates to an individual's beliefs about their abilities, Meinhold and Malkus (2005) analyzed the relationship of adolescent environmental behaviors and self-efficacy. In an empirical study of 848 students on the west coast, researchers found a correlation between attitudes related to conservation efforts and behavior. In addition, environmental content knowledge was a significant moderator between attitudes and behavior in terms of environmental concerns.

Similarly, in a British study of children and parents in an environmentally oriented group known as the Woodcroft Folk, researchers studied the impact of community based, informal environmental training and self-efficacy. The particular emphasis was on studying how this contextual setting influenced children's self-efficacy beliefs and their capability to control global warming. The organization supports over 18,000 members in the United Kingdom. From this population, a sample of 82 children and 57 adults participated in a survey. The comparison group included 59 children not involved in environmental training outside of school (Devine-Wright, Devine-Wright, & Fleming, 2004).

Children from the Woodcroft Folk sample had a greater sense of their capability to alter global warming as compared to children who did not participate in the group activities. In addition, Woodcroft Folk children perceived themselves to have a greater responsibility for conserving energy and using renewable energy sources in contrast with the comparison group. Researchers cited the experiences of environmental training in community oriented learning settings as having a positive impact on children's self-efficacy in terms of personal preparedness to protect natural resources. Data revealed children trained in personal responsibility had much higher levels of self-efficacy in impacting the natural world as compared to peers who had not received training outside of school. The implications of this study are that children who are engaged in less passive experiences related to environmental studies have an educational foundation rooted in competence and steered by high levels of self-efficacy (Devine-Wright, Devine-Wright, & Fleming, 2004).

Citizen Science and Scientific Observations. Originating in the 1880s, inquiry based instruction drives citizen science activities which provides information to scientists. Citizen science programs include volunteers who collect data for scientific database and often impact resource management decisions (Sutton, 2009). These contributions are essential for professional studies which encompass species population in widespread regions (Snäll, Kindvall, Nilsson, & Pärt, 2011). Citizen science programs shape adolescent self-perceptions about their capabilities in the science realm (Bombaugh, 2000). Further, one pilot program indicated that a citizen science program positively influenced student self-efficacy in terms of mastery performance, intrinsic interest, and career motivation (Hiller, 2012a). Other citizen science studies found a heightened level of cognitive development for participants (Brossard, Lewenstein, & Bonney, 2005; Crall, 2010; Harrison, Underhill, & Barnard, 2008; Sutton, 2009).

Pivotal in citizen science programs, scientific observations from the natural world provide specific knowledge about behaviors and interactions within a particular context (Cartwright, 1999). Often scientific observations are in the form of measurements which create a representation of the natural environment (Cartwright, 1989). As a result, scientific observations steer findings and are a key component to the development of expert field scientists (Eberbach & Crowley, 2005). Specifically, scientific observation skills require a synthesis of sensory information along with content understanding and include skills such as counting, classifying, collecting, and measuring (Cartwright; Eberbach & Crowley; Hiller & Reybold, 2011). Further, self-efficacy for classification

and measurement has been correlated with the mastery experiences, a source of self-efficacy (Hiller, 2012a).

Citizen Science, Science Literacy, and Content Knowledge. Within the last decade, several citizen science studies examined the impact of ornithological contributions on individual's content knowledge, science process skills, and attitudes for the environment (Brossard, Lewenstein, & Bonney, 2005; Trumbull, Bonney, Bascom, & Cabral, 2000; Trumbull, Bonney, & Grudens-Schuck, 2005). The first of these studies examined 700 letters of participants affiliated with the Cornell Laboratory of Ornithology citizen science program. Through the use of qualitative methods, a categorization system described the thinking processes of participants. The outcome of this study was to show that participants were engaging in scientific thought processes to varying degrees. From these findings researchers were not able to determine if the citizen science program directly affected these thought processes; however, this study generated information about the range of science inquiry among citizen science volunteers (Trumbull, Bonney, Bascom, & Cabral).

A subsequent extension to this first study centered on the impact of Classroom Feeder Watch on middle school inquiry and content knowledge development. One aspect of the evaluation of the newly created citizen science curriculum was to assess whether middle school students demonstrated gains on scientific processes following ornithological data collection (Trumbull, Bonney, & Grudens-Schuck, 2005).

The applied measures for this study included a pre and post content measure on bird biology, changes in attitudes about scientific work, and inquiry knowledge. There

were two open ended questions related to bird identification skills and research design skills. Participants ranged from fifth to seventh grade totaling 528 participants on the pre measure and 451 participants on the post. Although there were gains on the content measure, researchers found that the data did not support the hypothesis that the Feeder Watch program influenced inquiry learning. These results were attributed to the lack of training by way of scaffolding to support independent inquiry skills (Trumbull, Bonney, & Grudens-Schuck, 2005).

Concurrently, Brossard, Lewenstein, and Bonney (2005) studied changes in content understanding, attitudes towards the environment, and knowledge of scientific processes following participation in the Birdhouse Network of the Cornell Laboratory of Ornithology. Pre and post measures assessed the impact of this program with samples taken from 798 adults involved in the citizen science program. Researchers developed a measure to assess gains in content knowledge. A modified version of the Attitude Toward Organized Science Scale (National Science Board, 1996) measured views on science. One subscale from the New Environmental Paradigm Scale (Dunlap & Van Liere, 1978) assessed attitudinal changes towards the environment. As in other ornithological citizen science study, the program impacted content knowledge but did not influence attitudes toward the environment or science process development (Brossard, Lewenstein, & Bonney).

A study situated in Minnesota and Texas incorporated partnerships with teachers, students, and scientists. This program trained middle and high school teachers as team members with some of their own students. Teachers and students participated in a two

week training period centering on the migration patterns of the monarch butterfly. While studying in Minnesota and Texas, teams of teachers and students worked together in creating investigations in monarch related research problems. The teams received training and feedback from scientists in the field and in the classroom. During the hiatus of training sessions which occurred in the spring and fall, teams of students and teachers continued study by participating in the Monarch Larva Monitoring Project. All teams of teachers and students monitored monarch butterflies in their region and contributed their observations to the citizen science database. Teachers and students used high levels of content knowledge both in science and mathematics using statistical tests such as *t*-tests and chi square analysis. In addition, high standards of teams' research reports resulted in several rewrites. Results indicated increased levels of content knowledge and self-efficacy for teacher/student collaborative teams (Jeanpierre, Oberhauser, & Freeman, 2005).

Cronje, Rohlinger, Crall, and Newman (2011) created a pilot to measure to assess the impact of a citizen science program on science literacy. Fifty-seven participants completed the Science and Engineering Indicators (National Science Board, 2008) used previously by Brossard, Lewenstein, and Bonney (2005) and four items related to science literacy following a two day citizen science program on monitoring invasive plants. In addition, 90 individuals served as the control group by completing the same measures via mail without participating in the intervention.

Results from the invasive plant monitoring study found that pre measures were the same for the treatment and comparison group. Further, there were no main effects for

groups based on the Science and Engineering Indicators (National Science Board, 2008). There were main effects between the two groups on the four items related to science literacy. From this pilot study, researcher concluded that the citizen science program on invasive plant monitoring did positively influence science literacy (Cronje, Rohlinger, Crall, & Newman, 2011).

Another study based on invasive plant monitoring, tested the effect of a citizen science program on science literacy, content knowledge, and attitudes towards the environment. Adult participants completed a series of measures to assess science literacy, content knowledge including the Attitude Toward Organized Science Scale (Brossard, Lewenstein, & Bonney, 2005), the Science and Engineering questions related to the behaviors of scientists at work (Brossard, Lewenstein, & Bonney; National Science Board, 2008), an environmental attitude survey known as the New Environmental Paradigm (Dunlap and Van Liere, 1978; Dunlap and et al.,1992), and open ended questions on science literacy, and a content measure (Crall, Jordan, Holfelder, Newman, Graham, & Waller, 2012).

The treatment group consisted of 166 adult participants while the control group included 48 adults. The results of this study supported previous research in that there were minimal changes in science literacy and environmental attitudes due to the short duration of the activity. However, individuals engaged in the citizen science program demonstrated higher science literacy with context specific measures and content knowledge (Crall, Jordan, Holfelder, Newman, Graham, & Waller, 2012).

Citizen Science, Interest, and Motivation. Several citizen science research studies in the last decade centered on the impact of a citizen science intervention on science literacy and content knowledge. Using an alternative framework, a mixed method study examined the impact of a citizen science program known as *ebird* on student cognitive processes, autonomy, competence, relatedness, and motivation for fifth, seventh, and eighth grade students. Tomasek (2006) analyzed whether citizen science curriculum related to inquiry instruction, and its influence on student belief systems. One hundred thirty-seven participants including 22 fifth graders, 70 seventh graders, 45 eighth graders, and three teachers participated in a series of self-report surveys and focus group interviews. The piloted 25 item scale established a Cronbach's alpha of .89 and six factor loadings.

Quantitative results revealed correlations between autonomy, competence, relatedness, and motivation. Of these factors, there were main effects in motivation following the citizen science program. In terms of cognitive development, statistically significant main effects in observation skills occurred based on gender and by grade level in terms of explaining results. Findings from cognitive processes indicated that the citizen science curriculum was reflective of authentic scientific inquiry. However, two-thirds of the students did not develop high levels of self-efficacy related to their competency for performing citizen science activities (Tomasek, 2006).

Interest, a central component of motivation, was the focus of study in a citizen science research study based on plant phenology through the Sequoia and Kings Canyon National Park which examined the impact of a citizen science intervention on scientific

literacy, interest and attitudes. Forty-nine, fifth grade students received training by field experts within their classroom to study climate changes through field work related to plants. Of the students enrolled in the school, 95% were of Hispanic origin and 70% were English language learners. Following classroom instruction, students had the opportunity to work with field expert journaling and making observations for two months. In order to prepare for plant phenological data collection, students identified plants, studied insect interaction, and practiced handling observational tools (Sutton, 2009).

Results from the mixed method study indicated that student literacy, interest, and affect was positively influenced based on the intervention. Sutton (2009) found that student use of technical terms and understanding of scientific processes was accurate over 75% of the time in journal writing samples. Further students demonstrated a keener sense of interest in plant studies and protection of the environment based on journaling and survey results.

Citizen science studies have analyzed the effect of collaborative field work experiences on content knowledge, science literacy, science processes, motivation, and attitudinal changes. This focus is relevant as citizen science programs influence student perceptions about their capability to participate in scientific activities and as partners with scientific professionals (Bombaugh, 2000). Though adults more often participate in citizen science programs, field experts claim that children's observation skills often surpass those of adults (Hiller & Reybold, 2011). By including children in data collection, possibilities arise to set a precedent for science oriented career paths (Bombaugh).

Through science literacy and content knowledge gains, citizen science literature supports the development of mastery experiences which foster self-efficacy. In turn, heightened self-efficacy shapes career decisions (Luzzo, Hasper, & Albert, 1999). Access to an expert mentor improves an individual's performance, motivation, and self-efficacy (Day & Allen, 2002). The basis of social cognitive career theory and informal natural science learning setting literature intersect in terms of the influence of modeling to foster career motivation.

Citizen Science and Social Cognitive Career Theory. Self-efficacy stems from the perception an individual has about personal abilities and can greatly impact a person's resiliency for difficult tasks. In addition, modeling by an expert can help to enhance an individual's self-efficacy. Bandura (1997) posited that there are four main sources of self-efficacy; mastery experiences, vicarious experiences, social persuasion, and physiological states. Of these four factors, mastery experiences in which an individual develops high skill level, has been shown to affect academic achievement (Britner & Pajares, 2006). Developing strong observation skills during field work is reflective of mastery experiences in which an individual develops fine grained skills through the use of modeling. Social persuasion is a third aspect underlying self-efficacy and relates to confidence and support from surrounding individuals. The fourth source of self-efficacy relates to physiological status, anxiety, and negative emotional reactions (Bandura).

Scientific observation skills steer mastery and vicarious experiences during field work (Bowen & Roth, 2007; Eberbach & Crowley, 2009; Hiller, 2012a). In the first instance, students collaborating with naturalists become immersed in behaviors

associated with effective data collection practices (Bowen & Roth). Through modeling and emulation students master skill sets while developing self-perceptions of competence in comparison to trained experts (Britner & Pajares, 2006; Kitsantas, Zimmerman, & Cleary, 2000). This particular support is pivotal when considering that there is a striking difference between the use of observations skills by professional biologists, students, and teachers. Whereas students and teachers focus on specific structures within an environmental context, scientists connect observations to structures, behavior, and functions to form multi-dimensional conceptual understanding (Hmelo-Silver & Pfeffer, 2004). Without systematic training, student observations have limited applications (Eberbach & Crowley, 2009).

Previous qualitative research of naturalists' perceptions of effective environmental education emphasizes scientific observation skills and the positive impact of outdoor learning and citizen science on student affect. Fifteen participants ($n = 15$) across a 270 mile geographical range participated in semi-structured interviews based on field expert's perceptions of effective environmental education practices particularly related to citizen science programs (Hiller & Reybold, 2011).

Through the use of a constant comparative analysis approach data revealed that field experts placed emphasis on promoting positive affect and scientific observation skills. Field experts cited scientific observations skills such as classifying, counting, measuring, and collecting as critical science processes within natural studies. From their perspective, citizen science provided the opportunity to develop these skills and promote

affect, a source of self-efficacy, through field expert modeling and instruction (Hiller & Reybold, 2011).

Few studies have examined the impact of outdoor learning in citizen science programs in terms of career paths. One mixed method pilot study analyzed the effect of a horseshoe crab citizen science program on student self-efficacy, task interest, and career motivation. Participants included 12, eighth grade students ($n = 12$) from a public middle school who received instruction on horseshoe crabs during 24 one hour sessions as part of a career development program. As a culminating project, students collected data on horseshoe crabs to assist a biologist with exploratory research and to participate in a mock survey reserved for adults. Specifically, students focused on measuring the interocular, the distance between the eyes. Students identified the horseshoe crabs by gender and relative age as well (Hiller, 2012a).

Data collection included pre and post surveys which encompassed the vicarious and mastery subscales of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006), a pilot Citizen Science Self-Efficacy Scale (Hiller, 2012a), and an interest scale modeled after Zimmerman and Kitsantas (1997) and based on student preferences for outdoor activities such as drawing, collecting seashells, or studying horseshoe crabs. Participants engaged in semi-structured interviews and were videotaped and audio taped during protocol training and horseshoe crab studies (Hiller).

Data analysis stemmed from descriptive statistics, pairwise t -tests, Pearson correlations, and Wilcoxin tests. Results indicated that there were correlations between the pre and post results for the Mastery subscale, the Vicarious subscale, and Task

Interest. Further there was a correlation between the post Mastery subscale and post Classification subscale. Based on the pairwise *t*-test, the results indicated a statistically significant difference between participant responses on pre and post items for the Mastery subscale of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006) and for the Measurement subscale on the Citizen Science Self-Efficacy Scale (Hiller, 2012a). A Wilcoxin test was conducted to evaluate whether there were significant differences among participant responses in pre and post scale responses. Findings from the Sources of Science Self-Efficacy Scale (Britner & Pajares) indicated a main effect between pre and post mastery experiences (Hiller). Qualitative results illuminated the impact of the activity on self-efficacy. Overall, the participants felt that the experience improved their science skills. Another finding related to the emergent theme of trust via collaborative efforts as participants articulated the impact of being included in scientific research. The experience to collect data for a meaningful purpose influenced participants' perceptions about their abilities and possible career paths. Following the activity, all of the participants indicated that they would consider participating in a citizen science program again (Hiller).

The implications of this pilot study were that the citizen science program specifically influenced the mastery subscale of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006) which has been found to be the dominant influence on academic achievement. Further, this study aligned with previous literature on social cognitive career theory in that the intervention influenced the constructs of self-efficacy

and interest. This study was one of the first to analyze constructs related to social cognitive career theory within a natural science context (Hiller, 2012a).

A limitation within the social cognitive career theory literature is the absence of qualitative findings. Predominantly the relationship between self-efficacy, interest, choice goals, and outcome expectations has been analyzed through structural equation modeling. In general, a variety of studies have examined this relationship by altering the mediator and outcome variables often with the backdrop of Holland themes to analyze the effect of these variations by subject field. Although this method captures the dynamics among constructs, incorporating qualitative data further examines the complexity of these variables and their influence on individuals particularly in terms of self-efficacy, interest, and career motivation.

Various studies have focused on the relationship between self-efficacy, interest, outcome expectations, choice goals, academic achievement, social supports, and barriers with vocational themes as an underlying component. Citizen science studies have targeted content knowledge, science process skills, and attitudinal changes for science and the environment. At this point, few studies have incorporated social cognitive career theory within the context of learning in the outdoors with the support of field experts.

Future projections cite societal pressures for maintaining local environments as the impetus to an increase in an environmentally oriented labor force (U. S. Department of Labor, 2012b). Based on upcoming demands for field experts, studies which analyze social cognitive career theory in natural science learning settings are timely and relevant.

Gender Differences and Vocational Science Interest. A key consideration in the research design of this study relates to gender differences. There are conflicting findings on gender and academic achievement based on a variety of contexts (Matthews, Morrison, & Ponitz, 2009). Gender differences have been found to have an interaction effect with variables such as academic achievement, motivation, and choice goals. Specifically, peer relations influence teenage females (Wigfield & Wagner, 2005). Other studies have found that gender is not a mediating factor in terms of social cognitive career theory (Navarro, Flores, & Worthington, 2007). Gender inconsistencies remain in previous literature related to self-efficacy, academic achievement, and motivation. Due to the discrepant nature of gender results within literature related to self-regulation and motivation, and limited gender information within informal natural science learning literature, no gender differences were expected within the current work.

Several studies cited no gender differences in terms of competencies or general science interests. However, interest in specific occupations differ by gender across subject domain (Hannover & Kessels, 2006) and significantly diverge from kindergarten to twelfth grade with females preferring biology whereas males demonstrate an interest for physics and technology (Baram-Tsabari & Yarden, 2011). Further, the sense of competence for both males and females greatly influences occupational interests and career paths (Lent, Tracey, Brown, Soresi, & Nota, 2006).

Buccheri, Gürber, and Brühwiler (2011) examined gender differences for science vocational interests across cultural backgrounds. Their study included high performing students from Korea, Australia, and Switzerland to represent the geographical regions of

North East Asian, Anglo-Saxon, and Germanic cultures. Finland, the highest performing country, represented the Nordic students. The sample included 7,819 students from the four countries with 3,403 females and 4,416 males.

In order to analyze student interest in specific domains across gender and cultural contexts, data were analyzed from the 2006 PISA questionnaire using cross table analysis, independent *t*-tests, and point-biserial correlation tests. In Finland and Switzerland, females expressed a greater interest in biology whereas males preferred chemistry and physics equally over biology. In Korea and Australia there were no statistically significant differences in preferences for chemistry. Korean and Australian females preferred biology over chemistry and physics. Australian males preferred physics and chemistry over biology. Korean males preferred biology and chemistry equally over physics. In terms of vocational intentions, 91% of males selected computer science. A significant portion of males selected engineering and architecture as well. Researchers did not identify a trend for females among the four countries. Finnish and Swiss females favored medical occupations. In Australia and Korea, medical preferences were equivalent across gender. Other scientifically oriented technical fields were dominantly selected by Finnish and Swiss females and Korean and Australian males. Overall, the results indicate that interest in biology corresponds with pursuits in the medical field resulting in a saturation of females in medical occupations and underrepresentation in other technical fields such as engineering and computer science worldwide (Buccheri, Gürber, and Brühwiler, 2011).

One way to examine the progression of gender gaps in science interest through primary and secondary school interest was to study the types of questions children asked in four different websites in the United States and Israel. Over 7,000 questions were coded by group grades of kindergarten to third grade, fourth grade to sixth grades, junior high, and senior high. Subsequently, questions were coded based on subject domain and representations of metacognitive levels. Concurrently, 526 Israeli students in fourth through twelfth grade completed questionnaires in which students developed science questions they thought were interesting and in a second section, selected intriguing questions (Baram-Tsabari & Yarden, 2011).

Based on chi-square tests and the Minkowski distance (Weisstein, 2009), between each grade and domain group, researchers concluded that female and males science interest developed differently over time. In younger grades, there were no gender differences and males and females had similar interest in biology. Both males and females continued to increase the level of biology related questions in middle school. By high school, both gender groups had increased interest in biology with males at 39.4% and females at 57.8% (Baram-Tsabari & Yarden, 2011).

In terms of technology, male interest fluctuated across grade levels while female interest decreased. Males and females asked more questions about chemistry as they grew and less about astrophysics. Females tended to request information about ethology, botany, biology and health care where males showed greater interest in mathematics, physics, and technology. Male questions related to process whereas females focused on open ended questions. In general male interest for the sciences was twenty times greater

than that of females (Baram-Tsabari & Yarden, 2011). These findings correspond with gender related studies in that career decisions and interest for vocational choices strongly develops in high school (Quinn & Lyons, 2011). In fact, interest is an overriding factor in motivation as compared to gender differences or positive feedback. Those individuals with interest in a specific domain are able to perform regardless of a lack of positive instructional support or gender (Katz, Assor, Kanat-Maymon, & Bereby-Meyer, 2006).

Self-efficacy and self-concept are influential determiners of student career paths in high school. To examine gender differences in terms of career choices, Quinn and Lyons (2011) analyzed responses on a survey based on career intentions. Three thousand eight hundred, 15 year old Australian students completed the survey. Data were analyzed using hierarchal regression. Although males and females expressed similar enjoyment for the sciences, males related science to other fields more often and had higher self-efficacy. Researchers concluded that some females did not enjoy science less than males but rather preferred other subjects. One way to counter low self-efficacy for females was through positive interaction with instructors (Quinn & Lyons).

As career interests develop in high school (Baram-Tsabari & Yarden, 2011; Quinn & Lyons, 2011), citizen science programs offer the potential of developing interest in biological studies that differs from formal classrooms. Specifically, as females tend to prefer biological studies (Buccheri, Gürber, and Brühwiler, 2011), citizen science is a natural extension to previously cultivated interests. Concurrently, citizen science programs have the potential to motivate students in engineering fields (Bombaugh, 2000). As a result, citizen science programs offer possibilities for encouraging students with a

variety of interests and backgrounds to consider science related professions. The purpose of the present study was to examine the impact of a horseshoe crab citizen science program on student self-efficacy, interest, outcome expectations, choice goals, and academic achievement within a social cognitive career theory framework.

Research Questions

1. How does involvement in a horseshoe crab citizen science program affect self-efficacy, interest, outcome expectations, choice goals, academic achievement and career motivation in a social cognitive framework?
2. Are there differences in these effects based on gender (male and female) and treatment versus comparison groups?
3. How does a citizen science experience influence children's perceptions of their science abilities and career trajectories?

CHAPTER 3

METHOD

The current study centered on a specific citizen science program which supports population studies of horseshoe crabs along the eastern coast of the United States. For this mixed method quasi experimental study, the treatment group collected data to help scientists study horseshoe crabs. In order to assist with data collection, the participants counted horseshoe crabs during the spawning season, identified males and females, determined relative age, and measured the interocular distance. The comparison group did not have exposure to the intervention. Eighth grade students from both groups participating in this research, learned about ecological niches in their geographical region based on state curriculum standards. The comparison group had instruction within a formal classroom setting. Although these participants did not work with field experts in the outdoors, their instructor was familiar with data collection for horseshoe crab surveys and incorporates this instruction within the classroom setting. Both groups received instruction through a PowerPoint developed by a professional field expert. The purpose of this research design was to analyze the effect of a horseshoe crab citizen science project on student self-efficacy, interest, choice goals, outcome expectations, academic achievement, and career motivation in a social cognitive career theory framework.

Participants and Setting

Participants for this study ($n = 86$) were students in eighth grade from two public schools in the northeast region of the United States. The students in the treatment group ($n = 46$) assisted a professional scientist with exploratory research focusing on speciation issues related to horseshoe crabs while some students in the treatment group simultaneously participated in a mock survey. The comparison group included 41 students ($n = 41$). The average age of the participants was 13.69 years, $SD = 1.51$. Males and females comprised 43% and 57% of the participants respectively. The racial/ethnic distribution was 30.2% African American, 57% European American, 1.2% Asian American, 4.7% Latino American, and the remainder of participants identified themselves as “other.” Both schools located in the same town within one mile from each other, focus on developing student career paths through an additional morning program, and the science teachers followed the same science curriculum outlined by the state.

Applying an a priori power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) with an alpha level of .05, a power of 0.95, and an effect size of .35, the sample which would provide adequate power to reject the null when it is false was 79 participants. As this study included 86 participants from both the treatment and comparison groups, the sample provided suitable statistical power to analyze measures.

Research Design

A mixed method quasi experimental design captured the effect of the citizen science intervention on self-efficacy, interest, outcome expectations, goals, academic achievement, and career motivation. A variety of methods highlighted the relationship

and nuances of these constructs. The mixed method component of the study was an interactive dialogue in which qualitative and quantitative findings influenced each other. This approach is preferable to a fragmented, sequential approach (Maxwell, 2005). For example, a qualitative study informed the design of the Citizen Science Self-Efficacy scale (Hiller, 2012a, 2012b; Hiller & Reybold, 2011). Semi-structured interviews illuminated the relationship between constructs and the impact of the intervention in a way that is not always visible from statistical analysis (Greene, 2007). The degree to which scientific observations influenced the study was examined by way of a self-efficacy scale, an event measure, and interviews. By creating a dialogue between the two methods, an enhanced basis for credibility emerged (Patton, 2002). Due to the number of variables in this work and the length of the document, a concern was that a braided dialogue between two methodological viewpoints would be difficult to follow. For this reason, methods and results have been described separately in quantitative and qualitative sections and are dually considered in the discussion.

The participants spent two semesters examining different areas of interest before selecting a program for a third semester. Within each semester, individuals met for 12 weeks on Thursday mornings from 7:30-8:30. Some individuals participating in the study selected a horseshoe crab citizen science program for their third semester. A culmination project for the third semester was to engage in collecting data for scientific research. The purpose of collecting horseshoe crab data is to assist a professional biologist in exploratory studies on proportional relationship between the length of horseshoe crabs and the interocular distance. Through this work, students contributed to an understanding

of a decline in the horseshoe crab population and potential speciation differences. In addition, some students participated in a mock citizen science program generally reserved for individuals over 18 years old. Generally twelve to eighteen students sign up for one of the three semesters. For the present study, all eighth grade students received an invitation to participate in the horseshoe crab field trip. Of the individuals in the treatment group participating in the study, 64% did not receive training in horseshoe crab measurement protocol prior to the field experience during the talent development program.

Participants in the comparison group ($n = 41$) were eighth grade students from a suburban school in the same district. Students in the comparison had a teacher who oversees a citizen science horseshoe crab talent development class for approximately 15 students. The participants of the comparison group were students from the eighth grade science course who learned about horseshoe crabs within the neighboring ecological niche without access to field work. Out of the comparison group, 98% of students did not participate in the horseshoe crab talent development program. The population demographics of both groups were nearly identical. The eighth grade science teacher invited students to participate in the comparison group and received extra credit for homework. Survey administration occurred at the school site. The self-efficacy scales were given prior to the PowerPoint discussion whereas the content measure, the outcome expectations, task interest, and career goals scales were given following the presentation.

The setting for the treatment group included a public school in the northeast, two national park facilities, a local naturalist center, and a private beach. Students received content knowledge training in all locations. Protocol training occurred at one of the park

facilities and the private beach. Due to the high tide cycle which only allowed one event to access horseshoe crabs, some students participated in data collection for a biologist while others collected data for a mock survey in the early evening. Both groups received direct instruction from a naturalist. Students in the treatment group completed a pre content measure one week prior to the field trip. Students completed the pre self-efficacy scales on the morning of the field trip prior to instruction at the park facility. Following the horseshoe crab intervention, the treatment participants completed a post content measure, task interest, outcome expectations scale, and choice goal scale at the same park facility.

Intervention

The intervention consisted of training, modeling, and participation in a citizen science program related to horseshoe crabs. Since data validity is a central consideration in citizen science programs, consistent protocol is essential in the instruction of volunteers (Snäll, Kindvall, Nilsson, J., & Pärt, 2011). During the training, the field experts taught students about horseshoe crab anatomy, life cycles, and interactions within the ecological niche through discussion and modeling. Students emulated data collection techniques under the supervision of the field experts. Finally students collected data to contribute to scientific studies independently in teams of two. During this type of intervention, the sequence of skills involves content knowledge, demonstration and replication of data collection techniques, and an application of the skills through horseshoe crab data collection.

In the initial session a field expert trained students on handling horseshoe crabs, the anatomical structure of horseshoe crabs, the interaction of the organisms within the ecosystem, and collecting measurements suitable for a database through a PowerPoint discussion. Students conducted a lab to analyze how Limulus amoebocyte lysate (LAL), a reagent from copper rich horseshoe crab blood, detects the presence of bacteria. Following the morning session, students visited a naturalist center to learn more about horseshoe crabs through interactive displays and handling small horseshoe crabs in an aquarium. In the afternoon, students received additional instruction on protocol for collecting data. The teacher separated students into one of two groups; those individuals collecting data for a professional biologist conducting exploratory research on horseshoe crab speciation and individuals collecting data for a mock survey. Data collection focused on measuring and recording the interocular distance, identifying gender, and relative age of horseshoe crabs. All teams received individualized training from a field expert. Participants collected data for approximately one and a half hours. As participants worked, the field experts monitored the accuracy of data collection. Following the evening session, students analyzed their data and learned how the information assisted the professional scientists in studying horseshoe crab population.

Quality and Ethics

I first became aware of the learning potential of the natural sciences when I served as the liaison between Loudoun County Public Schools and The Smithsonian's National Museum of Natural History. During this time frame, I became involved in managing and protecting a collection of 36,000 natural specimens. In addition, I planned field trips for

nearly 20,000 students and oversaw a specimen loan collection for teachers. After this experience, I began to use specimens extensively in my math and science instruction when I returned to the classroom. In addition, I began to incorporate the outdoor classroom as part of my curriculum.

In retrospect, I realize that the natural sciences have been a consistent component in my life as a child, in my personal academic development, and as a practitioner. When I was a child, I often went camping. In addition to family trips, I spent time in the outdoors in Massachusetts and then in Belgium. During these excursions, I would compare the plants from the two areas informally. Subsequently, when I entered college, quite a few of my electives related to geology. I continued this pattern in my master's program while training in science curriculum.

As a researcher, my subjective lens has been shaped by my experiences as a child and through my personal training with natural specimens. From my perspective, the natural world affords a wide range of learning opportunities. Based on my experiences, I bring some underlying assumptions to this dissertation. My perception is that the natural sciences should be as prevalent a course offering as chemistry and physics within the school curriculum. In addition, working with scientists on substantial projects allows students to extend their academic skills while potentially reshaping self-beliefs about their capabilities. The opportunity to participate in authentic scientific study is an experience which is difficult to mimic in a formal classroom structure. This perspective steers the quality of the present research design in terms of examining meaning, social contexts, and processes within a specific outdoor context.

According to one study of naturalists' perceptions of effective practices in informal settings, there is some debate as to whether children are capable of collecting data that is valid. Many of the naturalists concur that given specific protocol, children's observation skills are an asset to professional scientific databases (Hiller & Reybold, 2011). As a result, I selected the horseshoe crab citizen science project because there are limited groups of children participating in citizen science, particularly as part of a formal school program. Secondly, the participants received specific protocol from field experts which is the cornerstone of quality specifications in citizen science programs. Finally, this group is of particular interest because they collected data for a professional scientific database examining the decline of horseshoe crab populations and speciation issues. This alliance with scientists to solve a tangible world problem provides a context which may be particularly potent in developing science skill self-efficacy, interest, choice goals, outcome expectations, academic achievement, and career motivation.

A component of qualitative studies with layers of data analysis is theoretical sensitivity; a process which encompasses self-reflection in order to draw comparisons and extend thought processes (Charmaz, 2006). Using theoretical sensitivity, I monitored my interpretations of participants' viewpoints through reflexivity as a self-awareness strategy (Guba & Lincoln, 2005). In particular, I considered the research choices I made including the individuals I contacted to conduct this study. The group I selected to work with was in an unfamiliar region, there was access to a citizen science program with field experts, and the school administrators and teachers had a prior history of engaging in career path development as part of the school structure in informal natural science

learning settings. To offset reactivity by the participants, I used recordings rather than observational notes during the protocol training and event measure observations. To ensure individual privacy, I assigned a pseudonym to each individual and locked the transcriptions in a cabinet securely.

Data Collection Instruments

Instrument selection centered on previous literature related to social cognitive career theory. Specifically, the constructs of self-efficacy, interest, outcome expectations, choice goals, and academic achievement are sections within the six scale survey four of which are seen in Appendix A. Prior to conducting confirmatory factor analyses the assumption of multivariate normality for each observation was examined by testing for skewness and kurtosis. Generally skewness greater than 2.0 and kurtosis greater than 7.0 indicate potential difficulties in conducting confirmatory factor analysis (Dimitrov, 2012). Based on the findings, each observation fell under the cut off score for both skewness (< 2.00) and kurtosis (< 7.00).

Qualitative data sources included semi-structured interviews, and video recordings of student participation in the intervention. Event measures examined observations which focused on the accuracy of student data collection techniques.

Sources of Science Self-Efficacy Scale. According to Bandura (1997) there are four sources of self-efficacy which influence overall academic achievement. For the scale development of Sources of Science Self-Efficacy, Britner and Pajaras (2006) cite Cronbach's alpha reliability indexes as 0.90 for Mastery, 0.80 for Vicarious, 0.88 for Social Persuasion, and 0.91 for Physiological States for students in grades five through

eight. Each subscale was analyzed in terms of the influence on self-efficacy. Although there are correlations between the subscales, generally mastery experience is predictive of academic performance. Participants completed the entire scale. Questions included items such as, “My career role models (those people I want to be like) are mostly in fields that involve science,” and “Among my friends, I am usually the one who figures out science answers first.” Questions were answered using a five point Likert-type scale with options ranging from “Strongly Agree” to “Strongly Disagree.”

Citizen Science Self-Efficacy Scale. The second measure of the survey was the Citizen Science Self-Efficacy Scale which has been developed based on two pilot studies (Hiller, 2012a, 2012b). Using a five item Likert-type scale participants ranked their confidence in conducting activities like counting horseshoe crabs and taking measurements. Responses for each item ranged from five as highly confident and one as not confident. The original foundation for item development was a qualitative study of field experts’ perceptions of effective practices in learning in outdoor settings particularly as related to citizen. The naturalist research revealed a common theme of the need to develop scientific observation skills which include collecting, counting, measuring, and comparing organisms (Hiller & Reybold, 2011). For the first pilot study, two subscales emerged which included self-efficacy for measurements skills and classification skills. Test items were rewritten and administered in a second pilot study (Hiller). Based on factor loadings, one scale emerged with eight items. The measure was validated with the pilot results and the comparison group of this study for a total of 113 participants ($n =$

113). The Cronbach's alpha coefficient for internal reliability was .90. Factor loadings for each item appear below in Table 1.

Table 1

Factor Loadings for Exploratory Factor Analysis of the Citizen Science Self-Efficacy Scale (Hiller, 2012b)

Scale Item	Factor Loading
Rate how well you can conduct the activities listed below:	
Locate horseshoe crabs	.66
Count horseshoe crabs	.75
Make observations of horseshoe crabs	.88
Distinguish differences between horseshoe crabs	.78
Use a tape measure accurately	.74
Measure the distance between the eyes of a horseshoe crab accurately	.74
Distinguish horseshoe crabs from other animals	.79
Collect data for a scientist's research study	.75

Task Interest Scale. The Task Interest Scale (Hiller, 2012c) examined student preferences for outdoor activities which include analyzing water samples, bird watching, measuring horseshoe crabs, collecting seashells, and drawing. The level at which participants demonstrated an interest for each of these activities was independent of all other activities (Hiller).

Citizen Science Outcome Expectations Scale. The Citizen Science Outcome Expectations Scale (Hiller, 2012c) included six items based on outcomes related to participating in a citizen science program. Items originated from the qualitative portion of a pilot study which incorporated student motivation for participating in this type of program (Hiller & Reybold, 2011). A sample item was, “Studying horseshoe crabs will help me decide if I want to be a scientist.” The items stemmed from a 5 point Likert-type scale with five as “Strongly Agree” and one as “Strongly Disagree.” Exploratory factor analysis identified the Cronbach’s alpha at .83 as seen in Table 2.

Table 2

Factor Loadings for Exploratory Factor Analysis of Citizen Science Outcome Expectations Scale (Hiller, 2012c)

Scale Items	Factor Loading
Studying horseshoe crabs will help me understand the work of scientists.	.82
Studying horseshoe crabs will help me decide if I want to be a scientist.	.68
Studying horseshoe crabs will help me improve my science skills.	.75
Studying horseshoe crabs will help me improve my science grades.	.70
Studying horseshoe crabs helps me to understand their ecological niche.	.66
Studying horseshoe crabs helps scientists with their work.	.81

Career Related Goals Scale. In line with social cognitive career theory, Mu (1998) developed the Career Related Goals scale to measure goal setting of individuals related to career planning. Participants responded to items centering on how much

participants agree or disagree with statements on a four point scale. Items included “I have a clear set of goals for my future,” and “I know what I want to do in terms of an occupation or career.” The internal reliability coefficient for the original sample of high school students was .92. In another study related to high school students and career planning, the internal reliability for treatment group one and two was .86 and .89 respectively (Roger & Creed, 2011). For the present study, Cronbach’s alpha for internal reliability was .90.

Horseshoe Crab Content Measure. The purpose of the Horseshoe Crab Content Measure (Hiller, 2012c) was to examine the impact of the horseshoe crab field experience on student academic achievement in terms of content mastery. The items were developed from a training PowerPoint used by a field expert to work with students during horseshoe crab studies (Kreamer, 2011). Items were analyzed for suitability by three middle school science teachers. The measure focused on horseshoe crab content related to identifying the following domains: form and function, cycles, and systems and interactions. In the form and function portions, students were assessed on identifying specific anatomical parts and functions of the horseshoe crabs. For example, participants determined anatomical parts of the organisms such as the telson as well as its function. The second section targeted life cycles of horseshoe crabs in which participants identified gender, mating classification, and relative age based on described situations or photographs. The third section focused on systems and interactions between organisms in the horseshoe crab ecological niche and with humans, particularly in terms of biomedical advances.

The content measure was administered as a pre and posttest with the treatment group in May following the horseshoe crab program to identify gains in content mastery. The comparison group took the content measure once in May.

Interviews. The task interest section of a second pilot study steered participant selection for this study. Interview selection centered on a purposeful sample selected based on maximized variations. The criteria for participant selection was participants demonstrating high levels of intrinsic interest and low levels of intrinsic interest on a pilot measure administered in the fall. In this second pilot study (Hiller, 2012b), participants ranked the order of preference of outdoor activities on a scale from one to five with five being the most preferred activity. Participants were interviewed based on high levels (4, 5) of interest and low levels (1, 2) of interest following the daytime field experience. The interview protocol prior to horseshoe data collection contained questions about participants' favorite subjects, possible career choices, and the opportunity to assist professional scientists with data collection. Semi structured interview questions appear in Appendix B.

Event Measure. Students' motivation and actions vary based on settings and required tasks. Event measures are a form of qualitative observational notes which captures behaviors related to required skills. Cleary & Zimmerman (2004) espouse the use of these types of measures to capture actions and self-perceptions of individuals related to a specific task. The purpose of the event measure (Hiller, 2012c) was to examine the technical and content knowledge of the participants. During the horseshoe crab data collection session, the researcher and a trained field expert observed the

students' quality of work. The accuracy of data collection was confirmed by the researcher and the field expert. Specific skills checked for accuracy included items such as measuring the interocular distance and distinguishing between males and females accurately as seen in Appendix C.

Video Recordings. Stakeholders of citizen science programs place great emphasis on protocol training to substantiate the credibility of data collection. As a result, sessions related to protocol instruction were videotaped and analyzed using a variation of constant comparison analysis approach.

Design and Procedure

The design of the study followed a mixed method quasi experimental design which encompasses both quantitative and qualitative methods. The quasi experimental portion of the design centered on a treatment and comparison group. The majority of the scales given to the treatment group followed the intervention program with the exception of the content measure and self-efficacy scales which were taken before and after the intervention. Observational notes, video recordings, and event measures were taken at the beach, and interviews occurred at the national park reserve. All data, with the exception of the pre content measure, were collected over a three day period in May. The combination of methods illuminated the impact of the intervention in a multi-dimensional way.

Data Analysis

A mixed method format in research design creates a joint dialog during data analysis. A drawback to relying solely on quantitative methods is that correlations

between the program and outcomes may be inaccurate. Another risk is that the testing instrument is so narrow that the results are not particularly meaningful (Maxwell, 2005). In contrast, qualitative results may oversimplify the context (Maxwell, 1996). Therefore, the strengths of qualitative and quantitative methodologies, and the way they influence each other, are relevant to this design (Eisenhart, 2005). The integrative methodological design was sequential as each phase of the study informed subsequent methods. By infusing a variety of methods within this study, various perspectives highlighted the impact of the intervention.

In addition, this combined methodological approach was reflective of triangulation; a strength in research design which allows consistency in data interpretation (Patton, 2002). Specifically, this study applied three forms of triangulation. Data triangulation included a variety of data sources, investigator triangulation encompassed interpretive checks by including several researchers, and methodological triangulation in that both quantitative and qualitative methodologies were applicable to this study (Denzin, 1978).

Each domain required specific attention in order to establish high levels of credibility and rigor. For the quantitative methods described below, some general assumptions which were met include independence, normality, and homogeneity. Specifically, in order to analyze data from scales the dependent scores were independent. Further, the data set was normally distributed and had a constant variance (Dimitrov, 2008).

In terms of qualitative data, Glesne (2006) recommends that a researcher reflects on their personal history to check for potential biases. The foundation of inquiry based qualitative research lies in trustworthiness of data representation and authenticity which refers to a reflexive awareness of the researcher as a testing instrument (Patton, 2002). A qualitative study developed with rigor enables individuals to view connections through the researcher's filtering systems (Hammersley, 2000). Fine (1994) claims that a researcher inherently functions as an oppressor because this individual identifies the problem, reports on the topic, and steers the quality of the work. Participants' views were monitored via my interpretations through reflexivity on a regular basis to refrain from marginalizing individuals and to curtail biases.

Quantitative Analysis

The quantitative methods in this study aimed to determine the impact of the horseshoe crab intervention on social cognitive career theory in addition to drawing correlations between constructs such as self-efficacy, interest, outcome expectations, choice goals, and academic achievement. As described by Britner and Pajares (2006), and following the example of the original developers of the Sources of Mathematics Self-Efficacy (Lent, Lopez, & Bieschke, 1991), all four subscales of the Sources of Science Self-Efficacy Scale (Britner & Pajares), the Citizen Science Self-Efficacy Scale (Hiller, 2012b), and the Career Goals Scale (Mu, 1998) were analyzed using confirmatory factor analysis via SPSS. The pilot Citizen Science Outcome Expectations Scale (Hiller, 2012c) was analyzed using exploratory factor analysis. ANOVA results showed differences on

each variable based on the citizen science intervention and pairwise t-tests may were used for comparison of test items.

An advantage of these approaches was to compare the results of three established instruments, the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006), the Citizen Science Self-Efficacy Scale (Hiller, 2012b), and the Career Goals Scale (Mu, 1998) with a piloted Citizen Science Outcome Expectations Scale (Hiller, 2012c).

Cronbach's alpha assessed the internal consistency estimates of reliability. Correlational coefficients range between zero and one, and a higher correlation was indicative of a higher level of internal reliability of a measure (Dimitrov, 2008).

Qualitative Analysis

For this present study, the qualitative methods centered on the meaning of events and activities, social context of these activities, and process related to the activities (Glesne, 2006; Maxwell, 2005). The purpose of the qualitative measures was to examine the impact of the horseshoe crab citizen science program on self-efficacy, interest, outcome expectations, choice goals, academic achievement, and career motivation. Affect is a key consideration for naturalists working with children in the outdoors (Hiller & Reybold, 2011), and the qualitative methods highlighted the perspective of children in a way that was distinctive from survey scales.

Semi-structured interviews were the foundation for developing subsequent emergent themes. Fontana & Frey (1998) recommend that in examining an organizational group, a structured interview process lends itself to encoding data. For this reason, each

interview consisted of a list of open-ended questions. A semi structured format accommodated differing types of data and promote open minded interpretations.

Data analysis centered on a variation of a constant comparative analysis approach which flows from layers of coding to form inductive, connected themes (Denzin, 2005). The benefit of this type of approach is to recognize trends in interviews and other data sources (Glesne, 2006). Data analysis included a sequence of open coding, axial coding, and emergent themes (Creswell, 2008). Open coding involved the labeling of transcripts in units. One type of initial coding called descriptive coding (Saldaña, 2009) relates to applying descriptive nouns to summarize ideas within the transcript. Descriptive coding is particularly useful when examining several data sources. The axial coding phase followed and established relationships between identified ideas in the open coding phase. The third phase in a constant comparative analysis approach is known as selective coding in which themes develop (Creswell). As a result, a clearer understanding of individuals' perspectives related to contextual situations emerges from analyzing multidimensional aspects in a given situation (Patton, 2002). For the present study, selective coding which requires data analysis and reflection between interviews was not possible due to time restrictions. Emergent themes were drawn based on comparisons from the axial phase.

A variation of constant comparative analysis approach was applied across data sources of interviews, video recordings, and event measures with an emphasis of describing training protocol, participants' reactions and motivational levels. Rather than having a specific predetermined observational protocol, recordings and interviews were coded using a modified constant comparative analysis method to allow for emergent

themes. Coding was analyzed using researcher consensus with another doctoral student studying Science Leadership. Thirty percent of the data was coded by both researchers and compared for consensus. Incorporating another researcher in coding analysis follows the tenets of Patton (2002) who espouses investigator triangulation to check for researcher bias and to further establish consistency within data interpretation.

The purpose of the event measure was to examine the accuracy with which students collected data following the training protocol. A common concern with working with individuals in a citizen science program is the validity of data collection for suitable scientific data analysis (Snäll, Kindvall, Nilsson, & Pärt, 2011). This concern may be a hindrance to the inclusion of students in data collection for professional research (Hiller & Reybold, 2011). As a result, field experts and the researcher analyzed the team data following the protocol based on interocular measurement accuracy, gender identification, and relative age dating. Results were tabulated using a frequency code as described by Saldaña (2009). Rather than using tallies to record observations, correct scores were given a “1” whereas incorrect scores earned a “0.”

The strength of the research design was the interaction between variance and process theory in steering design choices. The variance methods (quantitative) captured relationships whereas the process (qualitative) methods illuminated how variables influenced each other. An exchange of these two methods laid the progression of research design choices. The foundation for the plan stemmed from two previous studies. The first work centered on the perceptions of environmental educators on effective pedagogical practices with a strong emphasis on scientific observation skills. The second pilot study

involved the development of a citizen science self-efficacy scale rooted in scientific observation skills. The onset of the design included pre content and self-efficacy measures and a pilot study from the fall. Participant selection for the interviews stemmed from the task interest scale administered in the fall based on low and high interest. During the intervention, process theory captured the nuances between variables through observations and event measures focused on self-efficacy for scientific observation skills. Semi-structured interviews continued the sequence in capturing the relationship between processes. Post measures following the interviews aimed to capture the relationship of academic achievement, self-efficacy, task interest, outcome expectations, and career goals while analyzing gender differences and treatment and comparison differences. The continual dialogue between variance and process theory enhanced data interpretation, strengthened rigor, and offset potential validity threats as seen in Figure 4.

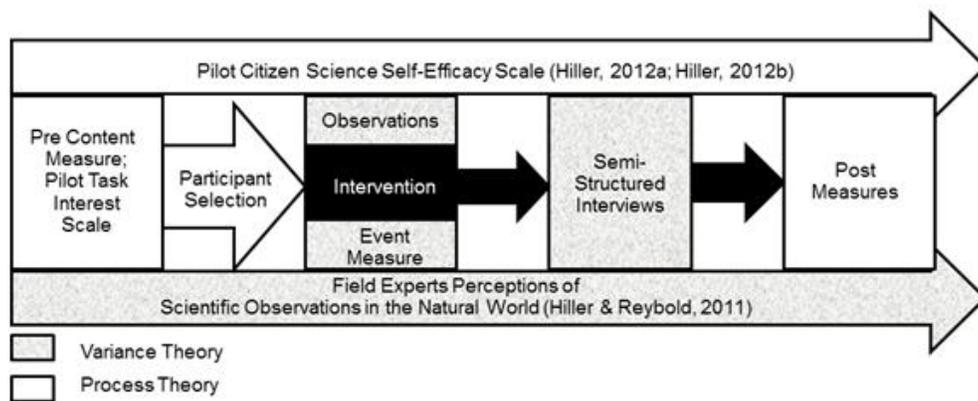


Figure 4. Research design sequence.

Validity

Validity refers to whether applied measures align with research design. Variance theory (quantitative) establishes relationships between constructs measured with

variables. In contrast, process theory (qualitative) centers on how events and behaviors influence factors within a series of events (Eisenhart, 2005). By employing both methods within this research design, the goal was to create triangulation between data sources and offset validity threats thereby checking for consistency in data interpretation (Denzin, 2005). According to Maxwell (2005), “Validity is a goal rather than a product; it is never something proven or that can be taken for granted... Validity threats are made implausible by *evidence*, not methods...” (p. 105).

Analyzing validity threats was a key component to the research design as conclusions may not correspond with actual data (Maxwell, 2005). The primary validity threats included participant sampling for variance methods and participant selection for process methods, instruments, implementation of instruments, and coding methods. The validity matrix as seen in Figure 5 examines potential validity threats which may inadvertently steer false or overstated conclusions.

<i>What type of method will I use?</i>	<i>Is this method choice base in variance or process theory?</i>	<i>What is the potential for an alternative conclusion?</i>	<i>What type of validity threat does this alternative pose?</i>	<i>What steps will be taken to reduce this validity threat?</i>	<i>Is this validity check based on variance or process theory?</i>
Method	Variance or Process Approach	Validity Concern	Type of Validity Threat	Validity Check	Variance or Process Approach
Sources of Science Self-Efficacy Scales, Citizen Science Self-Efficacy Scale, Interest Scale Citizen Science Outcome Expectations Scale, Career Goals Scale	Variance	Sample Size/Power	Statistical Conclusion Validity	Principal Component Analysis Cronbach's Alpha	Variance
		Researcher Bias	Construct Validity	Interviews Researcher Consensus	Process
Citizen Science Outcome Expectations Scale	Variance	Piloted Instruments	Internal Validity	Exploratory Factor Analysis Cronbach's alpha	Variance
Citizen Science Self-Efficacy and Intrinsic Interest Scale	Variance	Pilot Test did not have enough participants for statistical power	Statistical Conclusion Validity	Triangulation with Interview, Recordings, and Observation	Process
		Pilot Test did not have enough statistical power	Statistical Conclusion Validity	Principal Component Analysis with larger sample	Variance

<i>What type of method will I use?</i>	<i>Is this method choice base in variance or process theory?</i>	<i>What is the potential for an alternative conclusion?</i>	<i>What type of validity threat does this alternative pose?</i>	<i>What steps will be taken to reduce this validity threat?</i>	<i>Is this validity check based on variance or process theory?</i>
Method	Variance or Process Approach	Validity Concern	Type of Validity Threat	Validity Check	Variance or Process Approach
Close proximity to repeated measures	Variance	Interaction Effects	Internal Validity	Comparison to qualitative findings	Process
		Interaction Effect	Internal Validity	Comparison to previous studies	Variance
Interviews; Constant Comparative Analysis	Process	Researcher Bias	Construct Validity	Triangulation of Participant Sources	Process
	Process	Researcher Bias	Construct Validity	Researcher Consensus	Process
Observations and Recordings; Constant Comparative Analysis	Process	Researcher Bias	Construct Validity	Correspondence with findings from scales	Variance

Figure 5. Validity matrix

Sample size and participant sampling was a concern in this study in terms of variance theory. Although the 86 participants included in the study was sufficient for statistical power, an increase would allow for the inclusion of structural equation modeling in data analysis, a technique which is prevalent in the social cognitive career theory literature. Further, the students in the treatment group were volunteering to attend the horseshoe crab program. Although the participants included in the study was sufficient for statistical power, an increase would allow for the inclusion of structural equation modeling in data analysis, a technique which is prevalent in the social cognitive career theory literature. Further, the students in the treatment group were volunteering to

attend the horseshoe crab program. As a result, levels of intrinsic interest may be skewed in comparison to the general school population for both participant sampling and participant selection. A possible factor which can be an internal validity threat is interaction between the treatment and control groups (Dimitrov, 2008). By including two separate schools, this internal reliability threat was diminished.

A key factor in analyzing repeated measures is time duration between test administrations. The effect of pretesting within close proximity may alter results. Triangulation with qualitative findings and comparison to previous studies may account for potential interaction effects.

The Citizen Science Outcome Expectations Scale (Hiller, 2012c) presented an internal validity threat as a pilot measure. In order to test reliability, the results from the first scale underwent principal component analysis. Findings were compared to other tested scales and previous literature.

Three qualitative sources in this study included interviews, event measures, and video recordings. A variation of the constant comparative analysis approach was applied across data sources. A potential threat was researcher bias. In particular, qualitative findings are often incorrectly interpreted as variance processes which focus on differences and correlations. One of the primary benefits of qualitative findings is to examine meaning, context, and processes shaping events (Maxwell, 2005). In order to examine potential bias, researcher consensus was used by training another researcher in the coding methods. Both researchers followed a list of defined labels developed during the open coding phase and based on a pilot study as seen in Appendix D. The researchers

analyzed 30% of the transcriptions to examine potential validity threats. Following initial coding, the two researchers met and compared codes item by item. In addition, triangulation of methods was used to check researcher bias and potential overreliance on variance or process methods. Despite the focus on minimizing researcher bias, an individual's perspective inherently shapes interpretations (Greene, 2007). As the study unfolded, reflecting on emerging validity concerns and researcher bias was an integral component throughout the research study.

CHAPTER 4

RESULTS

Correlational Analyses

To address the research question targeting the effect of involvement in a horseshoe crab citizen science program on self-efficacy, interest, outcome expectations, choice goals, academic achievement and career motivation in a social cognitive framework, results from Pearson correlation analyses identified relations among the dependent measures which appear in Table 3. Of particular interest are the statistically significant correlations between the pre Citizen Science Self-Efficacy Scale (Hiller, 2012b) and the pre academic achievement measure ($r = .69$), the pre Mastery subscale and the pre Social Persuasion subscale ($r = .77$), the post Mastery subscale ($r = .93$), and the post Social Persuasion subscale ($r = .87$). Further, there were statistically significant correlations between the pre Social Persuasion subscale and the post Mastery subscale ($r = .79$), the post Vicarious subscale ($r = .78$), and the post Social Persuasion subscale ($r = .90$), the pre and post Anxiety subscale ($r = .81$), and the post Vicarious subscale and the post Social Persuasion subscale ($r = .79$.) In addition, there were statistically significant correlations between the pre Citizen Science Self-Efficacy Scale (Hiller) and pre and post academic achievement ($r = .69$ and $r = .46$), and outcome expectations ($r = .29$). Of particular note was the absence of a relationship among many of the variables and Career

Goals as compared to other constructs which were highly correlated. The statistically significant correlations related to Career Goals included the pre Mastery subscale ($r = .25$), the pre Social Persuasion subscale ($r = .24$), and the post Mastery subscale ($r = .36$).

Table 3

Pearson Correlations among Self-Efficacy, Task Interest, Outcome Expectations, Career Goals, and Academic Achievement

Variable	1	2	a	b	c	d	e	f	g	h	3	4	5	6	7	
1. Pre Academic	1.00															
2. Post Academic	.46**	1.00														
a. Pre Mastery	.39*	.28*	1.00													
b. Pre Vicari	.35*	.16	.64**	1.00												
c. Pre Persuas	.45**	.22	.77**	.72**	1.00											
d. Pre Anxiety	-.21	-.25*	-.59**	-.45**	-.50**	1.00										
e. Post Mastery	.44**	.34*	.93**	.61**	.79**	-.54**	1.00									
f. Post Vicari	.35*	.45**	.76**	.84**	.78**	-.43**	.77**	1.00								
g. Post Persuas	.42**	.28	.85**	.69**	.90**	-.45**	.87**	.79**	1.00							
h. Post Anxiety	-.20	-.33*	-.27	-.31	-.33*	.81**	-.38*	-.43**	-.44**	1.00						
3. Task Interest	.29	.11	.32**	.48**	.44**	-.08	.49**	.50**	.46**	-.03	1.00					
4. Pre CSSSS	.69**	.46**	.42**	.32**	.44**	-.21	.61**	.51**	.58**	-.26	.52**	1.00				
5. Post CSSS	.63**	.26	.42**	.43**	.49**	-.32*	.45**	.32	.49**	-.27	.28	.64**	1.00			
6. CS Out. Exp.	.36*	.29**	.39**	.54**	.51**	-.19	.54**	.49**	.38*	-.10	.54**	.36**	.30*	1.00		
7. Career Goals	.19	.02	.25*	.17	.24*	.02	.36*	.21	.35	-.10	.02	.08	.22	.21	1.00	

Note. * = $p < .05$, ** = $p < .001$.

To address the research questions on how involvement in a horseshoe crab citizen science program affects self-efficacy, interest, outcome expectations, choice goals, academic achievement and career motivation with differences in these effects based on gender (male and female) and treatment versus comparison groups, several summaries were developed with the use of SPSS software. Q-Q plots initially established that the sample came from a normal distribution, and a compilation of descriptive statistics compared means for the sample population as well as gender and groups (comparison and treatment).

Two measures targeted self-efficacy which is a cornerstone of social cognitive career theory. The first measure assessed the four sources of self-efficacy by way of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006). As data collection skills were a critical component in this context, the Citizen Science Self-Efficacy Scale (Hiller, 2012b) examined student self-efficacy for scientific observation skills. The treatment group completed both self-efficacy scales before and after the intervention. Both scales were given to the treatment and comparison group prior to PowerPoint instruction as a prejudgment of how well students expected to perform. Treatment post measures showed gains in self-efficacy following the horseshoe crab program.

The Task Interest Scale (Hiller, 2012c) highlighted student preferences for outdoor activities as a post measure. Participants ranked five outdoor activities including measuring horseshoe crabs on a scale of one to five with five being the favorite activity. Both treatment and comparison groups completed the interest measure following the intervention in order to identify differences in responses between groups.

As outcome expectations are a central factor in social cognitive career theory, students' perspectives of the consequences of engaging in a citizen science program emerged through the Citizen Science Outcome Expectations Scale (Hiller, 2012c). The purpose of this measure was to examine how students perceived the experience would shape the development of their science skills and career aspirations.

The fifth section included the Career Goals Scale (Mu, 1998). This instrument targets choice goals related to career development. By including a choice goals measure, the aim was to capture the interaction of constructs based in social cognitive career theory and to illuminate the impact of scientific collaboration on student career choices.

A Horseshoe Crab Content Measure (Hiller, 2012c) designed from a field expert PowerPoint and teacher feedback assessed student academic achievement. The measure included 21 items and student scores derived from a percentage of correct responses. The treatment group completed a pre and post content measure whereas the comparison group finished the post measure following PowerPoint instruction. The comparison group took the measures once in order to gauge differences between the two groups following the intervention.

Descriptive Statistics

In regards to academic achievement and self-efficacy, results provided support that overall students had higher academic achievement and self-efficacy beliefs after the intervention (see Table 4). Specifically, participants had higher means on academic achievement on the post content measure ($M = 64.86$, $SD = 17.49$, $n = 86$) as compared to the pre measure ($M = 58.17$, $SD = 18.97$, $n = 40$) Further, total population means were

higher on post self-efficacy beliefs for scientific observation ($M = 4.27$, $SD = .75$, $n = 45$) as compared to pre measures ($M = 3.46$, $SD = .88$, $n = 86$). There were gains in means scores for three sources of science self-efficacy including mastery experiences ($M = 3.49$, $SD = .61$, $n = 86$, and $M = 3.53$, $SD = .61$, $n = 45$), vicarious experiences ($M = 3.22$, $SD = .53$, $n = 86$, and $M = 3.30$, $SD = .52$, $n = 45$), and social persuasion ($M = 3.65$, $SD = .57$, $n = 86$, and $M = 3.69$, $SD = .62$, $n = 45$). Following the intervention, there was a slight decrease in mean scores for pre and post anxiety scores ($M = 2.33$, $SD = .73$, $n = 86$, and $M = 2.17$, $SD = .65$, $n = 45$).

Table 4

Means and Standard Deviations for Academic Achievement and Self-Efficacy for the population

Variables	Pre			Post			Cohen's <i>d</i>
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	
1. Academic Achievement	40	58.17	18.97	86	64.86	17.49	-0.37
2. Sources of Science Self-Efficacy							
Mastery	86	3.49	0.61	45	3.53	0.61	-0.07
Vicarious	86	3.22	0.53	45	3.30	0.52	-0.15
Social Persuas	86	3.65	0.57	45	3.69	0.52	-0.07
Anxiety	86	2.33	0.73	45	2.17	0.65	0.23
3. Citizen Science Self-Efficacy	86	3.46	0.88	45	4.27	0.75	-0.99

Task interest, outcome expectations, and career goals scales were administered as a post test. Means and standard deviations appear in Table 5. The purpose of these measures was to capture the interaction among constructs based on social cognitive career theory.

Table 5

Means and Standard Deviations for Task Interest, Outcome Expectations, and Career Goals for the Population

Variable	<i>N</i>	<i>M</i>	<i>SD</i>
Task Interest	86	3.47	0.72
Citizen Science Out. Exp.	86	3.56	0.71
Career Goals	86	4.30	0.64

In regards to academic achievement and self-efficacy, initial evidence supported the hypothesis that students in the treatment group would report higher academic achievement and self-efficacy beliefs than those in the comparison group based on means (see Table 6). Specifically, the mean scores revealed that the treatment group ($M = 73.18$, $SD = 14.18$, $n = 45$) outperformed the comparison group ($M = 55.73$, $SD = 16.30$, $n = 41$) on the content measure following PowerPoint instruction and the intervention. Further, the comparison groups post content mean scores ($M = 55.73$, $SD = 16.30$, $n = 41$) were similar to the treatment groups pre content mean scores ($M = 58.18$, $SD = 18.97$, $n = 40$) indicating that both groups had similar background knowledge based on classroom instruction. On the pre measure for the Citizen Science Self-Efficacy Scale (Hiller,

2012b), treatment participants had higher means on self-efficacy for scientific observation skills ($M = 3.71$, $SD = .77$, $n = 45$) than the comparison group ($M = 3.19$, $SD = .92$, $n = 41$). Means and standard deviations on the pre Sources of Science Self-Efficacy (Britner & Pajares, 2006) were similar for both treatment and comparison groups. Descriptive analyses of academic achievement and self-efficacy showed that both groups had similar content instruction and self-efficacy beliefs prior to the intervention.

Table 6

Means, Standard Deviations, and Effect Sizes for Academic Achievement and Self-Efficacy for Treatment and Comparison Groups

Variables	Pre Treatment			Post Treatment			Cohen's <i>d</i>
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	
1. Academic Achievement	40	58.18	18.97	45	73.18	14.18	-0.91
2. Sources of Science Self-Efficacy							
Mastery	45	3.51	0.59	45	3.53	0.61	-0.03
Vicarious	45	3.24	0.55	45	3.30	0.52	-0.11
Social Persuas	45	3.75	0.58	45	3.69	0.62	0.10
Anxiety	45	2.19	0.68	45	2.17	0.65	0.03
3. Citizen Science Self-Efficacy	45	3.71	0.77	45	4.27	0.75	-0.73
Variables	Pre Comparison			Post Comparison			Cohen's <i>d</i> Groups
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	
1. Academic Achievement	-	-	-	41	55.73	16.30	1.15
2. Sources of Science Self-Efficacy							
Mastery	41	3.47	0.63	-	-	-	0.07
Vicarious	41	3.19	0.52	-	-	-	0.09
Social Persuas	41	3.55	0.53	-	-	-	0.36
Anxiety	41	2.48	0.76	-	-	-	-0.40
3. Citizen Science Self-Efficacy	41	3.19	0.92	-	-	-	0.62

In terms of task interest, outcome expectations, and career goals (see Table 7), results corroborated with the hypothesis that the treatment group outperformed the comparison group. On all three measures administered following the intervention, mean scores were higher for the treatment group than the comparison group on task interest ($M = 3.65$, $SD = .65$, $n = 45$, and $M = 3.27$, $SD = .74$, $n = 41$), outcome expectations ($M = 3.77$, $SD = .66$, $n = 45$, and $M = 3.33$, $SD = .71$, $n = 41$) and career goals ($M = 4.28$, $SD = .74$, $n = 45$, and $M = 4.32$, $SD = .53$, $n = 41$).

Table 7

Means Standard Deviations, and Effect Sizes for Task Interest, Outcome Expectations, and Career Goals for Treatment and Comparison Groups

Variable	Treatment			Comparison			Cohen's <i>d</i> for Group
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	
Task Interest	45	3.65	0.65	41	3.27	0.74	0.55
Citizen Science Out. Exp.	45	3.77	0.66	41	3.33	0.71	0.64
Career Goals	45	4.28	0.74	41	4.32	0.53	-0.06

For the second research question, the hypothesis was that there would be no gender differences among constructs. Mean scores corresponded with this hypothesis with the exception of academic achievement (see Table 8 and Table 9). In addition, there

were slight gender differences for mean scores of self-efficacy of scientific observation skills and task interest.

To measure changes in academic achievement, results from the post content measure indicated that males ($M = 69.19$, $SD = 18.16$, $n = 37$) outperformed females ($M = 61.59$, $SD = 16.41$, $n = 49$). These findings showed an increase in content knowledge for males as pre content mean scores were similar for both genders. The mean score for the pre Citizen Science Self-Efficacy Scale (Hiller, 2012b) was slightly higher for females as compared to males ($M = 3.53$, $SD = .75$, $n = 49$, and $M = 4.20$, $SD = .68$, $n = 37$) as were the task interest scores ($M = 3.59$, $SD = .62$, $n = 49$, and $M = 3.30$, $n = SD = .81$, $n = 37$).

Table 8

Means, Standard Deviations, and Effect Sizes for Academic Achievement, and Self-Efficacy for Gender

Variables	Pre Male			Pre Cohen's <i>d</i> for Gender	Post Male			Post Cohen's <i>d</i> for Gender
	<i>N</i>	<i>M</i>	<i>SD</i>		<i>N</i>	<i>M</i>	<i>SD</i>	
1. Academic Achievement	18	57.39	20.47	-0.07	37	69.19	18.16	0.44
2. Sources of Science Self-Efficacy								
Mastery	37	3.51	0.56	0.07	19	3.51	0.62	-0.05
Vicarious	37	3.29	0.49	0.25	19	3.38	0.58	0.25
Social Persuas	37	3.60	0.60	-0.16	19	3.67	0.58	-0.07
Anxiety	37	2.20	0.67	-0.32	19	2.09	0.61	-0.22
3. Citizen Science Self-Efficacy	37	3.37	1.03	-0.18	19	4.18	0.68	-0.20

Variables	Pre Female			Post Female		
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>
1. Academic Achievement	22	58.82	18.12	49	61.59	16.41
2. Sources of Science Self-Efficacy						
Mastery	49	3.47	0.65	26	3.54	0.60
Vicarious	49	3.16	0.56	26	3.25	0.47
Social Persuas	49	3.69	0.54	26	3.71	0.65
Anxiety	49	2.43	0.77	26	2.23	0.68
3. Citizen Science Self-Efficacy	41	3.53	0.75	26	4.33	0.81

Table 9

Means Standard Deviations, and Effect Sizes for Task Interest, Outcome Expectations, and Career Goals for Gender

Variable	Males			Females			Cohen's <i>d</i> for Gender
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	
Task Interest	37	3.30	0.81	49	3.59	0.62	-0.41
Citizen Science Out. Exp.	37	3.55	0.82	49	3.56	0.63	-0.01
Career Goals	37	4.29	0.56	49	4.31	0.70	-0.03

Pairwise *t*-test results further addressed the first two research questions and appear in Table 10. Additionally, a two factor univariate analysis of variance (ANOVA), and path analyses examined the relationship between the social cognitive career theory constructs and academic achievement.

Paired Samples *t*-test Analyses

The paired samples *t*-test addressed components of the first research question centering on how involvement in a horseshoe crab citizen science program affects self-efficacy and academic achievement (see Table 10). Specifically, the paired samples *t*-test was applied to the academic achievement measure, the subscales of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006), and the Citizen Science Self-Efficacy Scale (Hiller, 2012b). The Bonferroni adjustment determined the alpha level by dividing .05 by the number of pairwise comparisons resulting in an alpha level of .01. The results indicated main effects between treatment participant responses on pre and post items for academic achievement, the Mastery subscale of the Sources of Science

Self-Efficacy (Britner & Pajares) and for the Citizen Science Self-Efficacy Scale (Hiller) as seen in Table 10.

An initial comparison of the treatment pre content scores with the comparison post content scores had no statistically significant differences. This finding establishes the congruency of instruction within the classrooms based on state curriculum standards. Changes in content scores occurred for the treatment group following the intervention. In terms of academic achievement, the pre test scores ($M = 58.18$, $SD = 18.97$, $n = 40$) were significantly lower than the posttests ($M = 73.88$, $SD = 14.28$, $n = 40$). These two findings in conjunction provide evidence for the hypothesis that the horseshoe crab intervention positively affected student academic performance.

For the subscales of the Sources of Science Self-Efficacy (Britner & Pajares, 2006), there were no main effects except for mastery experiences which decreased from pre ($M = 49.14$, $SD = 8.27$, $n = 43$) to post measures ($M = 46.10$, $SD = 8.06$, $n = 43$). The findings from the Citizen Science Self-Efficacy Scale (Hiller, 2012b) further supported the hypothesis in terms of self-efficacy growth. There was a significant positive difference between the treatment pre ($M = 29.92$, $SD = 6.47$, $n = 44$) and post measures ($M = 35.17$, $SD = 5.79$, $n = 44$).

Table 10

Paired Samples t-Test Results for Academic Achievement, Sources of Science Self-Efficacy and Citizen Science Self-Efficacy

Variable	Pre		Post		<i>t</i>
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	
1. Academic Achievement	58.18	18.97	73.88	14.28	-5.59**
2. Sources of Science Self-Efficacy					
Mastery	49.14	8.27	46.06	8.06	6.45**
Vicarious	39.91	6.18	40.45	6.17	-0.93
Social Persuas	44.23	7.15	43.57	7.54	1.26
Anxiety	17.70	5.43	17.46	5.36	0.45
3. Citizen Science Self-Efficacy	29.92	6.47	35.17	5.79	-6.89**

Note. * = $p < .05$, ** = $p < .001$.

Factorial Analyses

To address the second research question of the effect of a horseshoe crab citizen science program on self-efficacy, interest, outcome expectations, choice goals, and academic achievement based on gender and group differences, a 2 (gender) x 2 (group) multivariate analysis of variance (ANOVA) was performed. Prior to analysis, the assumptions of independence, normality, and homogeneity should be met (Dimitrov, 2008). Tests for these assumptions included Q-Q plots, skewness, and kurtosis to establish normal distributions, test for differences in symmetry, and to assess the peak level of the distribution (Dimitrov, 2012). Sample scores were independent of each other. The Levene's Test for Equality determined homogeneity or equal variances for the populations and skewness and kurtosis scores were in an acceptable range. Following the

establishment of these assumptions, each dependent measure was analyzed via univariate F tests.

Following classroom instruction on the ecological interactions in their local region based on state curriculum standards and prior to the intervention, both treatment and comparison participants completed the Horseshoe Crab Content Measure (Hiller, 2012c). The results centering on academic achievement indicated main effects on post measures for both gender and group. The results of the Levene's Test of Equality of Error Variances indicated that the assumption of homogeneity was met, $F(3, 82) = 2.070, p = .11$. Further, the results of the univariate test showed that there was a main effect between gender $F(1,82) = 5.79, p = .018, p\eta^2 = .07$, and groups $F(1,82) = 33.29, p < .001, p\eta^2 = .29$. The unique contribution of gender to the differences between groups was seven percent whereas the unique contribution of groups to the differences between genders was 29 percent. There were no main effects between the interaction of gender and group ($p = 3.20$ and $p = .077$).

For academic achievement, the Estimated Marginal Means indicated that treatment group ($M = 74.21, SD = 2.20, n = 45$) outperformed the comparison group ($M = 55.85, SD = 2.30, n = 41$). Additionally, males ($M = 68.86, SD = 2.40, n = 37$) had higher scores than females $M = 61.20, SD = 2.09, n = 41$). Males and females in the treatment group outperformed their counterparts. Treatment males had higher gains than comparison males ($M = 80.90, SD = 10.32, n = 19$ and $M = 56.83, SD = 16.45, n = 18$), whereas treatment females outscored comparison females ($M = 67.54, SD = 14.10, n = 26$ and $M = 54.87, SD = 16.50, n = 23$).

Both the comparison and treatment group completed a pre measure of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006) and the Citizen Science Self-Efficacy Scale (Hiller, 2012b) to determine how students perceived their abilities in terms of science skills. Based on gender and group results, the findings for the Sources of Science Self-Efficacy Scale (Britner & Pajares) showed no main effects between gender and groups prior to the PowerPoint instruction and intervention. The results of the Levene's Test for Equality showed that the assumptions of equal variances were met for the Mastery, $F(3,77) = 0.35, p = .79$, Vicarious, $F(3,75) = 0.14, p = .94$, Social Persuasion, $F(3,75) = 0.37, p = .78$, Anxiety subscales, $F(3,75) = 0.37, p = .78$ and the Citizen Science scale, $F(3,82) = 1.90, p = .14$. There were no main effects on conditions, gender, or interaction effects for the Mastery, Vicarious, Social Persuasion, and Anxiety subscales. This means that for both groups and gender, participants had similar views on the Sources of Science Self-Efficacy (Britner & Pajares).

Distinct from the results of the Sources of Science Self-Efficacy (Britner & Pajares, 2006) there was a significant univariate main effect on the pre Citizen Science Self-Efficacy Scale (Hiller, 2012b) between the treatment and comparison group whereas there were no differences between gender or interaction between gender and groups. The results of the Levene's Test for Equality showed that the assumption of equal variances was met for the pre Citizen Science Self-Efficacy Scale (Hiller), $F(3,82) = 1.90, p = .14$. Results from the ANOVA indicated that there were main effects between groups, but not for gender, or group and gender interaction, $F(1,82) = 9.16, p = .003, p\eta^2 = .10$. The unique contribution of group differences was ten percent. The Estimated Marginal Means

indicated that the treatment group ($M = 26.64$, $SD = .94$, $n = 45$) outperformed the comparison group ($M = 22.51$, $SD = .98$, $n = 41$). This means that individuals in the treatment group perceived themselves to have stronger science skills based on the expectation that they would be conducted field work with a scientist in unlike their counterparts.

For both the Task Interest Scale and the Outcome Expectations Scale (Hiller, 2012c) main effects occurred with the treatment group surpassing the comparison group. Based on the results of the Levene's Test of Equality of Error Variances, the assumption of homogeneity was met for both post measures, $F(3,82) = 1.81$, $p = .15$ and $F(3,81) = 0.611$, $p = .61$. The results of the univariate test shows that there was a main effect between groups for both measures, $F(1,82) = 9.85$, $p = .002$, $p\eta^2 = .11$ and $F(1,81) = 10.43$, $p = .002$, $p\eta^2 = .11$. The unique contribution of groups to differences on the task interest and outcome expectations was 11 percent for each. On the Task Interest Scale (Hiller), the Estimated Marginal Means showed that the treatment group outperformed the comparison group, ($M = 15.95$, $SD = 0.46$, $n = 45$ and $M = 13.86$, $SD = 0.48$, $n = 41$). This group trend occurred for the outcome expectations as well, ($M = 19.38$, $SD = 0.51$, $n = 45$ and $M = 16.99$, $SD = 0.54$, $n = 40$). There were no main effects for gender or interaction for task interest. For outcome expectations there were no gender differences, but there was a main interaction effect for group and gender, $F(1,81) = 6.61$, $p = .01$, $p\eta^2 = .01$. This means that one percent of the differences on the Outcome Expectations Scale (Hiller) can be attributed to interaction between group and gender differences. The Estimated Marginal Means showed that although treatment ($M = 18.53$, $SD = 0.66$, $n =$

26) and comparison females ($M = 18.04$, $SD = 0.72$, and $n = 22$) had closer scores, treatment males ($M = 20.24$, $SD = 0.78$, $n = 19$) outperformed comparison males ($M = 15.94$, $SD = 0.80$, and $n = 18$) on the outcome expectations measure.

ANOVA results for the final post Career Goals Scale (Mu, 1998) indicated that there were no main effects for groups, gender, or group and gender interactions. However, these results should be interpreted with caution as the Levene's Test of Equality of Error Variance did not establish the assumption of homogeneity, $F(3,81) = 3.71$, $p = .02$.

Path Analysis

A path analysis conducted with the use of LISREL further examined the effect of a horseshoe crab citizen science program on self-efficacy, interest, outcome expectations, choice goals, academic achievement, and career motivation in a social cognitive framework. Indices used to consider the model fit included the chi square value test, goodness-of-fit index (GFI) with $GFI > .95$ as a reasonable model fit comparative fit index, and the comparative fit index (CFI) which cites an acceptable model at $CFI > .93$ (Hu & Bentler, 1999.) The root mean square error of approximation (RMSEA) with a value equal to or less than .05 indicates a good model fit (Steiger, 1990). The best model fit included all post measures and the pre Citizen Science Self-Efficacy Scale (Hiller, 2012b) focused on self-efficacy for scientific observation skills.

The connection between the constructs of self-efficacy, task interest, outcome expectations, choice goals, and academic achievement emerged through analysis of direct and indirect relationships for the population as seen in Figure 6. A chi square value of

$X^2(4) = 4.32, p = .36$ established a good model fit. The other goodness-of-fit indices indicated a good model fit: CFI = .99, NFI=.95, NNFI =.98, and RMSEA = .03. The connection between the constructs of self-efficacy, task interest, outcome expectations, choice goals, and academic achievement emerged through analysis of direct and indirect paths.

Analysis included post measures with the addition of the pre Citizen Science Self-Efficacy Scale (Hiller, 2012b) focused on self-efficacy for scientific observation skills. The results indicated main paths between self-efficacy and content knowledge (.46, $p < .001$), interest and outcome expectations (.53, $p < .001$), content knowledge and outcome expectations (.24, $p = .01$), and outcome expectations and choice goals (.21, $p = .04$). Further, there were indirect paths between content knowledge and outcome expectations (.11, $p = .05$), content knowledge and choice goals (.02, $p = .02$), outcome expectations and choice goals (.11, $p = .06$), and self-efficacy and choice goals (.05, $p = .05$). These results demonstrated that interest and self-efficacy initially affected content knowledge and outcome expectations. Further, the interaction among self-efficacy, interest, content knowledge, and outcome expectations ultimately influenced choice goals. Moreover, outcome expectations played a mediating role between content knowledge, self-efficacy, and interest on choice goals. These findings suggest that self-efficacy for scientific observation skills and interest jointly initiated a sequence which ultimately impacted choice goals in terms of career development based on the citizen science horseshoe crab intervention.

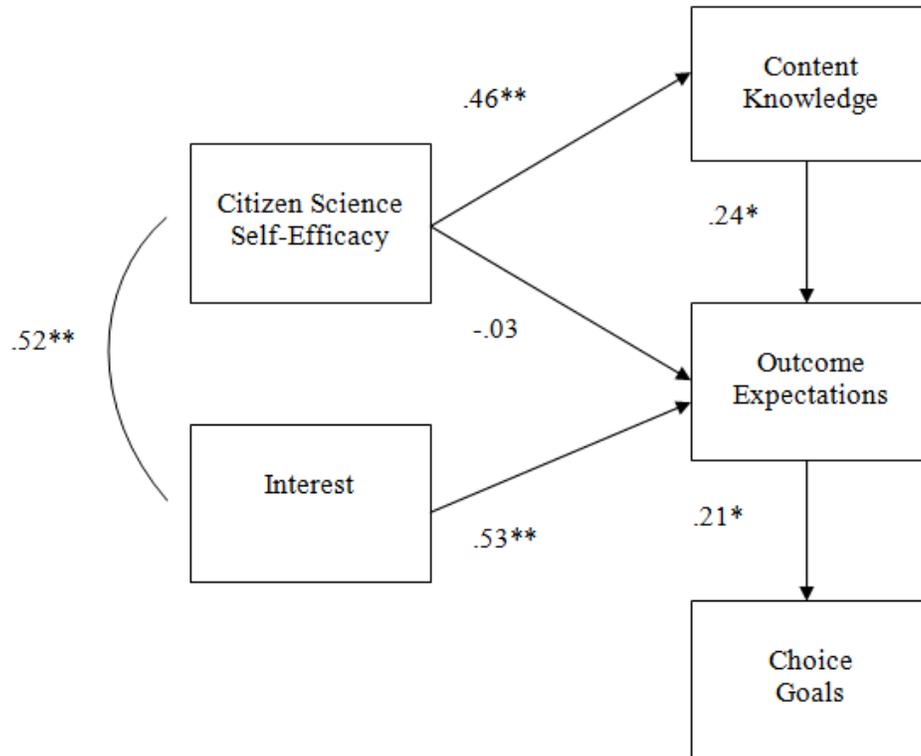


Figure 6. Model for the relationship between the five constructs for the population
 Note. * = $p < .05$, ** = $p < .001$.

Qualitative Results

Process oriented (qualitative) methods corroborated and expanded on the understanding of the ways the citizen science experience influenced student motivation and career paths. This focus addressed the first and third research questions related to the impact of the citizen science program on self-efficacy, task interest, outcome expectations, choice goals, and academic achievement as well as how the program influenced children’s perceptions of their science abilities and career trajectories.

A variation of constant comparative analysis approach examined the impact of the horseshoe crab citizen science program on student perceptions of their abilities and vocational interests. During the open coding phase, the transcripts were initially coded with noun labels as seen in Appendix D. Statements were then grouped together based on these noun labels. This approach is reflective of descriptive coding according to Saldaña (2009). The purpose of this type of coding is to begin analysis from a broad perspective in order to promote divergent interpretations. In order to strengthen rigor in data analysis, two researchers coded 30% of the data. The researchers consistently agreed on the coding scheme. One point of discussion was the concept of science skills and learning which one researcher considered as an intertwined connection and did not code as separate labels. Based on code comparisons, the raters agreed on 98% of the data, thereby establishing researcher consensus.

Saldaña (2009) posits that the processes of coding and categorizing are distinct forms of data analysis. During this process, the focus turned from studying impressions during the open coding phase, to categorizing during the axial phase (Charmaz, 2006). By combining labels through organization and synthesis of data, five general axial themes developed including (a) Motivation for Program Participation, (b) Accuracy and Science Skills, (c) Science Attitudes, Learning, and Fun, (d) Field Experts and Collaboration, and (e) Career Path Impact as seen in Figure 7.

The term Motivation for Program Participation encompasses the reasons students volunteered for the program. Accuracy and Science Skills refers to the emphasis participants placed on using science skills with as much precision as possible. Science

Attitudes, Learning, and Fun relates to student perceptions of what are enjoyable and thought provoking experiences. Field Experts and Collaboration encompasses participant's views of working with field experts as a team member. The fifth category of Career Path Impact highlights participants' views of how the experience influenced possible career choices.

Due to data collection occurring over a two day span it was not possible to conduct the third phase of constant comparative analysis known as selective coding (Patton, 2002). Selective coding stems from a series of interviews, transcription coding, and subsequent interviews. As the research was continual over the two day process, time boundaries restricted the transcribing and coding process between the consecutive 24 hour sessions. In the final stage of data analysis for this study, emergent themes developed by examining trends across axial themes. Three emergent themes surfaced which included (a) student perceptions of science skills, learning, and fun, (b) the influence of student and field expert training and collaboration, and (c) future careers. Based on the results of the constant comparative analysis approach, findings revealed that not only did students perceive that their skills had improved, but they had pronounced views of their levels of competence after collaborating with scientists.

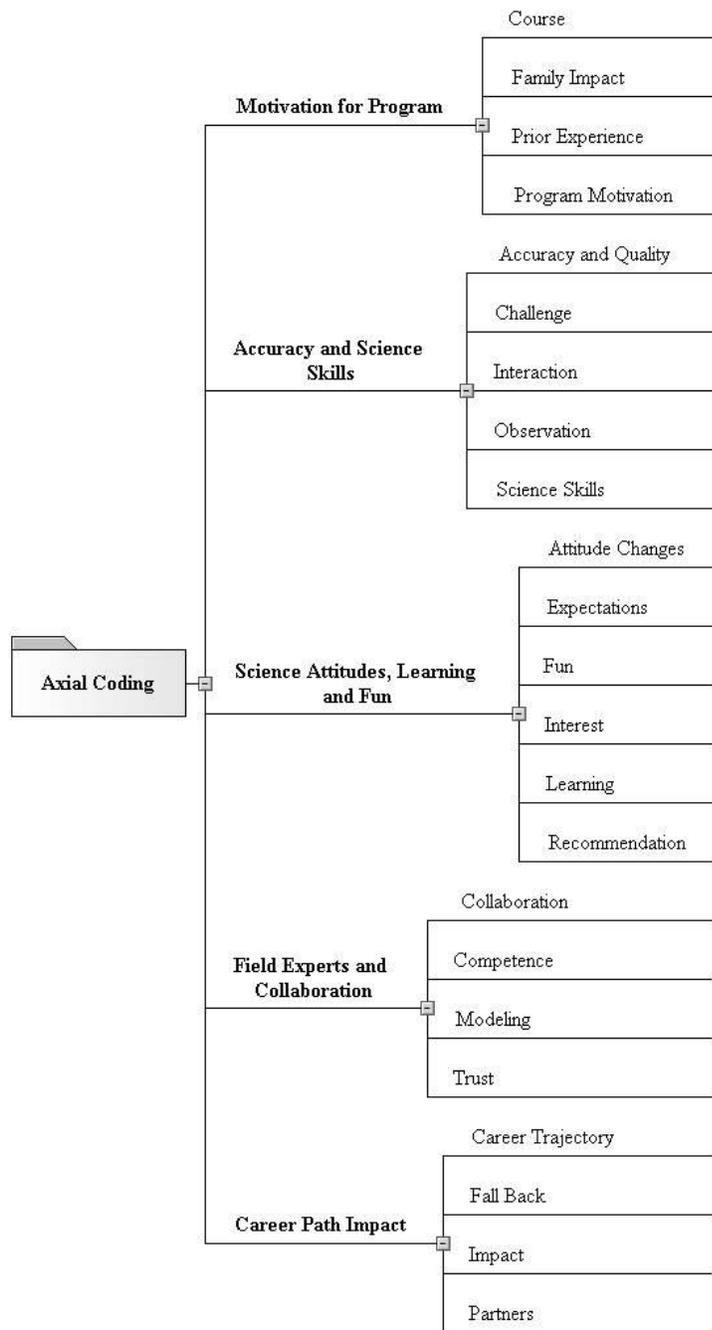


Figure 7. Theme development during the axial phase.

The 20 individuals who participated in interviews had a variety of reasons for attending the horseshoe crab citizen science program. Many of the participants were curious about the horseshoe crabs and wanted to experience something new. Some individuals attended because of a general curiosity about animals. For Val,

I was interested in the field of animal studies in science, and I wanted to learn more about the horseshoe crab which is really a big deal...I've lived here this long, I should have some idea of what they can do, the benefits, and all that kind of stuff.

The incentive for other individuals came through classroom instruction. In Tyler's words, "...Whenever we went over it in class it seemed pretty fun...So I thought it would be cool to learn more about it." The majority of the interviewed participants had learned about the horseshoe crabs primarily through the formal classroom experiences outlined by the state. Less than one fourth of the participants had been involved with horseshoe crabs during the talent development program before school. Despite motivational differences, common phrases describing the experience were "cool" and "fun."

While some individuals had seen horseshoe crabs during family vacations, other individuals hoped to enhance their career ambitions. As Kristine explained, "Well I wanted to experience something new. Like learn about something that will just inspire me to do something in this field." For other students like Samuel, attending the citizen science program was an opportunity to be outside of school. "I just wanted to like not sit in school and try something outdoors." Regardless of the motivation for attending the citizen science program or previous interest levels, commonalities emerged across data

sources which targeted student perceptions of science skills, training and collaboration, and future career choice (see Table 11).

Table 11

Outcomes of Qualitative Data Source

Theme	Quotation
Science Skills, Learning, and Fun	...It was pretty fun. You get to spend a day like out on the beach, looking at horseshoe crabs, collecting data...and learning something new that you hadn't learned in like awhile.
Training and Collaboration	Well I felt like I was helping mankind. I was helping people because my work would help the scientist and her studies and her data.
Future Careers	If being a lawyer doesn't work out I know I can always do something else...Because I always thought I didn't know that much about science. I wasn't any good at science...Well not anymore 'cause I learned a lot of things I thought I didn't know.

Science Skills, Learning, and Fun

Participants expressed a strong interest in learning science while having fun throughout the interviews. For them, a fun experience included gaining new knowledge and engaging in scientific behaviors reflective of a strong work ethic. A dominant topic of conversation, often initiated by the participants, was the need for accuracy in data collection. Despite the many challenges of collecting data in the outdoors, participants felt confident that they had completed quality work for the scientists. As individuals

described their experiences collecting data on the horseshoe crabs, a pivotal point was precise data collection. In particular individuals shared concern over collecting data that was suitable for scientific study. Kristine's statement mirrored many participants' views on data collection. "I didn't want to screw it up because it's like important. If I don't get something accurate I'm afraid that I'm going to screw up the whole data...I tried my hardest." Kristine continued by explaining that she tried harder to be thorough than she would during an experiment in school. Several participants noted that their work had value as it would affect the outcomes of the scientists' work.

Added challenges in sound data collection came on the first day of the study because the water conditions were rough. Leonard claimed, "When you tried to measure like the water kept coming up so you could barely see it...We kind of moved it...in the water to measure it, and then we put it back in the water." Participants tackled the situation by focusing on being precise to counter inaccuracies. Throughout the interviews, participants referred to working carefully and double checking for accuracy. When Leonard took measurements, "I did it again just so I was sure." Val said she and her partner made adjustments just as prepared scientists. As Dalton reflected on the quality of his work, he stated,

I believe if it was calmer we would have gotten more data. I think the quality might have stayed the same for my data because it just took longer because I was precise and made sure I got the correct data even though it was rough out.

In order to assist the scientists as thoroughly as possible, participants relied on scientific observation skills. According to Troy, “In science you really want to be as detailed as you possibly can.” Kristine agreed in that it was necessary to stay focused to get the “measurements right.” Quick glances would not be acceptable in her view.

Distinguishing the gender of horseshoe crabs is one example which requires a synthesis of observations skills and background knowledge due to anatomical variations. Participants learned to focus on other aspects of the horseshoe crabs other than size. Edward noted, “I always thought the males were smaller and the females were bigger. But I learned that males, they have a curved top...and females have claws that look like pinchers.” In addition, participants grappled with examining unexpected differences in horseshoe crabs. Justin claimed, “I found that interesting. All the horseshoe crabs with the deformations. Like the different telsons and the holes inside their shells.”

Participants cited these experiences as useful in extending their science skills. Carmen found that, “when we’re in class we always have to do observing when we’re doing something with temperature, and this helps with observations skills.” The experience of working outdoors influenced Charlie’s perceptions of his skill set within the classroom.

Like since I know firsthand what a horseshoe crab does, like what it feels like...what the eyes look like, how it feels just by touching it...the size of what males and females look like...when I go to take a test or we’re doing something in class...then I’ll know more about the horseshoe crabs.

Dana gained more confidence in her math skills based on using the tape measures and Dalton noted the experience promoted his understanding of experimental design in terms of data analysis and interpretation. Samuel, whose favorite subject is math, cited the experience as promoting his skill set. “I think it improved my data taking skills and maybe possibly my graphing because I’m pretty sure if my teacher asked me to graph this, I would be able to accurately.”

Analysis of the event measure corresponded with participants’ perspective on the quality of their observation skills. Following training by field experts, students collected data on sample horseshoe crabs with guidance from their instructors. Then, participants began to collect data in teams of two and three. As teammates collected data, the field experts would indicate to the researcher whether the data collection was taken accurately. Thirty one observations of horseshoe crabs were analyzed for accuracy across the student teams. The findings from this qualitative source appear in Table 12 .

Table 12

Outcomes of Event Measure

Task	<i>N</i>	Frequency Accurate	Percent Accurate	Frequency Inaccurate	Percent Inaccurate
The team accurately identified the organism as a horseshoe crab.	31	31	100.00	0	0.00
The team measured with centimeter units.	31	31	100.00	0	0.00
The team accurately measured the interocular distance.	31	29	94.00	2	6.00
The team accurately determined the gender.	31	27	87.00	4	13.00
The team accurately determined the relative age.	31	29	94.00	2	6.00

Of the tasks required for the scientists' work, participants accurately identified horseshoe crabs from other organisms and measured in centimeters regularly. Participants were successful in measuring the interocular distance and determining the relative age of horseshoe crabs. Identifying gender proved to be more challenging due to organism variations and natural conditions. Size is not necessarily a key identifier for gender. With a large volume of horseshoe crabs surrounding each other and rough tides, it was not always possible to determine which horseshoe crab was burying in the sand or had an arched shell. As would a professional biologist, students had to double check their work. The field experts on site noted that for the amount of experience the students had, their

data collection skills were acceptable. However, the field experts suggested that repeated exposure to the experience would improve data collection skills. Participants generally expressed that they felt they had done quality work and had improved their observation skills. The event measure based on feedback from the field experts coincides with the students' sense of accomplishment.

When asked about the overall experience of engaging in a horseshoe crab citizen science program, participants generally responded with “cool” or “fun.” Anna expanded by saying, “...It was pretty fun. You get to spend a day like out on the beach, looking at horseshoe crabs, collecting data...and learning something new that you hadn't learned in like awhile.” In line with Anna's comment, all of the students recommended the activity for other children. Michelle said the experience was “really fun and different and not everybody gets a chance to do it.” Sarah echoed these sentiments, “It made me feel really good, and I wasn't expecting to be able to do that, but it was actually really fun.” Troy felt that not only was the experience enjoyable but that it would be beneficial for students who were struggling in school.

It's definitely something new like for people who aren't able to learn as well in the classroom. They can actually come out and do something other than reading out of a textbook. That's how I am. Like I need to be there, and feel it, and see it, and see how it works. I mean it's better for those kinds of learners.

A striking similarity among participants was the link between students' perceptions of fun and learning. Sophie enjoyed collecting the data and seeing the

differences between males and females, and she was amazed by the volume of horseshoe crabs on the beach. Carmen wanted to stay longer because she

...learned so much. Like how to know male from female. The physical differences and all that so...If we got to stay here another day, I think I'd learn so much more, and it would be so fun.

Consistently the participants stated that what was fun was the learning aspect of the experience. Michelle indicated that the activity was fun because she was picking up the horseshoe crab even though it was slippery, measuring the horseshoe crab, seeing the different sizes, and telling the horseshoe crabs apart. Some individuals found the experience to exceed their expectations. For Justin, "I thought it was pretty cool because even with the weather I thought we weren't going to have as a good a day. I was kind of surprised how many horseshoe crabs let the scientists work."

Moreover, some participants found the experience to change their overall perceptions of science. Jerry said he valued and respected science more. Charlie thought, "...maybe this is something I can do in the future, and this is something I can try. And maybe I could be good at it because I had a lot of fun today." Holly, an aspiring meteorologist or pediatrician, wanted to continue working with horseshoe crabs. For others, the opportunity to work with professionals in the scientific community was enjoyable. Excited to have been taught by field experts, Elisa said,

I was really kind of shocked that I got taken with a professional scientist, but it felt pretty good to learn something I never learned before and then me...like

he would actually pick me to do it...I felt good about today. I learned a lot I never did before.

Many of the participants wanted to attend the program because they thought it would be fun to be on the beach with their friends. For Ron who was initially drawn for this reason, motivation increased when he learned he would be interacting with animals. Although all of the participants indicated they found the experience to be pleasant, a key benefit was collaboration with scientists and a new sense of competence.

Training and Collaboration

Training. Protocol training is a necessity for accurate data collection in citizen science programs. As scientific observations steer data analysis, scientists facilitate data collection through defining, modeling, and guiding (Snäll, Kindvall, Nilsson, & Pärt). Precision in data collection is a key consideration in any citizen science program, but validity concerns may lead to age restrictions (Hiller & Reybold, 2011). To counter potential errors in observations, students within this program interacted with five field experts who had substantial experience as educators. Protocol training occurred at two park facilities, a naturalist center, and a private beach throughout the day.

The training began at a park facility with a field expert/educator who reviewed the anatomy, life cycles, and interactions of horseshoe crabs within the ecological niche. The instructor placed emphasis on determining gender, measuring the interocular distance, and determining age throughout this interactive training. One fourth of the students participating each day had previous experience with the horseshoe crabs aside from the regular classroom curriculum by attending a career development program in the mornings

prior to school. A PowerPoint steered the conversation as the field expert explained the work of the professional scientist who the students were assisting. Participants learned that the scientist was conducting exploratory research to determine if speciation was occurring along the eastern coast of the United States due to variations in the size of females. Students then learned about biomedical uses for *Limulus* amoebocyte lysate (LAL), a protein derivative extracted from horseshoe crabs and used to detect bacteria for biomedical purposes. During the presentation, some students with familiarity participated while others listened attentively. Students interjected with questions like, “Are some females rejected? Do horseshoe crabs stop mating at a certain age? Is that what they eat?” As students asked questions, the presenter referred to previous scientific studies designed to test some of these questions.

Following the PowerPoint students had an opportunity to test LAL using their spit in comparison to distilled water. This experience created quite a bit of laughter and discussion as students saw how to detect the presence of bacteria with the gel clot test. Clotted samples were indicative of the presence of bacteria. The morning training session lasted approximately one and a half hours. Following this session, students visited a local naturalist center.

At the naturalist center, students conducted a scavenger hunt by viewing displays and natural specimens. They used this opportunity to ask questions of field experts. Some students had the opportunity to handle horseshoe crabs less than ten years old which usually stay at the bottom of the bay until they are mature. Students held the horseshoe

crabs tentatively as this was the first time most of them had touched a live horseshoe crab.

Students returned to the park preserve to learn about the protocol for data collection. The teacher instructed students through the use of photos and videos how to take readings for the professional scientist. Students learned how to handle the horseshoe crabs, how to use the tape measure accurately, and how to record the data on several forms. In addition to work for the biologist, the teacher asked some students to participate in a mock survey. The survey students learned how to pace off using a one square meter PVC pipe. These individuals counted horseshoe crabs within the frame and identified gender. Participants would record their data, pace off as directed by the field expert, and repeat the procedures. During this training session, students learned that their data was part of a broad data set and that inaccurate data was not usable.

On the beach, the experience became dynamic as waves crashed around a large volume of horseshoe crabs, and shorebird calls could be heard everywhere. In this setting, students were broken into small teams of two and three students. Field experts first reviewed handling procedures and the horseshoe crab anatomy. The field expert showed students not to put their hands between the head (prosoma) and tail spine (telson). One student said, "That would hurt a lot." As a guide held the horseshoe crab, children tentatively touched the legs of the horseshoe crabs. A student shrieked and another said, "It feels like a toothbrush."

One field expert asked a group of students to review the procedures, and they stated that they were to identify gender, measure the interocular distance, and if there was

a male to determine whether they were attached or satellite males. One team member explained that if there were satellite males, they were to use an alternate sheet comparing the satellite to the attached male.

As the guides showed students how to take measurements, identify gender, and relative ages with some horseshoe crabs on the beach, individuals would point to certain horseshoe crabs or make statements like, “There are a lot of them. There’s a satellite male. We’re going to have to move them.” The instructors would hold up a horseshoe crab and say, “What do you think about this one?” Children would shout out “Female.” Teams were shown how to identify attached males to females as opposed to satellite males. Then the teacher said, “Old or young?” Jerry and his teammates yelled out their observations and a discussion ensued about how the younger horseshoe crabs are shiny and have a greenish tint. The teacher agreed with Kristina who commented, “With all of this water coming up you have to look closely.” A challenge for groups using the PVC frame was to count the males and females while the waves were moving in and out. Students discussed which horseshoe crabs they identified as male and female. The field expert led the discussion and had the students count. Then he counted again to confirm their findings.

Following the initial modeling, teams began to collect data as the field expert monitored their progress. Sarah said, “Can I pick it up?” As she did, her teammates took the interocular measurement while the instructor reminded them of how to hold the horseshoe crab. As they worked Sarah said, “Oh, I’m holding a horseshoe crab!” Field

experts encouraged students to be precise when taking measurements as they distinguished between the difference between 14 centimeters and 14.5 centimeters.

The field scientists corrected errors in procedure through discussion and modeling such as directives that size alone does not indicate gender. Other cues included an arched shell or clasper claws. One student demonstrated for the camera, “This is a male because it’s arched and because I’m smart.” As students developed familiarity with the protocol, they began to collect data independently of expert guidance. A striking change throughout the session was that during initial stages of training and modeling, the field experts handled the horseshoe crabs, and the participants would point or comment. However, once students had early experience, they began to handle the horseshoe crabs with more confidence. When the scientists came to a group, students would hold the horseshoe crab as the discussion unfolded. Another commonality was that students were continually assisting each other in teams in a cooperative manner.

The field experts continued to monitor the quality of work throughout the session. One instructor reviewed the students’ record sheet and said, “You guys have been recording things properly. You are doing a good job.” As the trainers interacted with the participants, dialogue on varied aspects of horseshoe crabs ensued. Some horseshoe crabs had evidence of injury, and the field experts explained how the blood had functioned as a clot to repair the injuries. At one point, a participant ran up to show a guide that he had found a one eyed horseshoe crab. “How do you take an interocular measurement on a one eyed horseshoe crab?” the student joked. One team found a tagged horseshoe crab, and the field expert explained that there had been a previous study of horseshoe crabs in the

area. The instructor directed the student to phone in the location, gender, and relative age to the scientific researchers. Another team asked how the moon phases corresponded to spawning and the laying of eggs. The teacher indicated that although this process generally occurs during the full moon, temperature variations are a key factor. In another instance, field experts demonstrated how females used their pusher legs to move sand to lay eggs.

Once students had collected data for their worksheets, they returned to the park facility to compile their data for future analysis in the classroom and to contribute to the scientist's database. Students and teachers reviewed challenges from the experience and how the data could be graphed and analyzed. As Sarah reflected on her experience collaborating with scientists she said, "At first I was a little nervous because I didn't know what to do, but it was actually easier than what I expected."

Collaboration. While the experience at the beach created a lot of excitement and discussion, further analysis of interviews revealed that the opportunity to work with scientists was a central component of the field experience. Throughout the interviews participants placed the greatest emphasis on accuracy and collecting data for professional research. Val said, "I feel kind of proud of myself that my work is actually being used by real scientists to help them." Many of the participants like Barbara appreciated that there were many field experts to speak with. Kristina explained, "I just think it was good, all the interaction, between the different people who were working with us today. I know that helped tremendously with learning about the horseshoe crab." Ron felt that he was

“part of something big.” For Danny, “Well I felt like I was helping mankind. I was helping people because my work would help the scientist and her studies and her data.”

Moreover, the participants expressed the impact of receiving specific instructions from a scientist. Barbara stated, “I’ve never had someone like that to come and help me. So it was nice...I think that’s what helped me the most like having someone who’s really smart and knows everything about that, help me out.” Holly emphasized the benefits of having someone guide you to indicate if you were doing something wrong or right. Without this assistance, Holly claimed, it wouldn’t be a “true experience.” Kristine expanded on this idea,

Well if we just went in and tried to do it on our own, if we had questions, we’d be doing things that we just didn’t understand. It would be something just completely like out of range of what we’re capable of. So with people there, it helped you expand your range of thinking. And you got to ask questions. You got your answers, and you got to work with that into your data.

When referring to joint efforts between scientists and children, many of the participants expressed amazement at being included in data collection. All of the children stated that with proper training eighth grade students are capable of collecting data. Yet, they were surprised that adults trusted them to conduct authentic work. Dana said, “...honestly we don’t get included in a lot.” Dalton, who earlier emphasized precision and thoroughness in data collection said, “...usually kids are like not frowned upon, but our work, they would say, it wouldn’t be as valid a like a real scientist would do it.”

Many participants thought scientists would rely solely on adults for assistance. Edward said that even though children are bound to make mistakes, it was good to be included in the research. Michelle said, "...honestly, not many adults like kids doing stuff for them unless it's like sports programs or something." Sophie explained that she was surprised to be asked to participate because "I would think that he would want to get adults that he could trust." Sophie continued to say that she did feel children are trustworthy. The opportunity surprised Val "because people don't expect much from middle school level. They just want to focus on college level and high school level." Although all participants felt eighth grade students were capable of collecting data, many participants cautioned that students needed to be mature, focused, and trained.

The experience of being part of a scientific community had even stronger consequences for some individuals. Dana felt she had developed more confidence following the experience, and Danny was proud to overcome his fear of holding the horseshoe crabs.

Barbara explained that in school she is very nervous and never talks or raises her hand because she does not know if she is right or wrong. Barbara said when she was with the field experts she wasn't nervous. Having such intelligent people modeling and helping her made her feel like she could do science. She claimed to feel smarter working with the scientists than in school. As confidence developed, many of the participants indicated the program influenced potential career decisions.

Future Careers

One of the advantages of attending the horseshoe crab citizen science program was to prepare students interested in the biomedical field. Many of the participants involved in the experience planned to become pediatricians, paramedics, and nurses. Allison claimed, “I’m going to become a pediatrician which requires a lot of math and science so this kind of helped me out knowing that horseshoe crabs’ blood helps us detect like any new diseases.” Edward said as a future paramedic, it is helpful to understand the use of horseshoe crab blood in vaccinations. Leonard, an aspiring neurosurgeon, felt the experience enhanced his ability to study organisms.

For other students, the experience broadened career options. Anna felt the experience helped her “because I just want to be an early childhood teacher. But I didn’t really know what subject I wanted to teach so it kind of leaned me forward to well maybe I want to be a science teacher.” Sarah who’s unsure of her future plans remembered being interested in science when she was younger and thought she had a renewed interest. Carmen said she always wanted to be an architect, but that this type of science work was also appealing to her. Other students saw science as an alternate career option. From Troy’s perspective, “I want to be a mechanic...Learning about this is also a good background and something to fall back on if I had to. Because I’m good at science too.” Kristina appreciated the exposure to other career options.

Not all participants in the program were aspiring scientists. Their interests ranged from cosmetology, the police force, professional sports, and acting. For these students,

the outdoor experience, although enjoyable, did not directly relate to reaching their career goals. The primary benefit of the program in terms of career development for these students was team building. Ron explained, “I think it really helped build a couple of things like team working. I feel like I really got closer with someone...I feel like we work together well.” Working with peers was valuable to many of the participants. Charlie described how he had overheard the teacher say that he and his partner were both taking “really good data.” Val found the experience to help her “learn teamwork and go out into the field and do things hands on,” while Leonard described how he and his partner adapted to rough weather conditions. Troy viewed himself as part of a team with his classmates as they assisted the scientists.

Regardless of student career goals, based on student accounts, the experience influenced observation skills, content knowledge, self-efficacy for science, interest, and team work. The impact of the program was specific to a combination of each participant’s career aspirations, skills sets, and interest level. For some students the experience of collaborating with scientists in an authentic way was a portal to new opportunities. Danny, who claimed his confidence level increased after the experience said,

If being a lawyer doesn’t work out I know I can always do something else...Because I always thought I didn’t know that much about science. I wasn’t any good at science...Well not anymore ‘cause I learned a lot of things I thought I didn’t know.

Summary of Results

The findings of this study support the hypothesis that a horseshoe crab citizen science program positively influenced student self-efficacy, interest, outcome expectations, career choice goals, and academic achievement. Both groups of eighth grade students had similar experiences in a classroom setting through the state curriculum objectives. However, those students working with scientists outdoors outperformed their peers on the content measure. The experience positively influenced students' self-efficacy for scientific observation skills, and interest for studying organisms in the outdoors. Students who collected data on horseshoe crabs had higher outcome expectations about studying horseshoe crabs than the comparison group. Path analyses results indicated that the outdoor exposure created a chain of events starting with the joint influence of self-efficacy for scientific observation skills and interest on academic achievement and outcome expectations. Career choice goals were the end result in this sequence of construct interactions. Further, although the treatment group had greater self-efficacy for scientific observation skills, there were no group or gender differences for all four sources of science self-efficacy.

Additional analysis supported the hypothesis that there would be no gender differences on sources of self-efficacy, interest, outcome expectations, and career goals. Males did outperform females by 7% on the content measure thereby contradicting a null hypothesis for academic achievement.

Social cognitive career theory espouses that there is a connection between self-efficacy, interest, outcome expectations, goals, academic achievement, and social

supports and barriers (Lent, Paixão, Silva, & Leitão, 2010; Lent, Brown, Nota, & Soresi, 2003; Fouad, Smith, & Zao, 2002). The path analysis created in this study supports this construct relationship within the context of informal natural science learning.

Qualitative results described the influence of the horseshoe crab program on student perceptions of their science skills. The emergent themes included (a) Science, Learning, and Fun, (b) Training and Collaboration, and (c) Future Careers. Analysis of transcriptions corresponded with the Citizen Science Self-Efficacy (Hiller, 2012c) results in that students indicated higher self-efficacy for using observation skills. Further the Event Measure (Hiller, 2012c) validated students' perceptions of conducting quality work by recording accuracy of horseshoe crab measurements. Protocol training and accuracy were central considerations for the students. Involvement in collaborative efforts with modeling by field experts strengthened student self-efficacy, science skills, and sense of competence.

A notable trend within the qualitative analysis was the children's emphasis on the work of the field experts in comparison to the horseshoe crabs. Generally, students referred to the horseshoe crabs when describing their beliefs about their scientific observation skills. Many of the participants preferred to focus on the way the scientists were modeling and training the children. Of utmost importance to the students was collecting data that would be valid for professional scientists. This joint effort developed heightened self-efficacy. Many of the students noted that the experience encouraged them to explore further career options and bolstered perceptions about their competence to work in a science realm.

The design of the present study stemmed from an interactive dialogue between variance (quantitative) and process (qualitative) methods. The findings derived from both methodologies coincided to address the impact of the intervention on self-efficacy, interest, outcome expectations, choice goals, and academic achievement. As depicted in the methods matrix (see Figure 8), there is an alignment between variance and process results which illuminated the impact of the horseshoe crab program. Specifically findings from both methodologies indicated that the experience positively influenced all variables within the study.

Variable	Pairwise t-test	ANOVA	Path Analysis	Variance Findings	Emergent Theme 1: Science, Learning, and Fun	Emergent Theme 2: Training and Collaboration	Emergent Theme 3: Future Careers	Event Measure	Process Findings
Academic Achievement	V	V	V	Intervention positively influenced academic achievement; particularly for males	P	P	P		Charlie, "...when I go to take a test or we're doing something in class...then I'll know more about the horseshoe crabs
Self-Efficacy	V	V	V	Intervention positively influenced self-efficacy. Self-efficacy affected academic achievement	P	P	P	P	Event Measure confirmed accuracy of observations. Carmen, "When we're in class we always have to do observing... and this helps with observations skills.
Interest		V	V	Higher scores for treatment group	P	P	P		Anna, "...It was pretty fun. You get to spend a day like out on the beach, looking at horseshoe crabs, collecting data...and learning something new..."
Outcome Expectations		V	V	Higher scores for treatment group Outcome expectations influenced academic achievement	P	P	P		Kristine, "...Well I wanted to experience something new. Like learn about something that will just inspire me to do something in this field."
Choice Goals			V	Choice goals was the end point of a series of interactions between self-efficacy, interest, content knowledge, and outcome expectations.			P		Participants perceived the experience as helpful to career plans overall but did not cite experience as part of a specific series of steps to reach career goals.

Figure 8. Methods alignment matrix

This study addresses the benefits of a citizen science program for middle school students. The results align with previous social cognitive career theory writings which identify a relationship between self-efficacy, interest, outcome expectations, choice goals, and academic achievement (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010; Bonitz, Larson, & Armstrong, 2010; Lent, Lopez, Lopez, & Sheu, 2008). This work extends an understanding of best practices for citizen science programs. Although, gender differences were only apparent in content knowledge with males demonstrating higher achievement, for the individuals involved in the intervention, inclusion in scientific work influenced self-efficacy, interest, outcome expectations, choice goals, and academic achievement in terms of career planning. Variance and process methodologies corresponded to identify the impact of citizen science on student achievement and career motivation. In terms of career goal setting, the lack of findings for some measures may be due to the type of items on the Career Goal Scale (Mu, 1998) which targets individual's perceptions about steps in goal setting. Path analyses results and emergent themes demonstrated that the program contributed to career planning but not in terms of specific processes to reaching career goals.

CHAPTER 5

DISCUSSION

This mixed method, quasi-experimental study centered on the impact of a horseshoe crab citizen science intervention on student self-efficacy, interest, outcome expectations, choice goals, and academic achievement within a social cognitive career theory framework. The aim of the study was to examine the role of a horseshoe crab citizen science program on shaping student academic achievement and career motivation.

Findings from this present study supported the hypothesis that a citizen science horseshoe crab program affected student self-efficacy, interest, outcome expectations, and academic achievement. Although choice goals did not have main effects for multivariate analysis, path analysis established that the interaction of these constructs resulted in positive influences on career goals. Further the hypothesis that there would be no gender differences was supported with the exception of academic achievement in which treatment males outperformed females.

Of key interest in the educational experience was that students had the opportunity to analyze the interconnection between organisms and their ecosystem, understand that animal populations consists of many organisms of the same species, calculate population sizes, and examine the diversity of organisms. The horseshoe crab citizen science program was a way to meet these instructional objectives. The teacher

from the comparison school had been trained by the treatment instructor on citizen science programs for horseshoe crabs. Both groups viewed a PowerPoint developed by a local field expert; however, the comparison group had the additional experience of working with scientists in the outdoors.

The first two research questions for this study centered on whether a horseshoe crab intervention would affect student self-efficacy, interest, outcome expectations, choice goals, and academic achievement, and whether there would differences in these effects for gender and group. Pairwise *t*-test results indicated significant gains for the treatment group on academic achievement, the Mastery subscale of the Sources of Science Self-Efficacy (Britner & Pajares, 2006) and the Citizen Science Self-Efficacy Scale (Hiller, 2012b). Factorial analyses indicated main effects between the treatment and comparison groups for self-efficacy for observation skills, interest, outcome expectations, and academic achievement in favor of the treatment group. There were no gender differences with the exception of academic achievement in which the treatment males outperformed the comparison group as well as treatment females on academic achievement.

Pearson Correlations and path analyses further substantiated the interaction among constructs within an informal natural science learning setting. In terms of correlations, most of the constructs interrelated with the exception of career goals which only corresponded with the pre and post Mastery subscale and the pre Social Persuasion subscale of the Sources of Science Self-Efficacy Scale (Britner & Pajares, 2006). Strong correlations were found between the pre and post Mastery and Social Persuasion

subscales. Based on path analyses, there was a direct relationship among constructs. Specifically, content knowledge development stemmed from joint influence from self-efficacy and interest. In addition, interest influenced outcome expectations. The end result of the path model was that the interaction between self-efficacy, interest, content knowledge, and outcome expectations impacted career choice goals within the informal natural science learning setting.

Interviews, video recordings and the Event Measure (Hiller, 2012c) provided data for constant comparative analysis across data sources. Through the process of open and axial coding, emergent themes developed which included (a) student perceptions of science skills, learning, and fun, (b) the influence of student and field expert training and collaboration, and (c) future career choices. Video recordings and an event measure further examined the role of protocol training in developing a refined skill set. These findings revealed the nuances of the role of expert modeling, the development of scientific observation skills, and potential career pathways.

Discussion of Results

Research Question 1. How does involvement in a horseshoe crab citizen science program affect self-efficacy, interest, outcome expectations, choice goals, academic achievement, and career motivation in a social cognitive framework?

Research Question 2. Are there differences in these effects based on gender (male and female) and treatment versus comparison groups?

The results of this study supported the hypotheses in that the treatment group had gains on the content measure and self-efficacy. In addition, the treatment group

outperformed the comparison group with the exception of choice goals in which there were no main effects on statistical tests. In terms of gender differences, there was support for the hypothesis in that there were no gender differences except for academic achievement in which treatment males outperformed the comparison group and females.

A variety of studies based in social cognitive career theory established an intricate relationship between self-efficacy, interest, outcome expectations, choice goals, academic achievement, and social supports and barriers as elements in career motivation (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010; Navarro, Flores, & Worthington 2007; Patrick, Care, & Ainley, 2011; Rogers & Creed, 2011; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). This relationship has been established regardless of subject domain (Fouad, Smith, & Zao, 2002) or personality types for high school students (Lent, Brown, Nota, & Soresi, 2003). Typically, past studies examined formal classroom settings to test the relationship between constructs. The present study is unique in that the tenets of social cognitive career theory merge with informal natural science learning settings.

Pearson correlations established that there were relationships among most of the pre and post measures. The strongest relationships emerged between the pre and post Mastery subscales and Social Persuasion subscales. The connection between the intervention and the Mastery subscale mirrors the finding of a pilot horseshoe crab citizen study (Hiller, 2012a). Results from the path analyses indicated that self-efficacy for scientific observation skills and interest directly impacted academic achievement. Further, interest was a factor in terms of outcome expectations. The connection between

self-efficacy, interest, outcome expectations directly and indirectly influenced student choice goals in terms of career goal setting. In conjunction with previous models (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010; Fouad, Smith, & Zao, 2002; Lent, Brown, Nota, & Soresi, 2003; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010), there was a relationship between outcome expectations and choice goals.

Distinct from many social cognitive career theory studies, the incorporation of qualitative methods extended an understanding of the interconnections between self-efficacy, interest, outcome expectations, choice goals, academic achievement, and career motivation. Throughout the interviews, students expressed how their beliefs about their abilities, and interest levels transformed during the experience. Participants indicated their content knowledge, confidence levels, and interest had increased following the experience. Many children found that working with scientists to collect data had improved their content knowledge, science skill set, and perceptions about future vocational interests. Aside from methods used to study the connections among constructs, several approaches examined the intervention effect on each construct individually as well as for group and gender differences.

Self-Efficacy. Findings for self-efficacy supported the hypothesis that the intervention would influence student treatment group self-efficacy regardless of gender. Self-efficacy, an individual's perception about their capabilities in a specific area, is the cornerstone of motivation. Mastery experiences, vicarious experiences, social persuasion, and anxiety are the four components underlying self-efficacy (Bandura, 1997). As such, the research design incorporated two self-efficacy measures: The Sources of Science

Self-Efficacy (Britner & Pajares, 2006) and the Citizen Science Self-Efficacy Scale (Hiller, 2012b). In terms of treatment gains, the results of the Pairwise *t*-test identified a difference in pre and post measures for the Mastery subscale, the Social Persuasion subscale, and the Citizen Science Self-Efficacy Scale (Hiller). The gains on the Mastery subscale corresponded with a previous study on the impact of a horseshoe crab citizen science program on student self-efficacy (Hiller, 2012a). This finding is relevant to the foundation of social cognitive career theory because the Mastery subscale is the greatest source of self-efficacy and strongest determinant of academic achievement (Britner & Pajares).

Self-efficacy for scientific observation skills was a factor when considering the first emergent theme centering on science, learning, and fun, participants emphasized accuracy and quality of data collection. As data collection techniques steer scientific interpretations (Cartwright, 1989; Eberbach & Crowley, 2009; Hmelo-Silver, & Pfeffer, 2004), student perceptions about developing accurate skills aligns with the development of mastery experiences (Bandura, 1997; Turner & Lapan, 2005). Moreover, participants expressed the necessity of working with field experts. In order to progress from beginning to advanced stages of scientific work habits, expert modeling is essential (Cartwright; Eberbach & Crowley). This necessity echoed in the interviews as participants noted that a lack of field experts would result in an inadequate experience where skills set development would be left to intuition and trial and error. Collaboration with the scientists refined student data collection techniques and may have been the factor which created gain scores in mastery experiences.

Many of the participants noted that they attended the program because their friends were coming. Other students indicated that friends from previous years had enjoyed the experience which motivated them to join the trip. These instances are examples of social persuasion, a source of self-efficacy. Within this context, there was an association between social persuasion and all other constructs on the pre measure and all but outcome expectations and choice goals on the post measure. During the trip, there was a lot of interest in the interaction with field experts while being with friends. Participants mentioned working with their teammates and the benefit of team building skills. Differences in the social persuasion measure may be a result of social feedback about the experience and joint efforts collecting data. It is noteworthy that there were no group or gender differences for the four sources of self-efficacy which were given on the pre measure. Therefore, students from both schools and males and females had similar perceptions about the four sources of self-efficacy for science prior to the PowerPoint and intervention. Post measures indicated that the intervention had a positive effect on mastery knowledge and social influences for the treatment group.

The second self-efficacy measure, the Citizen Science Self-Efficacy Scale (Hiller, 2012b) analyzed participants' beliefs about their capability to use scientific observations skills. As this skill is essential in driving scientific analyses (Cartwright, 1989; Eberbach & Crowley, 2009; Hmelo-Silver, & Pfeffer, 2004), assessing student perceptions about their observation skills was relevant to this study. As in the first self-efficacy scale, there were no group or gender differences on the pre measures indicating similar beliefs about observation skills based on classroom instruction and laboratory practices. However,

self-efficacy for scientific observation skills increased for the treatment group following the horseshoe crab program.

Emergent themes and results from the Event Measure (Hiller, 2012c) corresponded with the gains on the Citizen Science Self-Efficacy Scale (Hiller, 2012b) for the treatment group. When discussing the experience, participants consistently emphasized the need to take accurate data. Students perceived this focus on detailed observations as key behavior, and many of the individuals claimed the experience improved their skill set. The results of the Citizen Science Self-Efficacy Scale (Hiller), qualitative interviews, and the Event Measure (Hiller) were congruent in terms of the impact of the intervention on students' scientific observation skills. In addition to gains on the Citizen Science Self-Efficacy Scale (Hiller), and the qualitative focus of students' perceptions of scientific observations, field expert observations of student performance cited high levels of accuracy. The results of data sources coupled with the findings of the Sources of Science Self-Efficacy (Britner & Pajares, 2006) triangulate support for the hypothesis that the horseshoe crab intervention positively impacted self-efficacy.

Moreover, findings from the path analysis further substantiated the role of self-efficacy for scientific observation skills within a social cognitive career theory. Self-efficacy and interest jointly served as a trigger in a sequence of events which influenced academic achievement, outcome expectations, and eventually choice goals. This chain reaction confirms the relevance of analyzing self-efficacy for scientific observation skills during citizen science programs.

Interest. The results of this study supported the hypothesis that the intervention would influence task interest and are in accordance with social cognitive models which include interest as a mediating factor between other constructs (Lent, Lopez, Lopez, & Sheu, 2008; Lent, Paixão, Silva, & Leitão, 2010). Results from multivariate analysis indicated that the treatment group outperformed the comparison group on interest, but there were no gender differences. This finding is indicative of the dominance of interest in career choices with gender as a less prominent influence (Katz, Assor, Kanat-Maymon, Bereby-Meyer, 2006).

Self-efficacy and interest have been found to be interdependent constructs (Nauta, Kahn, Angell, & Cantarelli, 2002; Patrick, Care, & Ainley, 2011), and the results of the path analysis confirmed the interconnection between constructs. As self-efficacy increased after the intervention, interest may have been inherently affected. Most participants claimed that they thought the experience would be “fun” or “cool.” This expectation may have affected interest outcomes in that all of the participants volunteered to attend the program. In fact, these individuals may have had more interest than their peers. Although other eighth graders were invited to attend the program, many students did not participate because of after school activities. In contrast to the comparison school, the treatment group may have had a high level of interest prior to the opportunity which may have been magnified. Buccheri, Gürber, & Brühwiler (2011), claim that interest for sciences in the general student population has declined within the last decade. For this reason, students involved in the intervention program may have a higher level of interest than most eighth graders.

Outcome Expectations. As with the other constructs, there was support for the hypothesis that the intervention would impact outcome expectations. Outcome expectations refer to an individual's judgment about the consequences of engaging in specific behavior. This construct is interdependent with self-efficacy, interest, and choice goals (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010). The hypothesis was that there would be differences between the treatment and comparison group, but no gender differences. Multivariate analyses indicated that the treatment group had higher outcome expectations, and there were no gender differences. However, there was an interaction effect between groups and gender. Females from both groups had similar scores; however, treatment males outperformed comparison males. This means that the intervention had a pronounced effect on how males perceived their work in terms of scientist's behavior. Items on this scale included "Studying horseshoe crabs will help me understand the work of scientists, and Studying horseshoe crabs will help me decide if I want to be a scientist." Males from the intervention group perceived the experience had implications for developing their skill set and career plans. This trend was apparent in participant discussions about how the experience had validated their views on their science skill levels and created new possibilities in terms of vocational options.

Choice Goals. Diverging from the other variable results in this study, there was no support for the hypothesis that choice goals would be influenced by the intervention based on multivariate analysis. Choice goals refer to decisions related to making career plans. This construct closely aligns with outcome expectations as well as self-efficacy and interest (Bonitz, Larson, & Armstrong, 2010). However, Fouad, Smith, and Zao

(2002) determined a weaker link between outcome expectations and choice goals for math and science as in other subject areas. In this study, choice goals related to outcome expectations and had indirect effects from self-efficacy and interest. Through path analyses, there were statistically significant paths between choice goals and outcome expectations.

The Career Goals Scale (Mu, 1998) centered on items such as “I know what I want to do in terms of an occupation or career,” and “I have a clear set of goals for my future.” The connection with the Career Goals Scale (Mu) and other constructs demonstrated that the tenets of social cognitive career theory are applicable to citizen science contexts in terms of influencing career paths.

During interviews, most students stated some career goals but were vaguer about the process of accomplishing the goals. Some individuals interested in biomedical fields cited the experience as helpful but did not outline specific steps for reaching their goals. The experience may have influenced career choices overall but not by directing students in the process of obtaining vocational credentials.

Academic Achievement. Findings supported the hypothesis that the intervention influenced student academic achievement as there were gains from pre to post measures for the treatment group. Further the treatment group outperformed the comparison group on the Horseshoe Crab Content Measure (Hiller, 2012c). This outcome is relevant as results established that the treatment and comparison group had comparable instruction within the classroom setting. Once the treatment group participated in the intervention, there was a substantial increase in the average mean scores for content knowledge.

Within the outdoor context, academic achievement stemmed from performance on the Horseshoe Crab Content Measure (Hiller) developed from a field expert's PowerPoint, curriculum objectives, and from three middle school science teachers' feedback. Contrary to the hypothesis, the only gender differences emerged on content performance in favor of treatment males. Although males and females involved in the intervention outperformed their counterparts, the experience had the greatest impact on male students. Based on path analyses, factors influencing academic growth were self-efficacy for scientific observation skills and interest. In turn, content knowledge influenced student outcome expectations. At the final stage of this sequence, the direct and indirect effects of the previous four factors resulted in changes in choice goals related to career goal setting.

Gender Differences. Findings from a previous middle school study based in a social cognitive career perspective found that gender did not play a mediating role in terms of career planning (Navarro, Flores, & Worthington, 2007) while other research studies cite gender differences in terms of academic achievement (Wigfield & Wagner, 2005). The results from the present study add to the complexities of understanding gender differences in that on all social cognitive career theory constructs except academic achievement there were no gender differences. Baram-Tsabari and Yarden (2011) claim that interest in biology for both males and females increases through the middle school years. Male performance within this field work context differs from science interest studies which find that on the international collegiate level females prefer biology whereas males are more likely to study physics and technology (Buccheri, Gürber, and Brühwiler, 2011). Perhaps a consideration as a result of this study is a possible link

between citizen science programs, engineering fields, and biological studies. Bombaugh (2000) claims that children involved in citizen science programs develop motivation to enter engineering fields. For this reason, citizen science programs may bridge interest for biological and technical fields thereby promoting new career options.

Research Question 3. How does a citizen science experience influence children's perceptions of their science abilities and career trajectories?

Emergent themes developed through a constant comparative analysis approach highlighted the impact of a horseshoe crab citizen science program on student perceptions of their science abilities and career trajectories. Based on participant feedback, the primary benefits of the experiences were changes in student perceptions of their science abilities, collaborative work in science research, and vocational options.

Throughout the interviews, participants discussed scientific observation processes. In order to collect valid data, individuals relied on sensory perceptions. Moreover, the participants reflected on their level of accuracy in data collection. Students indicated that without the field experts, their skill set would be based on intuition and trial and error. This sense aligns with previous writings which state that without specific training, children are able to make observations but are not able to classify the observations or use the information to draw inferences (Eberbach & Crowley, 2009; Hmelo-Silver, & Pfeffer, 2004). During the experience students countered environmental conditions by adjusting in order to be precise while working collectively. As a result, student perceptions of the work of a scientist became rooted in a work ethic driven by accuracy and collaboration.

The findings of the present study indicated that students involved in the horseshoe crab program improved their content knowledge. Many participants referred to the development of their knowledge base in addition to their science skills during the experience. In discussing the activity, participants would relate horseshoe crab interactions based on sensory experiences. However, a striking outcome of the qualitative data sources was the depth in which students spoke about the work habits and interactions with field experts. Although the experience did improve student content knowledge, participants were studying field expert behavior to a great extent in conjunction with horseshoe crab instruction.

By participating in this work, the students entered the realm of the scientist thereby reshaping their perceptions of their science skills and career choices. According to Eberbach and Crowley (2009),

The nature of the phenomena and the disciplinary framework inform the biologist's questions, which in turn, affect how data are collected, represented, and brought to bear in scientific argumentation. In addition, habits of practice may interact with a biologist's identity ... (p. 46).

Biological population studies which include student contributions increase science literacy (Cronje, Rohlinger, Crall, & Newman, 2011; Sutton, 2009; Tomasek, 2006) content knowledge (Brossard, Lewenstein, & Bonney, 2005) and mastery experiences (Hiller, 2012a). Not easily replicated within a formal learning setting, this citizen science program offered students a context to strengthen science skills and reshape self-images. For some participants, the program not only increased their self-efficacy but promoted

interest for science oriented fields. Children viewed themselves as capable members of a scientific team. In fact, several students interested in animal studies noted the experience validated their capability to function in the realm of biology.

Children attended the horseshoe crab citizen science program to have fun, to be inspired, and to learn. From a social cognitive orientation, the influence of the program linked to the three phases of self-regulation development including forethought, performance, and self-reflection (Zimmerman, 2000). This process is relevant as high achieving science students engage in all three phases of self-regulation (DiBenedetto & Zimmerman, 2010). The field experts were instrumental in training and modeling to enable the students to transcend through these phases. Aside from an enjoyable experience, students developed stronger self-efficacy for scientific observation skills, improved content knowledge, heightened interest for the sciences, and broadened career possibilities.

Implications for Instructional Practice

Career decisions emerge over a series of life events. For individuals, interest in specific domains alters from birth to fifteen years old (Buccheri, Gürber, & Brühwiler, 2011). Early experiences are critical in shaping career paths as identity formation becomes ingrained by the mid-twenties. The potential for dramatic changes in career paths diminishes after this time period. Lent and Hackett (1994) claim, “By adolescence, most people have a sense of their competence at a vast array of performance domains, along with convictions about the likely outcome of their participation in these activities” (p. 91). As such, involvement in citizen science programs during adolescence is one

vehicle for promoting interest in science related fields during an influential time period in children's development.

Another possible benefit for citizen science programs is to mitigate gender differences in science oriented fields. On an international scope, interest shapes career paths. Presently females are more likely to enroll in biomedical fields while males tend to enter technical fields (Buccheri, Gürber, & Brühwiler, 2011). This finding is relevant as gender and instructional feedback contribute to student development, but interest in a specific field is essential in career choices (Katz, Assor, Kanat-Maymon, & Bereby-Meyer, 2006). Citizen science may be a link between interest in biological and technical fields as this type of work motivates students towards engineering professions (Bombaugh, 2000).

Aside from career paths, scientific observation skills increased based on citizen science inclusion. Although these skills entail complex interactions between sensory input, content knowledge, and comparative approaches, some educators view observation as a simple skill (Eberbach & Crowley, 2009). Participation in citizen science programs affords students an opportunity to develop scientific observation skills by emulating scientists. As synthesizing these observations with content knowledge and comparative judgments is reflective of scientific work, an individual's sense of capability in this domain is essential. The Citizen Science Self-Efficacy Scale (Hiller, 2012b) assesses students' self-efficacy for scientific observation skills and offers new possibilities for analyzing the impact of outdoor instruction. Path analysis further substantiated the

prominence of self-efficacy for scientific observations skills in enhancing student performance and career motivation.

Several studies cite the need for improved measures related to citizen science programs. Brossard, Lewenstein, and Bonney (2005) recommend that measurements which assess projects should be applicable to a variety of contexts. Crall (2010) claims that scale items should focus on identifying gains from informal learning interventions which include specific training components within the program. Based on the present study, two reliable measures have been established which may be useful in other citizen science contexts with minimal modifications related to the organism surveyed. The Citizen Science Self-Efficacy Scale (Hiller, 2012b) captures the impact of a citizen science program on self-efficacy for scientific observation skills. Secondly, the Citizen Science Outcomes Expectations Scale (Hiller, 2012c) assesses student perceptions about the role of citizen science programs in achieving science related career aspirations.

From a social cognitive career theory perspective, the findings from this study align with previous literature on the interaction between self-efficacy, interest, outcome expectations, choice goals, and academic achievement (Lent, Paixão, Silva, & Leitão, 2010; Navarro, Flores, & Worthington, 2007). The advantage of this type of model is to highlight facets of career decisions (Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). A distinction in this study is that the research design targeted the influence of a citizen science intervention on middle school students, an age group which has not been studied as extensively as high school students in other social cognitive career studies (Lent, Brown, Nota, & Soresi, 2003; Lent, Paixão, Silva, & Leitão, 2010).

In conjunction with the literature base on career paths, self-efficacy and interest jointly influenced academic achievement and career goal setting (Bonitz, Larson, & Armstrong, 2010; Patrick, Care, & Ainley, 2011). Further, there was a relationship between outcome expectations and career choices in this study. Qualitative methods substantiated and revealed subtleties of the influence of the program on student career goals. Notably, this work incorporates a self-efficacy scale for scientific observation skills within a social cognitive career framework. The contribution of this work is that it is one of the first of its kind to merge social cognitive career theory within a natural science informal learning setting.

This is a relevant addition to current understanding of science instruction as heightened attention has emerged for developing science, technology, engineering, and math (STEM) education. Working in informal natural science learning settings is a primary component of improving STEM according to the National Science Foundation (Friedman, 2008) as expertise within informal learning science institutions provides a medium for collaborative opportunities (Martin, 2004). According to the President's Council of Advisors on Science and Technology (2012), "students who play an active role in the pursuit of scientific knowledge learn more and develop more confidence in their abilities, thereby increasing their persistence in STEM majors" (p. 6). With an emphasis on improving science education, Britner and Pajares (2006) state

Engaging students in authentic inquiry-oriented science investigations during middle school will provide mastery experiences necessary to the development of strong science self-efficacy beliefs...It is also important to focus

on helping students interpret these experiences in ways that bolster rather than diminish self-efficacy beliefs (pp. 494-495).

As social cognitive theory centers on the development of self-efficacy by way of modeling, field experts who work with children are key players in promoting a science oriented work force. In terms of practitioner applications, including students in citizen science programs is a viable medium for developing self-efficacy, science skills, content knowledge, and career possibilities (Brossard, Lewenstein, & Bonney, 2005; Hiller, 2012a). Turner and Lapan (2005) recommend that in order to encourage career interest “adolescents be exposed to non-traditional career-related role modeling...and be given opportunities to engage in mastery performance experiences” (p. 528). Despite the many logistical challenges of including students in this type of experience as part of a formal science curriculum, the exposure offers a great deal by way of maximizing student potential.

Limitations

Participant sampling and participant selection was a limitation in this study in that children volunteered to attend the program. As a result, these students may have been more interested than their peers in citizen science programs at the onset. In fact, out of over 200 students invited to attend in each of the schools, 86 students completed the surveys while 45 participated in the intervention. Some individuals indicated that they had alternate activities and could not stay overnight. A few students were subject to disciplinary action prior to the trip which prohibited attendance. However, it is unclear whether the participants had a greater interest than their peers at the start of the program.

Between the treatment and comparison groups, there were enough participants to establish statistical power. Although a variety of statistical tests were applied to the data, a larger number of students would have provided enough information to apply structural equation modeling, a common method in social cognitive career studies.

Another concern in the study was the time duration between repeated measures. Originally, the research design called for the pre content measure to be given two months prior to the trip. Logistical concerns due to research protocol and school day requirements delayed the administration of this measure until one week before the program. Further, at the comparison school, students were unable to take the measure during class due to an assembly. Many students returned at lunch to complete the survey while others preferred to go to the cafeteria.

An influential issue related to the training during the PowerPoint. Although the comparison and treatment school instructors coordinated instruction, the students in the treatment group received training from a field expert through the use of the PowerPoint. In addition, the treatment group had an additional opportunity to test Limulus amoebocyte lysate (LAL) during a hands-on activity. Based on the naturalist's level of expertise, instruction through the PowerPoint may have been more thorough for the treatment group. In addition, the treatment group may have had more time on task during instruction over the 24 hour period than the comparison group during the school day. Interestingly, post content measures for the comparison group corresponded with pre content measures of the treatment group. Once students worked at the beach, the post

content skills increased. This difference further demonstrated the impact of scientific field work for children beyond standard curriculum requirements.

Three limitations emerged based on the use of measures. In the first instance, the Sources of Science Self-Efficacy (Britner & Pajares, 2006), was not originally developed as a pre and post measure so its use in this study was an alternate application. The purpose of the Event Measure (Hiller, 2012c) was to highlight participants' accuracy in terms of collecting data. According to Ericsson and Ward (2007), "The key challenge for anyone interested in individual differences in expert performance is to measure highly representative performance under controlled conditions that are standardized for everyone tested." The circumstances on the beach which included waves crashing, wind blowing, and a lot of noise, created some disturbance during the Event Measure (Hiller). Field experts worked with the researcher to ensure that observations collected by students were accurate. Three field experts indicated that they would have preferred to work with the students over a repeated time period prior to taking the Event Measure (Hiller). They believed the students' limited experience influenced the assessment of students' skill levels.

The path analyses in this study generally corresponded with previous social cognitive career models in that there were interactions among constructs. Specifically, the interaction positively affected career goal setting. Nevertheless, the Career Goals Scale (Mu, 1998) did not correlate with most of the other constructs using Pearson Correlations and there were no main effects for multivariate analysis. A possible explanation is that the Career Goals Scale (Mu) had general statements about goal setting and career

possibilities. Questions more specifically related to steps to becoming a scientist or studying horseshoe crabs may have yielded different results. Lent, Brown, Nota, & Soresi (2003) noted that support systems within a given context alter choice goals to varying degrees. Perhaps the participants required repeated experiences over a longer period of time in order to detect the influence of this type of experience on career choice goals. Another change which might alter the results would be to use a microanalytic approach during the intervention rather than self-report surveys.

The final limitation stemmed from the conditions at the beach. Research incorporating informal natural science learning settings has specific challenges. Students encountered the same type of circumstances that professional scientists work with when conducting field work. These dynamics were an underlying component of the research results overall. Further, in previous years, students participated in the research for the professional biologist in the morning and the mock survey at night. Due to the lunar cycle and high tides during the week, there was only one opportunity to collect data in the late afternoon. For this reason, some participants retrieved data for the professional scientist while other students contributed to the mock survey. Both teams received direct instruction from field experts. Conducting two separate field experiences for each student during the one day interval as in previous years may have affected results in this study.

Recommendations for Future Research

The present study demonstrated that citizen science programs positively influenced student academic achievement and career motivation. As a result, this type of experience aligns with national initiatives related to improving science, technology,

engineering, and math (STEM) education. The National Science Foundation (Friedman, 2012) recommends the establishment of cooperative education programs between schools and professional institutions to create authentic experiences for students thereby increasing a scientifically oriented work force. The Congressional Research Service (Stine, 2008) cites experiential-based learning for middle school students as one way to promote an internationally competitive work force.

The findings of this study correspond with current policies as well as social cognitive career theory in that instructional support positively influenced student, self-efficacy, interest, outcome expectations, choice goals, and academic achievement (Patrick, Care, & Ainley, 2011; Rogers & Creed, 2011; Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). This relationship is significant because student beliefs about their capabilities in a specific domain are a strong determinant in career pathways regardless of gender (Lent, Brown, Tracey, Soresi, & Nota, 2006). Situated within a citizen science context, future research with larger sample sizes would support the interconnection of social cognitive career theory constructs. Specifically, structural equation modeling is a method generally applied to social cognitive career studies. Citizen science opportunities for larger numbers of children would extend the results of this study. With the use of a larger sample, the influence of choice goals in conjunction with other constructs should be retested with some additional choice formation measures.

Hidi and Ainley (2009), claim that repeated exposure in specific activities creates student motivation. Individuals who work with scientists during citizen science programs heighten interest and increase content knowledge and science literacy (Cronje, Rohlinger,

Crall, & Newman, 2011; Harrison, Underhill, & Barnard, 2008; Hiller, 2012a; Sutton 2009; Tomasek, 2006). This current study revealed the impact of student exposure to field work over 24 hours. In order to examine the impact of modeling of scientific work habits, a study which included repeated interactions with scientists may further illuminate the impact on self-efficacy, interest, outcome expectations, choice goals, academic achievement, and career motivation. A similar extension would be to conduct a longitudinal study of children participating in horseshoe crab citizen science programs in terms of career paths. Further, Mueller, Tippins, and Bryan (2012) recommend that future citizen science programs provide increased opportunities to collaborate with scientists in terms of research design, interpretations, and decision making. In order to progress from a preliminary skill set to a more advanced level, consistent interactions with scientists is preferable and is a natural progression from initial joint efforts with field work.

In conclusion, citizen science programs impact the development of content knowledge, science literacy, mastery experiences, self-efficacy, and interest (Cronje, Rohlinger, Crall, & Newman, 2010; Sutton, 2009; Harrison, Underhill, & Barnard, 2008; Hiller, 2012a; Tomasek, 2006). A gap in the current citizen science literature is the impact of data collection opportunities on individuals' science process skills (Crall, Jordan, Holfelder, Newman, Graham, & Waller, 2012). The findings of this study extend an understanding of the potential of volunteer contributions during field work with guidance and protocol training, particularly for children in terms of knowledge development and vocational trajectories. Students with access to this type of activity may visualize themselves in science and engineering fields (Bombaugh, 2000). For this

reason, citizen science is a medium for authentic scientific work which enables students to develop a sense of competence for science careers. As such, citizen science is an educational endeavor which engages students in critical thinking, decision making, and promotes a sense of environmental stewardship (Mueller, Tippins, & Bryan, 2012). Future research centered on long term academic achievement and career motivation for students engaged in collaborative efforts with scientists over the course of middle and secondary school would further establish the advantages of incorporating citizen science programs within formal education programs.

APPENDIX A

MEASURES

Name: _____ (First and Last)

Thank you for participating in this survey. Your input will help me to understand how to effectively teach science to middle school students.

I am a _____ boy _____ girl. My birthday is: _____
(Month, Day, Year)

I am Asian
 Black/African American
 Hispanic
 White
 Other

How many semesters have you participated in the Green Eggs and Sand Program?

0 times 1time 2 times 3 times

If you have participated in the horseshoe crab program more than 1 time, please describe how this program has helped you:

Task Interest Scale (Hiller, 2012c)

Rate how interested you are in the following activities:

	Very Interested	Interested	Not Certain	Disinterested	Strongly Disinterested
Analyzing water samples	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bird watching	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Measuring horseshoe crabs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collecting seashells	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Citizen Science Self-Efficacy Scale (Hiller, 2012b)

Rate how well you believe you can conduct the activities listed below on a scale of 1 to 5 with (5) as very sure and (1) as not sure at all.

	1	2	3	4	5
Locate horseshoe crabs	<input type="radio"/>				
Count horseshoe crabs	<input type="radio"/>				
Write down the things I see when looking at horseshoe crabs	<input type="radio"/>				
Find differences between horseshoe crabs.	<input type="radio"/>				
Use a tape measure accurately.	<input type="radio"/>				
Measure the distance between the eyes of a horseshoe crabs accurately.	<input type="radio"/>				
Distinguish horseshoe crabs from other animals	<input type="radio"/>				
Collect data for a scientist's research study	<input type="radio"/>				

Citizen Science Outcome Expectations Scale (Hiller, 2012c)

Rate how strongly you agree with the following statements below:

	Strongly Agree	Agree	Not Certain	Disagree	Strongly Disagree
Studying horseshoe crabs will help me understand the work of scientists.	<input type="radio"/>				
Studying horseshoe crabs will help me decide if I want to be a scientist.	<input type="radio"/>				
Studying horseshoe crabs will help me improve my science skills.	<input type="radio"/>				
Studying horseshoe crabs will help me improve my science grades.	<input type="radio"/>				
Studying horseshoe crabs helps me to understand their ecological niche.	<input type="radio"/>				
Studying horseshoe crabs helps scientists with their work.	<input type="radio"/>				

Horseshoe Crab Content Measure (Hiller, 2012c)

Part I: Horseshoe Crab Form and Function

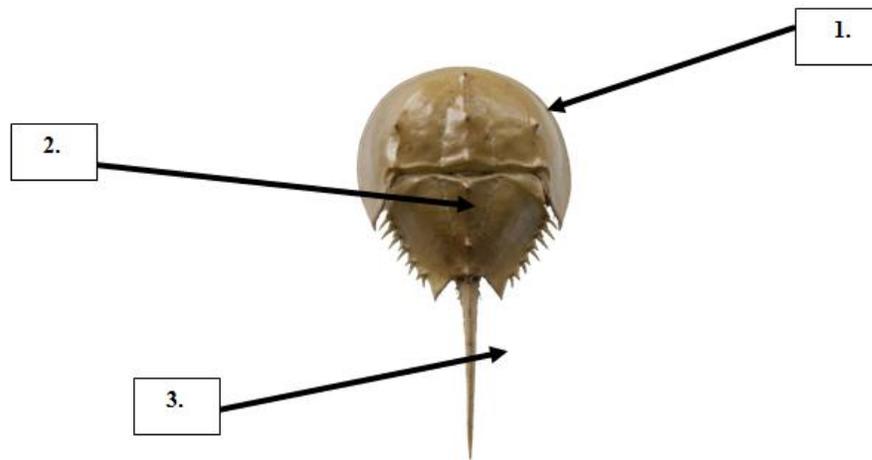


Figure 9. Top view of horseshoe crab by Jackson, A. Copyright, 2011. Reprinted with permission.

The horseshoe crab has three main body parts. Based on the diagram above, identify each part.

1. a) telson b) prosoma c) interocular d) book gills
2. a) opisthosoma b) telson c) gnathobases d) median
3. a) lateral b) flabellum c) telson d) prosoma
4. The mouth of the horseshoe crab is located
 - a) at the base of the spine.
 - b) in between the eyes.
 - c) next to the book gills.
 - d) in between the legs.

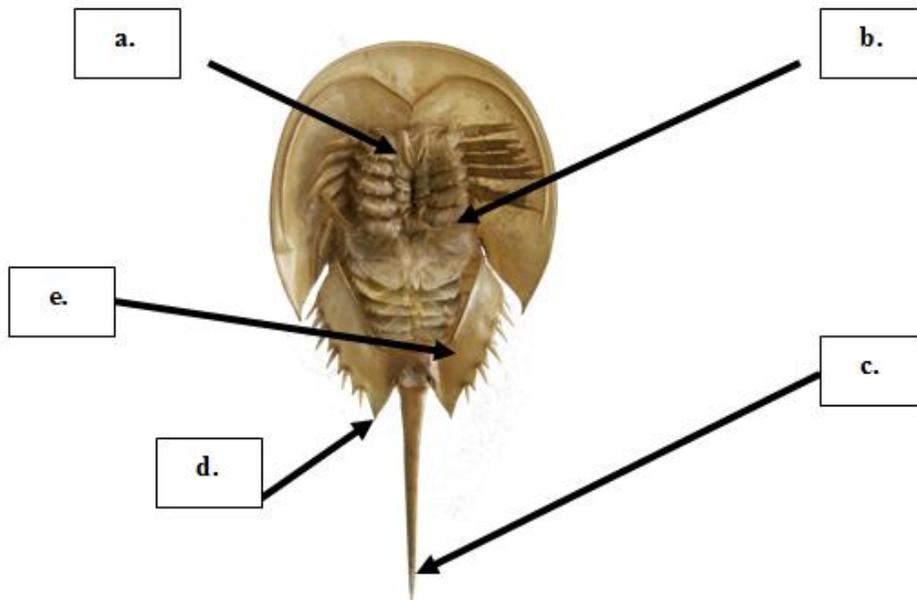


Figure 10. Bottom view of horseshoe crab by Jackson, A. Copyright, 2011. Reprinted with permission.

5. On the diagram above, which part of the horseshoe crab is used for breathing?

a. b. c. d. e.
6. On the diagram above, which part of the horseshoe crab is used as a lever to help the horseshoe crab when it is flipped over?

a. b. c. d. e.
7. On the diagram above which part of the horseshoe crab helps to feel along the bottom?

a. b. c. d. e.

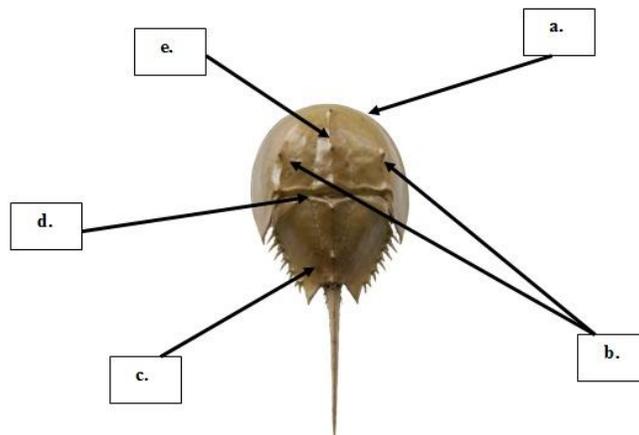


Figure 11. Top view of horseshoe crab by Jackson, A. Copyright, 2011. Reprinted with permission.

8. On the diagram above, where are the simple eyes (median)?

- a. b. c. d. e.

Part II: Horseshoe Crab Life Cycle

9. Horseshoe crab eggs develop

- a) in the ocean. b) in the sand. c) on coral reefs. d) in river beds.

10. Kyle found a small horseshoe crab with clasper claws and an arched shell. The

horseshoe crab is most likely a(n)

- a) female b) male c) juvenile d) adult



Figure 12. Horseshoe crab gender identification by Stubbolo, G. Copyright, 2012. Reprinted with permission.

Identify the following horseshoe crabs by number:

Female _____

Older Satellite Male _____

Younger Satellite Male _____

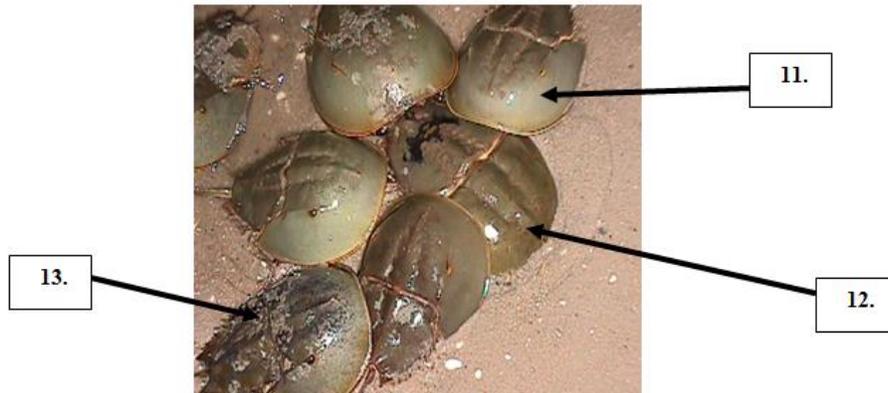


Figure 13. Spawning horseshoe crabs by Jackson, A. Copyright, 2011. Reprinted with permission.

14. Which of the following describes the function of the pusher legs?
- a. digging.
 - b. moving.
 - c. shaping eggs into clusters.
 - d. all of the above.

Part III: Horseshoe Crab Systems and Interactions

15. Horseshoe crabs are most closely related to the following organism
- a. blue crabs.
 - b. shrimp.
 - c. scorpions.
 - d. turtles.
16. Which ancient animal are horseshoe crabs related to?
- a. trilobite
 - b. ammonite
 - c. fossil millipede
 - d. belemnite
17. How many surviving horseshoe crab species exist in the world?
- a. One
 - b. Four
 - c. Ten
 - d. One Hundred

18. Which of the following organisms eat horseshoe crab eggs?
- a. striped bass. b. white perch. c. off shore birds. d. all of the above.
19. In the 1800s, humans most commonly used horseshoe crabs for
- a. medical research b. biological studies c. food source d. fertilizer
20. In the 1990s, horseshoe crabs have assisted which of the following medical advances?
- a. vaccinations b. pacemakers c. kidney dialysis d. all of the above
21. Horseshoe crabs are used in biomedical research because
- a. it is a species that has existed for over 200 million years.
- b. the copper rich blood detects the presence of bacteria.
- c. there are enough horseshoe crabs available.
- d. the blood is similar in composition to human blood.

APPENDIX B

SEMI-STRUCTURED INTERVIEW FORMAT

1. How did you feel about studying the horseshoe crabs during the Talent Development Horseshoe Crab Program?
2. During the Talent Development Horseshoe Crab Program, did you make any discoveries? If so, what was the process you went through?
3. Did studying the horseshoe crabs change the way you feel about studying science?
4. How did you feel about collecting data for a scientific database?
5. Did the experiences you had during the Talent Development Horseshoe Crab Program affect your future choices for a career?

APPENDIX C
EVENT MEASURE

Event measure (Hiller, 2012c).

<i>Team _____</i>	<i>Horseshoe Crab 1</i>	<i>Horseshoe Crab 2</i>	<i>Horseshoe Crab 3</i>
The team accurately identified the organism as a horseshoe crab.			
The team measured with centimeter units.			
The team accurately measured the interocular.			
The team accurately determined the gender.			
The team accurately determined the relative age.			

APPENDIX D
OPEN CODING DESCRIPTIVE LABELS

AQ- Accuracy and Quality; discussion of accuracy and quality of horseshoe crab data collection

AT-Attitude- discussion of changes in attitude towards science

C-Challenge; discussions related to the level of difficulty involved in tasks

CD-Conditions; discussions of outdoor conditions during data collection

CE-Childhood Experiences; discussions related to childhood experiences

CJ-Career Trajectory; discussions of possible career paths and professions

participants are considering for themselves.

CO-Collaboration; discussions of working with scientists or assisting scientists with data collection including emotions to contributing data to scientists

CP-Competence; discussions of students' beliefs about their own capabilities as well as their peers including maturity levels and focus

E-Expectations; discussions of expectations of working with horseshoe crabs in comparison to the actual event

FB-Fall back; discussions of falling back on science related careers if primary choices do not work out

FI-Family Impact; discussions of the impact of family members on participants' experiences

F-Fun; discussions related to having fun

GS-Green Eggs and Sand; discussion of experiences in the Green Eggs and Sand Talent Development program

I-Impact; discussions related to the impact of the horseshoe crab program on the participants

II-Intrinsic Interest; discussions related to participants' level of interest for horseshoe crabs

IN-Interaction; discussions centering on participants interaction with horseshoe crabs including touching, observing, emotions towards, and anatomy discussions

M-Modeling; discussions of teacher or field expert modeling

O-Observations; discussions of student observations related to the horseshoe crabs

P-Partners; discussions of interactions between peers during data collection and teamwork skills

PE-Prior Experience; discussions of prior experiences with horseshoe crabs including classroom instruction

PM-Program Motivation; discussions related to reasons participants had for joining the program.

R-Recommendations; discussions related to recommending the horseshoe crab program for other 8th graders

SS-Skill Set; discussions of participants' views on their science skill sets and their ability to use these skills

SU-Subject; discussion of participants' favorite subject

T-Trust; discussions of participants' views of scientists trusting eighth graders to collect data and contribute to research

V-Volume; discussions about the number of horseshoe crabs

VO-Volunteer; discussions of participants' willingness to volunteer to collect data for scientists in the future

APPENDIX E

HUMAN SUBJECTS REVIEW BOARD APPROVAL



Office of Research Subject Protections
Research Hall
4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-4121; Fax: 703-993-9590

TO: Anastasia Kitsantas, College of Education and Human Development

FROM: Keith R. Bushey 
Chief of Staff, Office of Research

PROTOCOL: 7403 Research Level: Class Project (G)

PROPOSAL NO.: N/A

TITLE: The Effect of a Horseshoe Crab Citizen Science Project on Student Self-Efficacy and Career Path Trajectories

DATE: February 22, 2012

Cc: Suzanne Hiller

On February 22, 2012, the George Mason University Human Subjects Review Board (GMU HSRB) reviewed and approved the continuation of the above-cited protocol as submitted following expedited review procedures.

Please note the following:

1. A copy of the final approved consent document is attached. You must use this copy with the HSRB stamp of approval for your research. Please keep copies of the signed consent forms used for this research for 3 years after the completion of the research.
2. **Any modification to your research (including the protocol, consent, advertisements, instruments, funding, etc.) must be submitted to the Office of Research Subject Protections for review and approval prior to implementation.**
3. Any adverse events or unanticipated problems involving risks to subjects including problems involving confidentiality of the data identifying the participants must be reported to Office of Research Subject Protections and reviewed by the HSRB.

The anniversary date of this study is 2/21/2013. **You may not collect data beyond that date without GMU HSRB approval.** A continuing review form must be completed and submitted to the Office of Research Subject Protections 30 days prior to the anniversary date or upon completion of the project. A copy of the continuing review form is attached. In addition, prior to that date, the Office of Research Subject Protections will send you a reminder regarding continuing review procedures.

If you have any questions, please do not hesitate to contact me at 703-993-3088.

APPENDIX F

INFORMED CONSENT AND MINOR ASSENT FORMS FOR TREATMENT GROUP

of this document
EXPIRES

FEB 21 2013

INFORMED PARENTAL CONSENT FORM Protocol # 7403
George Mason University

The Effect of a Horseshoe Crab Citizen Science Project on Student Self-Efficacy and Career Path Trajectories

RESEARCH PROCEDURES

Your child has been invited to participate in a research study as an eighth grade student. This research is being conducted to study how a horseshoe crab citizen science project known as the Talent Development Cluster, Green Eggs and Sand, affects student's beliefs about their ability to perform scientific investigations and the effect of this activity on career paths. During the study, your child will take a survey three times during the school year which would take 10 minutes each time. In addition, children participating in data collection related to horseshoe crabs would be interviewed for 10 minutes following the experience. During the day, groups studying the horseshoe crabs will be videotaped. At night, the group will be audio taped while collecting horseshoe crab data. Tapes will be used solely by the researcher and will not be shared publicly.

RISKS

There are no foreseeable risks for participating in this research.

BENEFITS

There are no benefits to your child as a participant other than to further research in the field of environmental education.

CONFIDENTIALITY

The data in this study will be confidential. Your child's name will not be included in any collected data, and a code will be used on collected data. Through the use of an identification key, the researcher will link your child's data to their identity. Only the researcher will have access to the identification key and all related materials will be securely locked.

PARTICIPATION

Your child's participation is voluntary, and you or your child may withdraw from the study at any time and for any reason. If you decide not to have your child participate or if you withdraw them from the study, there is no penalty or loss of benefits to which they are otherwise entitled. There are no costs to you or any other party.

CONTACT

This research is being conducted by Suzanne Hiller at George Mason University. She may be reached at 703-779-2081. For questions or to report a research-related problem, please contact Suzanne Hiller or Dr. Anastasia Kitsantas at 703-993-2688. In addition, you may contact the Office of Research Subjects Protections at 703-993-4121 if you have any questions or comments regarding your child's rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your child's participation in this research.

2/12/12

CONSENT

I have read this form and agree to have my child participate in this study.

Child's Name: _____

Parent's Signature: _____ Date _____

I give permission for my child to be audio taped video taped

Approval for the use
of this document
EXPIRES

FEB 21 2013

Protocol # 7403
George Mason University

2/12/12

APPENDIX G

INFORMED CONSENT AND MINOR ASSENT FORMS FOR COMPARISON GROUP

Approval for the use
of this document
EXPIRES

FEB 21 2013

INFORMED PARENTAL CONSENT FORM

Protocol # 7403
George Mason University

The Effect of a Horseshoe Crab Citizen Science Project on Student Self-Efficacy and Career Path Trajectories

RESEARCH PROCEDURES

Your child has been invited to participate in a research study as an eighth grade student. This research is being conducted to study how participating in outdoor activities affects student's beliefs about their ability to perform scientific investigations and the effect of this activity on career paths. Your child will be asked to take a survey about their perceptions of their science skills, interest in outdoor activities, science oriented career interests, and an assessment on horseshoe crabs. The survey will take approximately ten minutes and will be administered once.

RISKS

There are no foreseeable risks for participating in this research.

BENEFITS

There are no benefits to your child as a participant other than to further research in the field of environmental education.

CONFIDENTIALITY

The data in this study will be confidential. Your child's name will not be included in any collected data, and a code will be used on collected data. Through the use of an identification key, the researcher will link your child's data to their identity. Only the researcher will have access to the identification key and all related materials will be securely locked.

PARTICIPATION

Your child's participation is voluntary, and you or your child may withdraw from the study at any time and for any reason. If you decide not to have your child participate or if you withdraw them from the study, there is no penalty or loss of benefits to which they are otherwise entitled. There are no costs to you or any other party.

CONTACT

This research is being conducted by Suzanne Hiller at George Mason University. She may be reached at 703-779-2081. For questions or to report a research-related problem, please contact Suzanne Hiller or Dr. Anastasia Kitsantas at 703-993-2688. In addition, you may contact the Office of Research Subjects Protections at 703-993-4121 if you have any questions or comments regarding your child's rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your child's participation in this research.

CONSENT

I have read this form and agree to have my child participate in this study.

Child's Name: _____

Parent's Signature: _____

Date _____

Minor Assent Form

Dear Student:

As an eighth grade student, you have been invited to participate in a research study. From your work, researchers will learn how collecting data in an outdoor setting helps students improve science skills and influences career choices. If you agree, you will be asked to complete one survey. There are no foreseeable risks for participating in this research, and there are no benefits other than to further research in science education.

The data in this study will be kept private. Your name will not appear with any data. The researcher will use a numeric code to keep track of data. Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide that you do not want to participate or if you withdraw from the study, there is no penalty. This research has been approved according to George Mason University procedures governing participation in research.

Assent

I have read this form and agree to participate in the study voluntarily.

Name

Date of Signature

Approval for the use
of this document
EXPIRES

FEB 21 2013

Protocol #: 7403
George Mason University

Revised 09/05/11

REFERENCES

REFERENCES

- Bandura, A. (1997). *The exercise of control*. New York, NY: W. H. Freeman and Company.
- Baram-Tsabari, A., & Yarden, A. (2011). Quantifying the gender gap in science interests. *The International Journal of Science and Mathematics Education, 9*, 523-550. doi: 10.1007/s10763-010-9194-7
- Betz, N. E. Klein, K. L., & Taylor, K. M. (1996). Evaluation of the short form of the career decision-making self-efficacy scale, *Journal of Career Assessment, 4*(1), 47-57. doi: 0.1177/106907279600400103
- Betz, N. E., & Voyten, K. K. (1997). Efficacy and outcome expectations influence career exploration and decidedness. *The Career Development Quarterly, 46*, 179-189. doi: 10.1002/j.2161-0045.1997.tb01004.x
- Bierle, S. Singletary, T. J. (2008). Environmental education and related fields in Idaho secondary schools. *The Journal of Environmental Education, 39*(3), 19-31. doi: 10.3200/JOEE.39.3.19-31
- Bonitz, S. V., Larson, L. M., & Armstrong, P. I. (2010). Interests, self-efficacy, and choice goals: An experimental manipulation. *Journal of Vocational Behavior, 76*, 223-233. doi:10.1016/j.jvb.2009.09.003
- Bombaugh, R. (2000) From citizen scientist to engineers. *Journal of Professional Issues in Engineering Education and Practice, 126*(2), 64-68. doi: 10.1061/(ASCE)1052-3928(2000)126:2(64)
- Bowen, G. M., & Roth, W. M. (2007). The practice of field ecology: Insights for science education. *Research Science Education, 37*, 171-187. doi: 10.1007/s11165-006-9021-x
- Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*(5), 485-499. doi: 10.1002/tea.20131
- Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education, 27*(9), 1099-1121. doi: 10.1080/09500690500069483

- Buccheri, G., Gürber, N. A., and Brühwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education*, 33(1), 159-178. doi: 10.1080/09500693.2011.518643
- Byars-Winston, A., Estrada, Y., Howard, C., Davis, D., & Zalapa, J. (2010). Influence of social cognitive and ethnic variables on academic goals of underrepresented students in science and engineering: A multiple-group analysis. *Journal of Counseling Psychology*, 57(2), 205-218. doi: 10.1037/a0018608
- Cachelin, A., Paisley, K., & Blanchard, A. (2009). Using the significant life experience framework to inform program evaluation: The Nature Conservancy's Wings and Water Wetlands Education Program. *The Journal of Environmental Education*, 40(2), 2-14. doi: 10.3200/JOEE.40.2.2-14
- Cartwright, N. (1989). *Nature's capacities and their measurements*. Oxford, UK: Clarendon Press.
- Cartwright, N. (1999). *The Dappled World*. Cambridge, UK: Cambridge University Press.
- Charmaz, K. (2006). *Constructing grounded theory*. Los Angeles, CA: Sage.
- Chawla, L., & Cushing, D. F. (2007). Education for strategic environment. *Journal of Environmental Education*, 13(4), 437-452. doi: 10.1080/13504620701581539
- Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools*, 41(5), 537-550. doi: 10.1002/pits.10177
- Costa, P. T., Jr., & McCrae, R. R. (1989). *NEO-PI/FFI manual supplement*. Odessa, FL: Psychological Assessment Resources.
- Crall, A. W. (2010). *Developing and evaluating a national citizen science program for invasive species* (Doctoral dissertation). Retrieved from Proquest Information and Learning Company. (UMI No. 3421961)

- Crall, A. W., Jordan, R., Holfelder, K., Newman, G. J., Graham, J., & Waller, D. M. (2012). The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy. *Public Understanding of Science*, 0(0), 1-20. doi: 10.1177/0963662511434894
- Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education, Inc.
- Cronje, R., Rohlinger, S., Crall, A., & Newman, G. (2011). Does participation in citizen science improve scientific literacy? A study to compare assessment methods. *Applied Environmental Education and Communication*, 10, 135-145. doi: 10.1080/1533015X.2011.603611
- Day, R., & Allen, T. D. (2002). The relationship between career motivation and self-efficacy with protégé career success. *Journal of Vocational Behavior*, 64, 72-91. doi: 10.1016/S0001-8791(03)00036-8
- Denzin, N. K., & Lincoln, Y. S. (Eds.). (2005). *The handbook of qualitative research* (3rd ed.). Newbury Park: Sage.
- Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods* (2nd ed.). New York: McGraw Hill.
- Devine-Wright, P., Devine-Wright, H., & Fleming, P. (2004). Situational influences upon children's beliefs about global warming and energy. *Environmental Education Research*, 10(4), 493-506. doi: 10.1080/1350462042000291029
- DiBenedetto, M. K., & Zimmerman, B. J. (2010). Differences in self-regulatory processes among students studying science: A microanalytic investigation. *The International Journal of Educational and Psychological Assessment*, 5, 2-24.
- Dimitrov, D. M. (2008). *Quantitative research in education*. New York, NY: Whittier Publications Inc.
- Dimitrov, D. M. (2012). *Statistical methods for validation of assessment scale data in counseling and related fields*. Alexandria, VA: American Counseling Association.
- Dunlap, R. E., & Van Liere, K. D. (1978). The new environmental paradigm: A proposed measuring instrument and preliminary results. *Journal of Environmental Education*, 9, 10-19.

- Dunlap, R. E., et al. (1992, August). *Measuring endorsement of an ecological worldview: A revised NEP scale*. Paper presented at the meeting of the Rural Sociology Society, State College, Pennsylvania.
- Eberbach, C., & Crowley, K. (2009). From everyday to scientific observation: How children learn to observe the biologist's world. *Review of Educational Research*, 79(1), 39-68. doi: 10.3102/0034654308325899
- Eisenhart, M. (2005). Hammers and saws for the improvement of educational research. *Educational Theory*, 55(3), 245-261. doi: 10.1111/j.1741-5446.2005.00002.x
- Ericsson, K. A., & Ward, P. (2007). Capturing the naturally occurring superior performance of experts in the laboratory. *Current Directions in Psychological Science*, 16(6), 346-350. doi: 10.1111/j.1467-8721.2007.00533.x
- Faul, F. Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39, 175-191. doi: 10.3758/BF03193146
- Fine, M. (1994). Working the hyphens: Reinventing self and other in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 70-82). Thousand Oaks, CA: Sage.
- Fisher, T. A., & Stafford, M. E. (1999). Reliability and validity of the career influence inventory: A pilot study. *Journal of Career Assessment*, 7, 187-202. doi: 10.1177/106907279900700207
- Fontana, A., & Frey, J. H. (1994). Interviewing: The art of science. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 70-82). Thousand Oaks, CA: Sage.
- Fouad, N. A., Smith, P. L., & Enochs, L. (1997). Reliability and validity evidence for the Middle School Self-Efficacy Scale. *Measurement and Evaluation in Counseling and Development*, 30, 17-31.
- Fouad, N. A., Smith, P. L., & Zao, K. E. (2002). Across academic domains: Extensions of the Social-Cognitive Career Model. *Journal of Counseling Psychology*, 2, 164-171. doi: 10.1037//0022-0167.49.2.164
- Friedman, A. J. (Ed.). (2008, March). *Framework for evaluating impacts of informal science education projects* (NSF Order Number DACS06D1421). Washington, D. C.: National Science Foundation. Retrieved from the National Science Foundation website: http://inisci.org/resources/Eval_Framework.pdf

- Glesne, C. (2006). *Becoming qualitative researchers*. Boston, MA: Pearson Education, Inc.
- Greene, J. C. (2007). *Mixed methods in social inquiry*. San Francisco, CA: John Wiley & Sons, Inc.
- Guba. E. G., & Lincoln, Y. S. (2005). Paradigmatic controversies, contradictions, and emerging influences. In Denzin and Lincoln's (Eds.), *Qualitative research* (3rd ed.). Thousand Oaks: Sage.
- Hammersley, M. (2000). The relevance of qualitative research. *Oxford Review of Education*, 26(3), 395-405.
- Hannover, B., & Kessels, U. (2006). How the image of math and science affects the development of academic interests. In M. Prenzel's (Ed.), *Studies on the educational quality of schools*. Münster, Germany: Waxmann.
- Harmon, L. W., Hansen, J. C., Borgen, F. H., & Hammer, A. L. (1994). *Strong Interest Inventory applications and technical guide*. Stanford, CA: Stanford University Press.
- Harrison, J. A., Underhill, L. G., & Barnard, P. (2008). The seminal legacy of the Southern African Bird Atlas Project. *South African Journal of Science*, 104, 82-83.
- Hidi, S., & Ainley, M. (2009). Interest and self-regulation: Relationships between two variables that influence learning. In D. H. Schunk and B. J. Zimmerman's (Eds.) *Motivation and self-regulated learning*. New York, NY,: Routledge.
- Hiller, S. E. (2012a, April). *The effect of a horseshoe crab citizen science project on student self-efficacy and career trajectories*. Roundtable presentation at the annual conference of the American Educational Research Association, Vancouver, Canada.
- Hiller, S. E. (2012b). The development of the citizen science self-efficacy scale. Unpublished manuscript, College of Education and Human Development, George Mason University, Fairfax, Virginia.
- Hiller, S. E. (2012c). Pilot measures based in a social cognitive career theory perspective. Unpublished manuscript, College of Education and Human Development, George Mason University, Fairfax, Virginia.

- Hiller, S. E., & Reybold, L. E. (2011, October). *Field expert's perceptions of scientific observations in the natural world*. Paper presentation at the annual research symposium of the North American Association for Environmental Education, Raleigh, NC.
- Hiller, S. E., & Reybold, L. E. (2012). *The Impact of Scientific Observations on Student Affect, Cognition, and Competence: Naturalists' Perspectives of Children as Citizen Scientists*. Unpublished manuscript, College of Education and Human Development, George Mason University, Fairfax, Virginia.
- Hmelo-Silver, C. E., & Pfeffer, M. G. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science*, 28, 127-138. doi: 10.1016/S0364-0213(03)00065-X
- Holland, J. L. (1994). *The self-directed search* (2nd Australian ed.). Melbourne, Australia: ACER.
- Holland, J. L. (1997). *Making vocational choices: A theory of vocational personalities and work environments*. Odessa, FL. Psychological Assessment Resources.
- Howard, K. A. S., Ferrari, L., Nota, L., Solberg, V. S. H., & Soresi, S. (2009). The relation of cultural context and social relationships to career development in middle school. *Journal of Vocational Behavior*, 75, 100-108. doi:10.1016/j.jvb.2009.06.013
- Hu, L. T., & Kano, Y. (1992). Can test statistics in covariance structure analysis be trusted? *Psychological Bulletin*, 112, 351-362. doi: 10.1037/0033-2909.112.2.351
- Institute of Education Sciences, National Center for Education Statistics (2012, May). *The condition of education* (NCES Report No. 2012045). Retrieved http://nces.ed.gov/programs/coe/indicator_isp.asp
- Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching*, 42(6), 668-690. doi: 10.1002/tea.20069
- Katz, I., Assor, A., Kanat-Maymon, Y., & Bereby-Meyer, Y. (2006). Interest as a motivational resource: Feedback and gender matter, but interest makes the difference. *Social Psychology of Education*, 9, 27-42. doi: 10.1007/s11218-005-2863-7

- Kitsantas, A., & Dabbagh, N. (2010). *Learning to learn with integrative learning technologies*. Charlotte, NC: Information Age Publishing, Inc.
- Kitsantas, A., Zimmerman, B. J., & Cleary, T. (2000). The role of observation and emulation in the development of athletic self-regulation. *Journal of Educational Psychology, 92*(4), 811-817. doi: 10.1037/M»22-0663.92.4.811
- Kreamer, G. (2011, May). *Ten things to know about the horseshoe crab*. PowerPoint presentation. Department of Natural Resources, Dover, DE.
- Lent, R. W., & Brown, S. D. (2006). On conceptualizing and assessing social cognitive constructs in career research: A measurement guide. *Journal of Career Assessment, 14*(1), 12-35. doi: 10.1177/1069072705281364
- Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*, 79-122. doi: 10.1006/jvbe.1994.1027
- Lent, R. W., Brown, S. D., Nota, L., & Soresi, S. (2003). Testing social cognitive interest and choice hypotheses across Holland type in Italian high school students. *Journal of Vocational Behavior, 62*, 101-118. doi: 10.1016/S0001-8791(02)00057-X
- Lent, R. W., Brown, S. D., & Sheu, B. (2010). The self-efficacy interest relationship and RIASEC type: Which is figure and which is ground? Comment on Armstrong and Vogel (2009). *Journal of Counseling Psychology, 57*(2), 219-225. doi: 10.1037/a0019039
- Lent, R. W., Brown, S. D., Tracey, T. J. G., Soresi, S., & Nota, L. (2006). Development of interests and competency beliefs in Italian adolescents; an exploration of circumplex structure and bidirectional relationships. *Journal of Counseling and Psychology, 53*(2), 181-191. doi: 10.1037/0022-1067.53.2.181
- Lent, R. W., & Hackett, G. (1994). Sociocognitive mechanisms of personal agency in career development. In M. L. Savickas and R. W. Lent's (Eds.) *Convergence in career development*. Palo Alto, CA: CPP Books.
- Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. *Journal of Counseling Psychology, 38*(4), 424-430. doi: 10.1037//0022-0167.38.4.424

- Lent, R. W., Lopez Jr., A. M., Lopez, F. G., & Sheu, H. (2008). Social cognitive career theory and the prediction of interests and choice goals in the computing disciplines. *Journal of Vocational Behavior*, *73*, 52-62. doi: 10.1016/j.jvb.2008.01.002
- Lent, R. W., Paixão, M. P., Silva, J. T., & J., Leitão, L. M. (2010). Predicting occupational interests and choice aspirations in Portuguese high school students: A test of social cognitive career theory. *Journal of Vocational Behavior*, *76*, 244-251. doi:10.1016/j.jvb.2009.10.001
- Liao, H.-Y., Armstrong, P. I., & Rounds, J. (2008). Development and initial validation of public domain basic interest markers. *Journal of Vocational Behavior*, *73*, 159-183. doi:10.1016/j.jvb.2007.12.002
- Lokan, J. (1984). *Career development inventory Australia*. Hawthorn, Victoria: Australian Council for Educational Research.
- Luzzo, D. A., Hasper, P., & Albert, K. A. (1999). Effects of self-efficacy-enhancing interventions on the math/science self-efficacy and career interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology*, *46*(2), 233-243. doi: 10.1037/0022-0167.46.2.233
- Malecki, C. K., Demaray, M. K., & Elliott, S. S. (2000). *The Child and Adolescent Social Support Scale*. DeKalb: Northern Illinois University.
- Martin, L. (2004). An emerging research framework for studying informal learning and schools. *Wiley Periodicals Inc*. Retrieved from the Wiley Interscience website: www.interscience.wiley.com. doi: 10.1002/sce.20020
- Matthews, J. S., Morrison, F. J., & Ponitz, C. C. (2009). Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology*, *101*(3), 689-704. doi: 10.1037/a0014240
- Maxwell, J. A. (1996). Diversity and methodology in a changing world. *Pedagogia*, *30*, 32-40.
- Maxwell, J. A. (2005). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage.
- Meinhold, J. L., & Malkus, A. J. (2005). Adolescent environmental behaviors: Can knowledge, attitudes, and self-efficacy make a difference? *Environment and Behavior*, *37*(4), 511-531. doi: 10.1177/0013916504269665

- Mu, X. (1998, August). *High school experience and career maturity in young adulthood*. Paper presented at the 24th international congress of Applied Psychology. San Francisco, CA.
- Mueller, M., Tippins, D., & Bryan, L. (2012). The future of citizen science. *Democracy & Education, 20*(1), 1-12.
- National Science Board (1996). *Science and Engineering Indicators 1996* (Report No. NSB 96-21). Washington, DC: U. S. Government Printing Office.
- National Science Board (2008). *Science and Engineering Indicators 1996* (Report No. NSB-01A) Washington, DC: U. S. Government Printing Office.
- National Science Board (2010). *Science and engineering indicators 2010* (Report No. NSB 10-01). Washington, DC: U. S. Government Printing Office.
- National Science Board (2012). *Science and engineering indicators, 2012* (Report No. NSB 12-01). Washington, DC: U. S. Government Printing Office.
- Nauta, M. M., Kahn, J. H., Angell, J. W., & Cantarelli, E. A. (2002). Identifying the antecedent in the relation between career interests and self-efficacy: Is it one, the other, or both? *Journal of Counseling Psychology, 49*(3), 290-301. doi: 10.1037//0022-1067.49.3.290
- Navarro, R.L., Flores, L. Y., & Worthington, R. L. (2007). Mexican American middle school students' goal intentions in mathematics and science: A test of social cognitive career theory. *Journal of Counseling Psychology, 54*(3), 320-335. doi: 10.1037/0022-0167.54.3.320
- North American Association for Environmental Education (2008). *Developing a state environmental literacy plan*. Retrieved from <http://eelinked.naaee.net/n/elp/posts/NAAEEs-Guide-to-Developing-a-State-Environmental-Literacy-Plan>
- Organisation for Economic Co-operation and Development (2010), *PISA 2009 Results: Executive Summary*. Retrieved from <http://www.oecd.org/pisa/pisaproducts/46619703.pdf>
- Patrick, L., Care, E., & Ainley, M. (2011). The relationship between vocational interests, self-efficacy, and achievement in the prediction of educational pathways. *Journal of Career Assessment, 19*(1), 61-74. doi: 10.1177/10690727110382615
- Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Newbury Park, CA: Sage.

- Perry, N. E., Turner, J. C., & Meyer, D. K. (2009). Classrooms as contexts for motivating learning. In Alexander and Winne's (Eds.), *Handbook of educational psychology*. New York, NY: Routledge.
- Peters, E.E. (2009). Developing content knowledge in students through explicit teaching of the nature of science: Influences of goal setting and self-monitoring. *Science & Education*. doi 10.1007/s11191-009-9219-1\
- President's Council of Advisors on Science and Technology (2012, February). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Retrieved from Office of Science and Technology Policy website:
http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf
- Quinn, G., & Lyons, T. (2011). High school students' perceptions of school science and science careers: A critical look at a critical issue. *Science Education International*, 22(4), 225-238.
- Rogers, M. E., & Creed, P. A. (2011). A longitudinal examination of adolescent career planning and exploration using a social cognitive career theory framework. *Journal of Adolescence*, 34, 163-172. doi: 10.1016/j.adolescence.2009.12.010
- Saldaña, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage.
- Savickas, M. L., & Lent, R. W. (1994). *Convergence in career development theories*. Palo Alto, CA: CPP Books.
- Schunk, D. H., & Pajares, F. (2005). Competence perceptions and academic functioning. In Elliott and Dweck's (Eds.), *Handbook of competence motivation*. New York, NY: The Guilford Press.
- Sheu, H., Lent, R. W., Brown, S. D., Miller, M. J., Hennessy, K. D., & Duffy, R. D. (2010). Testing the choice model of social cognitive career theory across Holland themes: A meta-analytic path analysis. *Journal of Vocational Behavior*, 76, 252-264. doi: 10.1016/j.jvb.2009.10.015
- Snäll, T., Kindvall, O., Nilsson, J., & Pärt, T. (2011). Evaluating citizen-based presence data for bird monitoring. *Biological conservation*, 144, 804-810. doi: 10.1016/j.biocon.2010.11.010.

- Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research*, 25, 173-180. doi: 10.1207/s15327906mbr2502_4
- Stine, D. D. (2008, January). *America competes act: Programs, funding, and selected issues* (Order Code RL34328). Washington, D. C.: Congressional Research Service. Retrieved from the STEM Coalition website: http://assets.opencrs.com/rpts/RL34328_20080122.pdf
- Sutton, S. (2009). *Increasing science literacy among English language learners through plant phenological monitoring: A citizen science program at Sequoia and Kings Canyon National Parks*. (Master's thesis). Retrieved from Proquest Information and Learning Company. (UMI Number 1473523)
- Tomasek, T. M. (2006). *Student cognition and motivation during the Classroom BirdWatch citizen science project*. (Dissertation thesis). Retrieved from the Proquest Information and Learning Company. (UMI Number 3242410)
- Trumbull, D. J., Bonney, R., & Grudens-Schuck, N. (2005). Developing materials to promote inquiry: Lessons learned. *Science education*, 89, 879-900. doi: 10.1002/sce.20081
- Trumbull, D. J., Bonney, R., Bascom, D., & Cabral, A. (2000). Thinking scientifically during participation in a citizen-science project. *Science education*, 84, 265-275. doi: 10.1002/(SICI)1098-237X(200003)84:2<265::AID-SCE7>3.0.CO;2-5
- Turner, S. L., & Lapan, R. T. (2005). Evaluation of an intervention to increase non-traditional career interests and career-related self-efficacy among middle-school adolescents. *Journal of Vocational Behavior*, 66, 516-531. doi: 10.1016/j.jvb.2004.02.005
- U. S. Department of Labor, Bureau of Labor Statistics (2012a, February), *Table 7. The 30 occupations with the fastest projected employment growth, 2010-20*. Retrieved from <http://www.bls.gov/news.release/ecopro.t07.htm>
- U. S. Department of Labor, Bureau of Labor Statistics (2012b, March), *Occupational Outlook Handbook, 2012-13 Edition*, Environmental Scientists and Specialists. Retrieved from <http://www.bls.gov/ooh/life-physical-and-social-science/environmental-scientists-and-specialists.htm>
- Weisstein, E. W. (2009). Minkowski Metric. *MathWorld-A Wolfram Web Resource*. Retrieved from <http://mathworld.wolfram.com/MinkowskiMetric.html>.

- Wigfield, A., & Wagner, A. L. (2005). Competence, motivation, and identity development during adolescence. In Elliott and Dweck's (Eds.), *Handbook of competence motivation*. New York, NY: The Guilford Press.
- Zimmerman, B. J. (2011). Motivational sources and outcomes of self-regulated learning and performance. In Zimmerman, B. J., & Schunk, D. H. (Eds.), *Handbook of Self-Regulation of Learning and Performance*. New York, NY: Routledge.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekart, P. R. Pintrich, and Zeidner, M. (Eds.) *Handbook of Self-Regulation*. New York, NY: Academic Press.
- Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, 81(3), 329-339. doi: 10.1037/0022-0663.81.3.329
- Zimmerman, B. J., & Kitsantas, A. (1997). Developmental phases in self-regulation: Shifting from process goals to outcome goals. *Journal of Educational Psychology*, 89(1), 29-36. doi: 10.1037/0022-0663.89.1.29
- Zimmerman, B. J., and Schunk, D. H. (2003). *Educational psychology: A century of contributions*. New York, NY: Routledge.

CURRICULUM VITAE

Suzanne E. Hiller was born on January 20, 1966, in Bryan, Texas. She received a Bachelor of Arts in History in 1988 and a teaching certificate in 1991, both from the University of Mary Washington. She earned a Master of Education in Science Curriculum and Instruction from Loyola College in 1995. She has been a math and science practitioner for 22 years. In addition, she has served as the Teacher Naturalist for the Smithsonian Institution's National Museum of Natural History. Her research interests center on promoting STEM education through integration of social cognitive career theory and informal natural science learning settings.