

CASE STUDY OF THE SCIENCE, ENGINEERING,
MATHEMATICS, AND AEROSPACE ACADEMY:
PARTICIPANT AND PARENTAL PERCEPTIONS

By

CATHERINE GRAVES

Bachelor of Science in Biology, Education
Bowling Green State University
Bowling Green, Ohio
1995, 1997

Master of Science in Biology and Education
University of Toledo
Toledo, Ohio
2000

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
July, 2016

CASE STUDY OF THE SCIENCE, ENGINEERING,
MATHEMATICS, AND AEROSPACE ACADEMY:
PARTICIPANT AND PARENTAL PERCEPTIONS

Dissertation Approved:

Dr. Toni Ivey

Dissertation Adviser

Dr. Julie Angle

Dr. Juliana Utley

Dr. Steve Marks

Outside Committee Member

ACKNOWLEDGEMENTS

This dissertation has been a journey of discovery that I could not have completed without support and assistance from numerous individuals. First, I would like to thank my dissertation committee and professors at Oklahoma State University. To my chair Dr. Toni Ivey, thank you for your endless support, encouragement, and guidance that kept me moving forward throughout these past five years. Thank you to my committee members Dr. Julie Angle, Dr. Juliana Utley, and Dr. Steve Marks for supporting and encouraging me during my time at Oklahoma State University. Especially thank you to Dr. Steve Marks without whom I would not have had the courage to start this doctoral program. Thank you for your endless support, guidance, and advice throughout my NASA education career and doctoral program.

I would also like to thank the NASA personnel, SEMAA Site Directors, SEMAA Instructors, and the SEMAA participants and their parents without whom this study would not have been possible. The NASA personnel who supported this study by facilitating access to SEMAA were: Robert LaSalvia, Darlene Walker, Priscilla Mobley, and Jerry Voltz. Richard Gilmore and Wendy Slone of Paragon TEC, Inc also supported this study by providing access to participation data and reports.

Name: CATHERINE GRAVES

Date of Degree: JULY, 2016

Title of Study: CASE STUDY OF THE SCIENCE, ENGINEERING, MATHEMATICS,
AND AEROSPACE ACADEMY: PARTICIPANT AND PARENTAL
PERCEPTIONS

Major Field: EDUCATION

Abstract: The science, engineering, mathematics, and aerospace academy (SEMAA) is a federally-funded national out-of-school time (OST) science, technology, engineering, and mathematics (STEM) program that provides K-12 grade participants with hands-on activities and access to an aerospace education laboratory with the goals of increasing participants' engagement and interest in STEM and STEM careers. The SEMAA also provides support, resources, and training for SEMAA participants' parents through the Family Café. This multiple-case study investigated participants' and their parents' reasons for enrolling in the SEMAA and characterized the SEMAA in terms of its operations and infrastructure, instructors, learning environment, curriculum and instruction, and parental engagement. This study also assessed the role of the SEMAA in supporting participants' STEM college degree and career interests. Additionally, this study assessed the participants' attitudes towards science and science motivation factors. The findings of this study have implications for SEMAA and other OST STEM program providers related to: (a) recruitment and retention, (b) operations and infrastructure, (c) learning environments, (d) instructors, (e) curriculum and instruction, (f) parental engagement, and (g) OST STEM program outcomes.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION.....	1
The National Aeronautics and Space Administration’s (NASA) Role in K – 12 STEM Education.....	2
The Science, Engineering, Mathematics, and Aerospace Academy (SEMAA).....	3
Problem Statement.....	3
Purpose of the Study and Research Questions.....	4
Theoretical Framework.....	5
Theoretical Perspective.....	5
Theoretical Framework.....	6
Theoretical Framework and Methodology.....	6
Significance of the Study.....	7
Summary.....	8
II. REVIEW OF LITERATURE.....	9
STEM Ecosystems.....	9
Theoretical Foundation.....	10
Attributes of STEM Ecosystems.....	12
Formal and Informal STEM Education.....	13
Formal STEM Education.....	13
Informal STEM Education.....	14
Types of Informal STEM Education.....	15
OST STEM Programs.....	15
Types of OST STEM Programs.....	16
Afterschool Programs.....	17
Summer Camps.....	19
The SEMAA.....	20
Attributes of Effective OST STEM Programs.....	20
Contextual Factors.....	21
Instruction and Learning Environments.....	23
Parental Engagement.....	31

Chapter	Page
Attributes of the SEMAA	32
Participants' Attitudes Towards Science and Science Motivation Factors	32
Attitudes Towards Science	33
Science Motivation Factors.....	34
Interest in Science	34
SEMMAA's Roll in Participants' Attitudes Towards Science and Science Motivation Factors	35
Equitable Access to OST STEM Programs	36
Low-Income Communities	36
Historically Underrepresented Groups in STEM Professions	39
Equitable Access to the SEMMAA	41
OST STEM Programs Research and Evaluation Approaches	42
Qualitative Methods Used to Characterize OST STEM Programs and Assess Participant Outcomes	43
Summary	45
 III. METHODOLOGY	 46
Research Design	47
Qualitative Methodology	47
Case Study	47
Participants.....	49
Setting	50
Data Collection	53
Parent Questionnaire	55
Participant Questionnaire.....	55
Data Collection Access	58
Data Collection Process	59
Sampling Strategy	59
Data Analysis	61
Single-Case Study Qualitative Data Analysis.....	61
Cross-case Synthesis.....	62
Quantitative Data Analysis	63
Reporting the Findings.....	64
Trustworthiness.....	64
Credibility	64
Dependability	65
Confirmability.....	65
Transferability.....	65
Ethical Considerations	66
Confidentiality	66
Informed Consent.....	66
Peer Review	67
Reciprocity	67

Chapter	Page
Reflexivity.....	67
Conclusion	71
IV. FINDINGS.....	72
Study Participants	73
Parents’ Demographic and Background Information	74
Parents’ Locations.....	74
Participants’ Demographic and Background Information	75
Participants’ Locations.....	75
Research Question One: What are the Parents’ Perceptions of the SEMAA	76
Parents’ Reasons for Enrolling Their Child in the SEMAA.....	76
Parents’ Characterization of the SEMAA.....	78
Research Question One Summary	89
Research Question Two: What are the Participants’ Perceptions of the SEMAA	89
Participants’ Reasons for Enrolling in the SEMAA	89
Participants’ Characterization of the SEMAA.....	91
The SEMAA’s Role in Participants’ STEM College Degree and Career Ambitions	98
Research Question Two Summary.....	101
Research Question Three: What are the SEMAA Participants’ Attitudes Towards Science and Science Motivation Factors?	102
Participants’ Attitudes Towards Science	102
Participants’ Science Motivation Factors	104
Research Question Three Summary.....	105
Conclusion	106
V. CONCLUSIONS.....	106
Findings.....	109
Research Question One: What are the Parents’ Perceptions of the SEMAA?.....	109
Research Question Two: What are the Participants’ Perceptions of the SEMAA?.....	116
Research Question Three: What are the SEMAA Participants’ Attitudes Towards Science and Science Motivation Factors?.....	123
Limitations	124
Implications for Practices	125
Recruitment and Retention	125
Operations and Infrastructure	125
Learning Environment	126
Instructors	126
Curriculum and Instruction.....	127

Chapter	Page
Parental Engagement	127
OST STEM Program Outcomes	127
Further Research	128
Conclusion	128
REFERENCES	130
APPENDICES	141
Appendix A Parent Questionnaire	141
Appendix B Participant Questionnaire	145
Appendix C Parental Perceptions Cross-Case Synthesis Word Table Excerpt	150
Appendix D Participant Perceptions Cross-Case Synthesis Word Table Excerpt	155
Appendix E IRB Approval.....	159

LIST OF TABLES

Table		Page
1	Descriptions of SEMAA Components.....	52
2	Research Questions Aligned to the Data Sources and Analysis Procedures ..	54
3	Cronbach's α Values for Each Attitude Subscale.....	57
4	SEMAA participants' demographics	75
5	Analysis of Attitudes Towards Science Scores	103
6	Analysis of Motivation Factor Scores	104

LIST OF FIGURES

Figure		Page
1	Types of Informal Education	15
2	Summer 2015 SEMAA Site Locations	50
3	National Distribution of SEMAA Parent Questionnaire Respondents	74
4	National Distribution of SEMAA Participant Questionnaire Respondents	76

CHAPTER I

INTRODUCTION

Recent reports linking national economic prosperity to science and engineering innovation and development have brought increased attention to the need to provide high quality science, technology, engineering, and mathematics (STEM) education to all K-12 students (Bayer Corporation, 2013; Change the Equation, 2014; President’s Council of Advisors on Science and Technology, 2010). Despite numerous STEM reform efforts targeting formal education curriculum and practice, a critical shortage of STEM talent is projected for the decade to come (Bayer Corporation, 2013; Change the Equation, 2014). Increasingly, federal agencies and other STEM stakeholders are investing in out-of-school time (OST) STEM programs to complement formal STEM education, with the goal of increasing participant interest and capacity in STEM fields (Bevan, Michalchik, Bhanot, Rauch, Semper, & Shields, 2010; Committee on Science, Engineering, and Public Policy, 2010; NRC, 2008). The National Research Council (NRC) (2015) argued that OST STEM programs can: “a) contribute to young people’s interest in and understanding of STEM, b) connect young people to caring adults who serve as role models, and c) reduce the achievement gap between young people from low-income and high-income families” (p. 1-2). However, within the dynamic scope of OST STEM programs, prior research and evaluation studies have not garnered sufficient evidence to understand which programs and contexts work best for which individuals (NRC, 2015).

The National Aeronautics and Space Administration's (NASA) Role in K-12 STEM Education

The NASA works to address the national need to increase the breadth, depth, and diversity of our nation's STEM talent pool by investing in K-12 education programs (NASA, 2014). The overarching goal of the NASA's education programs is to "advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage K-12 students, teachers, and faculty in NASA's missions and unique assets" (NASA, 2014, p. 6). The NASA's education programs use the context of aerospace missions and research to add relevance to STEM content and inspire K-12 student interest in STEM careers.

The NRC's (2008) review of the NASA's K-12 education programs argued that engaging K-12 students in NASA's missions and research has the potential to "draw students to the pursuit of academic study and eventual careers in STEM" (p. 56). The report advocated that the NASA is uniquely positioned to employ its research facilities, missions and subject matter expertise to increase interest in technology and engineering, which are areas traditionally underrepresented in K-12 curriculum. However, the NRC (2008) noted a lack of substantial evaluation data that assessed the characteristics of the NASA's education programs and insufficient evidence to support the outcomes of the NASA's education programs. The NRC (2008) recommended rigorous, independent evaluation studies of the NASA's education programs that considered a variety of settings, levels of involvement, genders, and grade levels.

The Science, Engineering, Mathematics, and Aerospace Academy (SEMAA)

The SEMAA is an OST STEM program provided by the NASA with the goal of

inspiring and supporting K-12 students' STEM college degree and career ambitions. The SEMAA seeks to contribute to NASA's goals for education by engaging K-12 students in STEM activities designed to: a) strengthen their interest in STEM, b) inspire continued participation in advanced STEM courses, and c) encourage the pursuit of STEM careers (Dunbar, 2013). The SEMAA strategically partners with minority serving institutions and other institutes of higher education, K-12 education institutions, education professionals, and STEM professionals to target groups traditionally underrepresented in STEM fields. SEMAA partner sites provide OST STEM programs to K-12 students through implementation of NASA-themed curriculum enhancement activities, an aerospace education laboratory, and the Family Café – a STEM-themed training program for parents of the SEMAA participants (Dunbar, 2013).

Problem Statement

Despite over a decade of research and investment in STEM education, numerous reports indicate many United States K-12 students continue to lag behind their global peers in science and mathematics and too few students are pursuing college degrees and careers in STEM fields to meet workforce needs (Bayer Corporation, 2013; Change the Equation, 2014; Martin, Mullis, Foy, & Stanco, 2012; Mullis, Martin, Foy, & Arora, 2012). Increasingly, OST STEM programs are being considered as a tool to enhance in-school learning (Committee on Science, Engineering, and Public Policy, 2010; NRC, 2008). However, very little research focused on OST STEM programs has been conducted (Bevan et al. 2010; NRC, 2015).

This study contributes to the growing body of research exploring OST STEM programs. Specifically, this study characterized the processes and implementation of the

SEMAA from the perspectives of the program's participants and their parents to inform future OST STEM program design. Additionally, this study characterized the participants' attitudes towards science and science motivation factors to inform curriculum selection and instructional processes.

The SEMAA was purposefully selected as the focus of this study for two reasons: a) the SEMAA is a well established model for OST STEM learning and has been positively regarded by experts in the field; and b) the SEMAA model has been implemented nationally in a diverse array of contexts. A review of the NASA elementary and secondary education programs (NRC, 2008) indicated that the SEMAA effectively met its goals to inspire and sustain participant interest in STEM and STEM careers, reached its intended audiences including participants from groups traditionally underrepresented in STEM fields, and participants and their parents were satisfied with the program. The NRC (2008) also commended the inclusion of the Family Café and stated this element was well aligned with research that has demonstrated the importance of including family members in children's learning. Additionally, the SEMAA has been recognized as an effective model for OST STEM learning and received recognition from the Harvard University John F. Kennedy School of Government's Ash Institute for Democratic Governance and Innovation as a finalist for the 2007 Innovations in American Government Award (NASA, 2013).

Purpose of the Study and Research Questions

The purpose and research questions for this study were generated to build upon the results of past program evaluations of the SEMAA and align with the focused research agenda questions for OST STEM programs developed by the Learning and Youth Research and Evaluation Center (Bevan et al. 2010; Martinez et al. 2010). The purpose of this study

was to characterize the SEMAA from the parents' and participants' perspectives and to characterize the SEMAA participants' attitudes towards science and science motivation factors. The findings of this study will provide new understanding of the cognitive, affective, social, and contextual factors of the SEMAA that were positively and negatively regarded by participants and their parents that could be used to inform future SEMAA program design.

The three research questions that guided this study were:

- 1) What are the parents' perceptions of the SEMAA?
- 2) What are the participants' perceptions of the SEMAA?
- 3) What are the SEMAA participants' attitudes towards science and science motivation factors?

Theoretical Framework

Theoretical perspective. The theoretical perspective that informed the methodology, assertions, conclusions, and implications of this study was symbolic interactionism, a subdivision of interpretivism, which is grounded in relativism (ontology) and constructivism (epistemology). Relativism provides for "multiple intangible mental constructions, socially and experientially based, local and specific in nature" (Guba & Lincoln, 1998, p. 206). Relativism informs constructivism which argues that meaningful reality is multiple and constructed. Knowledge is generated through individually and collectively constructed meanings. Symbolic interactionism posits that human beings act toward symbols on the basis of the meanings that these symbols have for them (Crotty, 1999). According to Crotty, (1999) symbols are the thoughts, attitudes and customs of a society or sub-group and the meanings of these symbols are derived from social interaction that one has with one's fellow citizens.

Theoretical framework. Bronfenbrenner's ecological systems theory (EST) provided the theoretical framework of this study. EST argues that learning is a progressive process of development that evolves over an individual's lifespan and is embedded in multiple interrelated contexts (Fredricks, 2011). According to Bronfenbrenner (1993), influences on an individual's environment, personal characteristics of the individual, and the resources and contexts that an individual has access to interweave to steer the individual's developmental path. When learning is viewed through the lens of EST, the scope of physical and sociocultural resources that an individual has access to defines their learning opportunities (Fredricks, 2011). In alignment with EST, this study will gather the SEMAA participants' and their parents' perceptions of the physical and sociocultural resources of the SEMAA and assess the individual characteristics (attitudes towards science and science motivational factors) of the SEMAA participants to characterize the SEMAA.

Theoretical framework and methodology. Multiple-case study, including seven single-case studies, was used as the methodology for this study. Multiple-case study research employs qualitative research methods that allow participants' understandings to inductively emerge and are informed by symbolic interactionism (Yin, 2012). According to Yin (2012), qualitative research strives to understand the viewpoint of the subjects through their use of significant symbols such as language, gestures, objects, and actions. The subjects of this multiple-case study were the SEMAA participants and their parents. Specifically, data were collected from participants at seven summer 2015 SEMAA sites and their parents and included the participants' and their parents' perceptions of their current and past experiences with the SEMAA including afterschool programs, Saturday programs, and summer programs. A single-case study was conducted for each of the seven SEMAA sites that were

bound by their shared implementation of the SEMAA components (NASA-themed curriculum enhancement activities, aerospace education laboratory, and Family Café). A multiple-case study of the seven single-case studies was then completed using Yin's (2011) process described in chapter three.

The methods of data collection included open-ended response questions administered to participants and their parents. The open-ended questions were used to gain an understanding of the participants' and their parents' individual constructions, perceptions, feelings, and attitudes about the SEMAA. Inductive analysis was used to interpret the meaning and intent of data collected from open-ended response questions. According to Guba and Lincoln, inductive analysis is used to "distill a consensus construction that is more informed and sophisticated than any of the predecessor constructions" (1998, p. 207).

Significance of the Study

Increasingly, OST STEM programs are being viewed as an effective complement to enrich formal STEM education (NRC, 2015). In recent years, federal agencies including the National Science Foundation, the National Oceanic and Atmospheric Administration (NOAA), and the NASA have increased investments in OST STEM programs (Bevan et al. 2010). The increase in federal investment in OST STEM programs has catalyzed an increase in questions about the effectiveness of OST STEM programs and accountability requirements (Bell, Lewenstein, Shouse, & Feder, 2009; Lauer et al. 2006). As a result, the emerging field of research on OST STEM programs has primarily focused on assessing program outcomes and demonstrating return on investment (NRC, 2015). Few research studies have sought to characterize OST STEM program processes and implementation and very little research has included participants' perspectives (Luehmann, 2009; NRC, 2015).

This research study will contribute to the growing body of research focused on OST STEM programs by using participants' and their parents' perceptions of the SEMAA to characterize the programs' processes and implementation. Additionally, this study will assess the SEMAA participants' attitudes towards science and science motivation factors to inform curriculum selection and instructional methods. A large sample size and data collected from seven single-case studies of the SEMAA may increase the likelihood of transferability. However, caution should be used before applying the findings of this study beyond the SEMAA. Naturalistic generalizations that were revealed during this study may inform developers and instructors of similar OST STEM programs. Detailed descriptions are provided for readers to determine the applicability to similar cases.

Summary

Federal agencies and other STEM stakeholders are turning to OST STEM programs to enhance formal STEM education, with the goal of increasing participant interest and capacity in STEM fields. The emerging field of research focused on OST STEM programs has found some evidence of positive outcomes for participants in OST STEM programs. However, few studies have investigated the characteristics of OST STEM programs using participants' and their parents' perspectives. This study will contribute to the emerging field of research related to OST STEM programs by exploring the participants' and their parents' perceptions of the SEMAA. The following chapters describe the methodology, findings, and implications of this study. Chapter two examines the theory and research informing the design, practice, and analysis of OST STEM programs.

CHAPTER II

REVIEW OF LITERATURE

This chapter presents a review of literature related to out-of-school time (OST) science, technology, engineering, and mathematics (STEM) programs. First, this chapter positions OST STEM programs within the broad scope of STEM formal and informal education using a STEM ecosystem approach as defined by Bell et al. (2008) and the NRC (2015). This chapter will present Bronfenbrenner's (1977) ecological model for human development as the theoretical framework for STEM ecosystems and OST STEM teaching and learning. Next, a thorough discussion of the research literature related to OST STEM program types, outcomes, and attributes will be presented. A discussion of OST STEM programs' role in supporting participants' attitudes towards science and science motivation factors and equitable access to OST STEM programs is also included. This chapter concludes with a discussion of the research and evaluation approaches that are frequently used to investigate OST STEM programs.

STEM Ecosystems

Increased focus on STEM education in the United States has fostered a renewed emphasis on formal education reform that has been catalyzed by the release of the Common Core State Standards for Mathematics and the Next Generation Science Standards (NGSS) (National Governors Association Center for Best Practices & Council

of Chief State School Officers, 2010; NGSS Lead States, 2013). The national focus on STEM education has also sparked conversations about the influence of informal STEM learning opportunities on children's STEM cognitive and affective development and the acknowledgement that STEM learning occurs over time in multiple ways outside of school (NRC, 2015). Bell, Lewenstein, Shouse, and Feder (2009) proposed using a STEM ecosystem approach to understand the complex, dynamic interaction of cognitive, social, and cultural processes and outcomes that shape STEM learning across multiple contexts. Drawing on cognitive and sociocultural theories, the STEM ecosystem approach incorporates the collective contexts, resources, and activities of both formal and informal STEM learning (Bell et al. 2009; Falk et al. 2016). The STEM ecosystem approach argues that children only spend a fraction of their time learning in formal classroom settings. The remainder of their learning generally occurs through free-choice activities that are accessible to the child and align to the child's interests (Falk et al. 2016).

Theoretical foundation. The STEM ecosystem approach is based on Bronfenbrenner's ecological model of human development and ecological theories of learning, which argue that learning is a result of the dynamic interaction between an individual and multiple diverse contexts and the culture and community in which they are embedded (NRC, 2015). Bronfenbrenner defined the ecology of human development as:

the scientific study of the progressive, mutual accommodation, throughout the life span, between a growing human organism and the changing immediate environments in which it lives, as this process is affected by relations obtained

within and between these immediate settings, as well as the larger social contexts, both formal and informal, in which the settings are embedded. (1977, p. 514)

Bronfenbrenner's ecological theory of human development argues that learning is a progressive process of development that evolves over an individual's lifespan and is embedded in multiple interrelated contexts. Influences on the individual's environment (e.g., family, peers, culture, school), individual characteristics (e.g., interests, preferences), and access to resources and contexts steer the individual's developmental path (Bronfenbrenner, 1993).

Ecological theories of learning argue that increasing children's exposure to learning resources in multiple interrelated contexts will result in increased outcomes for the children (Fredricks, 2011). Learning ecologies interweave the physical dimensions (e.g., formal education, museums, nature) and sociocultural dimensions (e.g., peers, family, role models) of a child's learning. Explorations of learning ecologies have considered the interactions between the physical attributes, culture, history, and people that shape the ecosystem. Bevan (2016) argued that the scope of physical and sociocultural dimensions of the learning ecology that a child has access to defines his/her learning opportunities. Therefore, access to physical and sociocultural resources is necessary for learning to occur. Additionally, Bevan (2016) argued that the social interactions embedded in a learning ecology are grounded in cultural – historical theory which posits that individuals view the world through cultural lenses (e.g., language, social practices). Therefore, an individuals' learning ecology is bound by his/her cultural perspectives and influences how knowledge is developed (e.g. collaboratively or

individually) and how knowledge is represented. Understanding and recognizing an individual's cultural resources can be an effective tool for productive engagement.

Attributes of STEM ecosystems. The NRC (2015) defined a STEM ecosystem as “the dynamic interaction among individual learners, diverse settings where learning occurs, and the community and culture in which they are embedded” (p. 1–2). Bell et al. (2009) argued that an ecological perspective of STEM learning can facilitate a more cohesive practice across learning environments. STEM learning ecosystems represent the symbiotic relationship between formal and informal education and represent the contributions of educators, policymakers, families, and social networks have on an individual's development of STEM learning (Traphagen & Traill, 2014). The key components of a STEM ecosystem are: (a) relevance to a child's culture, (b) responsiveness to a child's individual interests, skills, and expertise, and (c) connection to a child's prior knowledge (Bevan, 2016; NRC, 2015). STEM learning ecosystems provide mechanisms to build on a child's prior knowledge and make connections between formal education curriculum and the child's STEM experiences in the broader world (Bevan, 2016).

Having access to a wide array of opportunities to engage with STEM in formal and informal contexts adds to the robustness of a STEM ecosystem (Krishnamurthi, Bevan, Rinehart, Coulon, 2013). STEM engagement opportunities include both material resources and social networks (e.g. peers, educators, family) that provide exposure to STEM learning. Examples of opportunities to engage with STEM include K-12 classes, libraries, museums, science centers, parks, broadcast media, digital media, and youth serving organizations (e.g., 4-H). Effective communication between formal and informal

education providers and other stakeholders is essential for the successful development of a STEM ecosystem. Falk et al. (2016) argued that treating all partners as equals and providing interconnected STEM learning opportunities are central to developing effective communication across a STEM ecosystem.

Formal and Informal STEM Education

Formal STEM education. Formal STEM education is the learning that occurs inside a classroom setting at schools and is typically a rigid, high-stakes environment (Fredricks, 2011). Stocklmayer, Rennie, and Gilbert (2010) argued that the central concern of formal K-12 STEM education is providing a comprehensive system that will both prepare some students for STEM careers and prepare all students to be STEM literate citizens (i.e., possessing knowledge of the fundamental concepts and practices underlying the science, technology, engineering, and mathematics disciplines). Formal education is characterized by compulsory attendance and structured curriculum and is focused on developing student's cognitive dimensions (Fredricks, 2011). In formal education settings, learning tends to be continuous and linear with little room for students to explore their own interests (Trans, 2011). Stocklmayer, Rennie, and Gilbert (2010) provided a list of typical characteristics of formal education: (a) participation is compulsory, (b) curriculum is structured and sequenced, (c) curriculum is legislated and controlled using standards, (d) students are formally assessed using standardized tests, (e) certified educators lead instruction, (f) instruction is generally teacher-centered, (g) social and cultural relevance is not central to instruction, and (h) teaching and learning occurs in a classroom setting.

Informal STEM education. Informal STEM education is the STEM learning that occurs outside of school in a variety of contexts and social settings. Attributes of effective informal education include: (a) encouraging direct interaction with natural scientific phenomena and engineering design, (b) providing dynamic representations of science, and (c) building on participants' prior knowledge and interests (Bell et al. 2009). Stocklmayer, Rennie, and Gilbert (2010) provided a list of characteristics of informal education: (a) voluntary participation, (b) curriculum is unstructured, (c) low-stakes, (d) learning is typically not assessed, (e) social interactions are prioritized, (f) instructors may not be certified teachers, (h) instruction is learner-centered, and (i) instruction uses participatory pedagogies. Attributes that differentiate informal and formal learning included that informal learning is typically self-motivated, voluntary, and guided by learner's needs and interests (Rennie, Feher, Dierking, & Falk, 2003).

Bell et al.'s (2009) report *Learning Science in Informal Environments* identified several positive outcomes of learning science in informal environments including: (a) developing positive science-related attitudes and identities, (b) learning science practices, and (c) appreciating the social and historical context of science. According to Fredricks (2011), researchers have also identified higher levels of engagement and more positive psychological states in children while learning science in informal education setting than in formal education settings. Fredricks (2011) argued that the reasons for higher levels of engagement were providing informal education participants with opportunities to experience challenge, be active, be in control, work in cooperative groups, and feel competent.

Types of informal STEM education. Bell et al.'s (2009) report *Learning Science in Informal Environments* differentiated informal learning environments into three categories: (a) everyday science; (b) designed settings, and (c) structured learning programs (Figure 1). Everyday science encounters with science, scientific ways of thinking, and science practices in day-to-day life can be spontaneous or planned. Designed settings are intentionally created settings designed to educate visitors to the physical or natural world (e.g. museums, exhibits, science centers) Structured learning programs have also been referred to as out-of-school time (OST) programs and include extended-day programs (e.g., homework help, tutoring), enrichment programs (e.g. the SEMAA, after-school programs, Saturday science programs, summer camps), and associated or integrated programs.

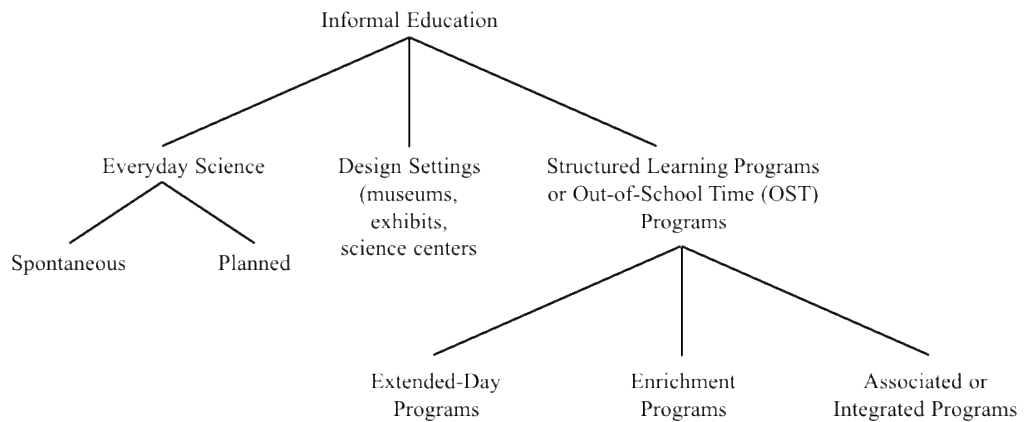


Figure 1. Types of informal education

OST STEM Programs

Over the past decade both the availability of OST STEM programs and participation in OST STEM programs has increased (Bell et al. 2009; Afterschool Alliance, 2015; NRC, 2015). According to Bell et al. (2009), researchers have argued that

OST STEM programs can help participants refine their STEM interests, engage with relevant learning resources, access other learning experiences, and identify with a community of STEM learners. OST STEM programs are typically designed to trigger and support participants' motivation to learn science, interest in science, and willingness to persevere through challenging STEM content (Bell et al. 2009; NRC, 2015). Many government and privately funded OST STEM programs have been designed with the goal of improving school-based performance and providing enrichment for low-income participants (Stocklmayer, Rennie, & Gilbert, 2010). Additionally, some OST STEM programs have been designed to increase the representation of African-American, Hispanic, and Native American individuals and women in STEM careers (NRC, 2015). Some OST STEM programs are held on college campuses to provide participants with opportunities to experience the campus and to interact with faculty and college students that may positively affect participants' attitudes towards and awareness of STEM college degrees and careers (Nadelson & Callahan, 2011).

Types of OST STEM programs. Bell et al. (2009) differentiated OST programs into three categories: (a) extended-day programs (b) enrichment programs, and (c) associated or integrated programs. Extended-day programs mimic classroom teaching and learning, occur in school settings, and are generally under school leadership. A common goal of STEM-focused extended-day programs is to improve participants' academic achievement and standardized achievement test scores (Bell et al. 2009; Bevan & Michalchik, 2013). According to Bevan and Michalchik (2013), extended-day programs are more closely aligned to school curriculum than enrichment programs.

Enrichment programs, also called expanded learning programs, are content-rich learning programs (e.g., afterschool programs, summer camps) that provide participants with opportunities to develop their capacities and interests (Bevan & Michalchik, 2013). A common goal of STEM enrichment programs has been to encourage future engagement with STEM content in academic settings and attainment of STEM careers (Bevan & Michalchik, 2013).

Associated or integrated programs fall at the intersection of extended-day and enrichment programs and provide a context that is explicitly coordinated with school teaching and learning. However, associated or integrated programs provide a different method of instruction that may take on characteristics of enrichment programs (Bell et al. 2009). A variety of timeframes are used to deliver OST STEM programs. However, the most common timeframes for delivery are afterschool programs or summer camp models (Lauer et al. 2006).

Afterschool programs. For more than a century, afterschool programs have been viewed as an effective mechanism to address societal concerns such as the need to: (a) provide caregivers for children after school, (b) provide academic enrichment for economically disadvantaged children, (c) reduce high risk behaviors in youth (e.g., crime, drug abuse), and (d) provide socialization experiences for children (Lauer et al. 2006). Afterschool programs originated in the early 1900s and were designed to provide a safe, healthy environment for children who lived in unsafe neighborhoods (Bell et al. 2009). An additional up-swing in the number of afterschool programs was seen in the 1940s as maternal employment increased leading to an increased need for childcare (Lauer et al. 2006). Researchers have found that participation in afterschool programs has risen

exponentially over the past twenty years (Fredricks, 2011; Lauer et al. 2006). More recently, policymakers have viewed afterschool programs as a means to improve K-12 student achievement and provide federal funds for afterschool programming such as the U.S. Department of Education's 21st Century Community Learning Centers (NRC, 2015).

Afterschool programs are guided by developmental goals for youth and exhibit a dynamic variety of contextual factors such as: (a) participant characteristics (e.g., age, experience level, interest), (b) instructor characteristics (e.g. background, expertise, experience), (c) logistics (e.g., length, time, location, setting), (d) resources, and (e) type of program (e.g., hands-on activities, research experiences, field work) (Krishnamurthi et al. 2013). The 2014 America After 3PM national study of parental attitudes and expectations for afterschool STEM programs indicated that the demand for afterschool programs is continuing to grow (Afterschool Alliance, 2015). The study found that despite the increased availability of afterschool programs, parents of nineteen and a half million children who are not currently participating in afterschool programs would like their children to participate (Afterschool Alliance, 2015).

Outcomes of afterschool STEM programs. Over the past century, the goals of afterschool programs have evolved from social outcomes (e.g., child safety) to an increased focus on cognitive and affective outcomes (Bell et al. 2009). A survey of experts in afterschool STEM programs conducted by Krishnamurthi et al. (2013), revealed that experts believed that afterschool STEM programs were well positioned to affect three outcomes: (a) developing participants' STEM interest, (b) building participants' capacity to complete STEM investigations, and (c) fostering participants' understanding of the value of STEM. Krishnamurthi et al. (2013) also found that

afterschool STEM program experts felt that afterschool STEM programs were best positioned to affect short-term outcomes related to generating participant's interests and engagement in STEM and less confident in afterschool STEM programs' abilities to affect longer-term outcomes related to increasing participants' STEM knowledge and skills, pursuit of additional STEM learning opportunities, and pursuit of STEM careers. Additionally, experts did not express confidence in afterschool STEM programs' ability to influence in-school STEM learning (Krishnamurthi et al. 2013).

Summer camps. Similar to afterschool programs, summer programs were originated to prevent behavior problems and provide care for participants in the absence of parental supervision during summer months (Lauer et al. 2006). In contrast to afterschool programs, summer programs tend to be focused on academic achievement (Lauer et al. 2006). Societal factors that have influenced the desire for summer programs include: (a) maternal employment, (b) single parent households, (c) global competitiveness of the U.S. educational system, and (d) high learning standards and proficiency requirements (Lauer et al. 2006). In the mid-1900s, policymakers began to consider how summer schools could remediate learning deficiencies (Lauer et al. 2006). Currently, summer schools and summer camps provide academic enrichment and some provide older participants with opportunities to earn academic credits that can be used towards early graduation (Lauer et al. 2006).

Outcomes of STEM summer camps. An emerging body of research focused on STEM summer camps has begun to provide evidence that participating in STEM summer camps can positively impact participants' dispositions regarding STEM (Sheridan et al. 2011; Ylimes et al. 2010). For example, a study conducted by Sheridan et al. (2011),

indicated that STEM summer camps that include certified teachers as instructors were found to positively influence participants' attitudes towards science (e.g., science learning is fun). Similarly, Ylmez et al.'s (2010), evaluation of an engineering-themed STEM summer camp that included hands-on engineering design activities revealed that the participants gained self-confidence and interest in engineering disciplines.

The SEMAA. The SEMAA is an OST STEM program that is offered through afterschool, Saturday, and summer camp models. The SEMAA is a structured learning program that can be further categorized as an enrichment program. However, in recent years, SEMAA has piloted an in-school model that blurred the boundary between formal and informal learning (Martinez et al. 2010). This research study will characterize the SEMAA from the participants' and their parents' perspectives. Characterizing the SEMAA from the perspectives of the participants who have directly experienced the program will provide new understanding of the position and role of the SEMAA within participants' broader STEM learning ecosystem.

Attributes of Effective OST STEM Programs

The emerging field of research on OST STEM programs has begun to identify attributes of OST STEM programs that have led to positive cognitive and affective outcomes for participants (NRC, 2015). However, the NRC (2015) argued that the body of research related to OST STEM programs is "not yet robust enough to determine which programs work best for whom and under what circumstances" (p. 2). The following section provides a brief summary of recent scholarly literature that has identified promising practices that may contribute to positive outcome for OST STEM programs participants.

Contextual factors. OST STEM research has begun to explore the design processes and contextual factors that contribute to effective OST STEM programs. For example, the NRC's (2015) report *Identifying and Supporting Productive STEM Programs in Out-of-School Settings* listed five actions for developing and supporting productive programs:

- (a) understand the local conditions that support STEM learning, (b) design programs to ensure equitable access and continuity with formal education (c) include appropriate evaluation strategies, (d) provide professional development for OST STEM program staff, and (e) develop a sustainable infrastructure. (p. 3)

Researchers have also encouraged OST STEM program providers to consider strategies to minimize barriers that may prevent individuals, from groups traditionally underserved or underrepresented in STEM field, from participating in OST STEM programs (NRC, 2015). For example, several researchers have found that program cost and location have served as barriers to equitable participation (Innes, Johnson, Bishop, Harvey, & Reisslein, 2012; Milgram, 2011). Researchers have recommended providing OST STEM programs to participants at no cost or reduced cost to promote participation of children from low-income families (Innes et al. 2012). Additionally, location of programs can be a barrier for participation for children whose families lack adequate transportation or are geographically isolated (Milgram, 2011).

Grade level. OST STEM programs have traditionally focused on secondary participants. However, increasingly, OST STEM programs for elementary school participants are becoming available (DeJaranette, 2012). Researchers have found that it is more difficult to attract and retain secondary participants in OST STEM programs,

because secondary participants find these programs less appealing than elementary school participants (Lauer et al. 2006). However, research has indicated that including physical or recreational aspects and social aspects in OST STEM programs are effective strategies for attracting and retaining secondary participants in OST STEM programs (Lauer et al. 2006). Additionally, the 2014 America After 3PM national parent survey found that some parents of high school students were uncertain about the ability of afterschool programs to offer sophisticated and intensive programming that would challenge their children and develop their STEM skills (Afterschool Alliance, 2015).

Duration. Several researchers have provided evidence that the duration of OST STEM programs is related to participant outcomes (Lauer et al. 2006; Milgram, 2011; McLaughlin and Pitcock, 2009). However, although researchers have demonstrated a link between program duration and participant outcomes, there is still debate about the optimal duration of OST STEM programs (NRC, 2015). Other researchers have argued that it is not the duration, rather what is done during the program that produces positive participant outcomes (Lauer et al. 2006).

Coordination with formal education. Researchers have argued that a lack of coordination and cooperation between formal and informal institutions contributes to fragmented STEM learning (Bell et al. 2009; Falk et al. 2016; Tran, 2011). Several researchers have recommended that formal and informal educators should meet regularly to: (a) coordinate connections between in-school and OST STEM learning, (b) develop an understanding of the contributions that schools and OST STEM programs make to participants' STEM learning, and (c) broker intentional connections for participants to engage in other STEM learning opportunities (Bell et al. 2009; Bevan, 2016; Falk et al.

2016; Krishnamurthi et al. 2013). For example, Tran's (2011) study of high school students' science learning experiences across contexts found that students' ability to make connections between formal and informal science experiences was associated with achievement, science interest, science careers, science self-efficacy, perseverance and science learning effort. Surprisingly, Tran also found that teachers' efforts to make connections between students' informal and formal science education was negatively associated with students' academic achievement and teachers did not feel they had sufficient knowledge of the students' informal science learning experiences to effectively make connections, which may have inadvertently caused confusion. Tran argued that more effective communication between formal and informal science educators may foster connections between in-school and out-of-school learning.

Partnerships. Researchers have argued that the capacity of OST STEM program providers to deliver high-quality programs can be enhanced through partnerships with STEM-rich institutions (Afterschool Alliance, 2015). Similarly, Bell et al. (2009) argued that building partnerships between science institutions and local communities is a promising practice for inclusive informal learning. Milgram (2011), also posited that developing partnership among OST STEM programs and community organizations could provide a sustainable revenue source to support program implementation.

Instruction and learning environments. Jensen and Sjaastad (2013) argued that the quality and qualifications of the OST STEM program instructors is among the most important factors that mediate a program's outcomes. According to Jensen and Sjaastad (2013), OST STEM program instructors must be equipped with: (a) evidence-based pedagogical skills and content knowledge and (b) the ability to create a positive

environment and develop interpersonal relationships with participants. Several researchers have found evidence that supports Jensen and Sjaastad's argument (Fredricks, 2011; Kidron & Lindsay, 2014; and Milgram, 2011). For example, Kidron and Lindsay's (2014) meta-analysis of mathematics-themed OST STEM programs found that the inclusion of certified teachers as instructors had a positive effect on participants' cognitive outcomes. Similarly, Fredrick's (2011) study of factors that promoted engagement in OST STEM programs revealed that effective OST STEM program instructors: (a) exhibited strong instructional management practices, (b) provided clear and consistent rules and expectations, (c) provided consistent feedback, and (d) facilitated smooth transitions to increase the cohesiveness between activities.

Bell et al. (2009) argued that effective OST STEM program instructors should be equipped to support and embrace the diversity of learners who participate in their programs. Similarly, Milgram's 2011 study of factors that attract women and minorities to STEM professions found that STEM programs are more effective at attracting and retaining women and minorities to STEM professions when they are instructed by adequately trained and supportive staff that reflect the lived experience of participants. Bell et al. (2009) recommended that OST STEM program instructors pose culturally relevant questions and integrate culturally relevant examples into their instruction to purposefully support the engagement of diverse participants.

Researchers have also revealed that personality traits of OST STEM instructors positively influenced participants' outcomes (Fredricks, 2011; & Jensen & Sjaastad, 2013). Specifically, researchers have found that participants in OST STEM programs instructed by personable instructors had more positive feeling towards the programs,

were more engaged in activities, and had higher expectancies for their future success in STEM (Fredricks, 2011; Jensen & Sjaastad, 2013). For example, Fredricks (2011) study of factors that contributed to participant engagement in OST STEM programs revealed that positive personality characteristics of instructors (e.g., fairness, warmth and closeness with participants, caring and supportive) and instructors' abilities to develop positive interpersonal relationships with participants contributed to increased participant engagement in OST STEM programs. In her study, Fredricks (2011) found that OST STEM program instructors were typically interested and enthusiastic about the topics they were teaching and modeled these attitudes during instruction. Fredricks (2011) recommended that instructors can develop positive relationships with participants by getting to know participant's individual interests and needs, demonstrating to participants that they care about them, being honest, soliciting and listening to participants' opinions. Similarly, Jensen and Sjaastad's (2013) study of a mathematics-themed OST STEM program on participants' STEM motivation revealed that participants' self-efficacy and expectancy for success in STEM increased when instructors provided encouragement. Additionally, Jensen and Sjaastad (2013) found that instructors who showed that they cared for the participants had a positive influence on participants' self-concept related to STEM learning and STEM careers.

STEM professionals and role models. Researchers have linked the inclusion of STEM professionals and role models in OST STEM program with participants' ability to identify with STEM careers (Jensen & Sjaastad, 2013; Muller et al. 2013; Wyss, Heulskamp, & Siebert, 2012). For example, Jensen and Sjaastad (2013) found that including positive STEM role models in OST STEM programs rectified participants'

misconceptions and negative stereotypes about engineers (Jensen & Sjaastad, 2013). Similarly, Muller et al. (2013) found that scientists working in partnership with teachers to facilitate OST STEM programs positively influenced participants' enjoyment of science, identification as scientists, and perceptions of science and scientists (Muller et al. 2013). Specifically, Muller et al. (2013) found that participants who interacted with scientists for as little as one day in an OST STEM program expressed increased interest in becoming a scientist and had more realistic perceptions of scientists and the work of scientists. Additionally, Wyss, Heulskamp, & Siebert (2012) found that showing students pre-recorded video interviews with STEM professionals that included practical information about what STEM professionals do also increased middle school students' interest in pursuing STEM careers.

Learning environment. According to the NRC (2015), contextual factors that have been found to increase participant's meaningful engagement in OST STEM programs include: (a) safety (physical and psychological), (b) belonging (social, community affiliation), and (c) positive learning environment. Positive OST STEM program learning environments have been characterized by curriculum focused on participants' interests and choices, unassessed activities, multi-age grouping, and fluid usage of time (Fredricks, 2011; NRC, 2015). Researchers have associated positive OST STEM learning environments with higher participant engagement and retention and development of participants' STEM interests, attitudes, and intrinsic motivation (Fredricks, 2011; Jensen & Sjaastad, 2013; NRC, 2015). For example, Jensen and Sjaastad (2013) found that a positive OST STEM program learning environment that provided a fun, engaging context had success in retaining participants. Additionally,

Fredricks (2011) found that OST STEM programs with positive learning environments that fostered a nurturing, family-like context were highly regarded by participants. Similarly, Innes et al.'s (2012) study of an engineering-themed OST STEM program found that creating a low-stakes learning environment positively influenced participants' engagement in the program and lowered participants' anxieties related to performance pressures. Innes et al. (2012) argued that OST STEM programs should promote a positive, low-stake learning environment that accepts failure as a part of the learning process and avoids the use of traditional assessments and grades).

Positive social relationships. Several researchers have recommended that OST STEM program instructors should intentionally foster positive social relationships and facilitate peer networks using instructional strategies such as small group activities (Bell et al. 2009; Fredricks, 2011; Jensen & Sjaastad, 2013; Milgram, 2011). Fredricks (2011) defined positive social relationships in OST STEM programs as a friendship between academically oriented peers that (a) encourage and model learning, (b) share information, (c) ask questions and explain answers, (d) work in cooperative groups, (e) provide a sense of belonging, and (g) share positive social norms. Researchers have found that participants who have positive social relationships within OST STEM programs have higher levels of engagement in the programs and tend to participate in the program over longer periods of time (Fredricks, 2011; Jensen & Sjaastad, 2013). Jensen and Sjaastad (2013) also found that positive social relationships with peers who valued STEM learning and achievement positively influenced participants' STEM education and STEM career identities. Additionally, some OST STEM programs have successfully used positive social relationships to recruit new participants (Fredricks, 2011).

Educational resources and activities. Several researchers have outlined qualities of effective and appropriate OST STEM program activities: (a) age appropriate, (b) varied, (c) interesting and enjoyable, (d) challenging, (e) connected to real world, (f) flexible, and (g) provide opportunities for choice, autonomy, ownership, active involvement, wonder, and discovery (Fredricks, 2011; Kesidou & Koppal, 2004; Stocklmayer, Rennie, & Gilbert, 2010). Bell et al. (2009) argued that since common goals of OST STEM programs are for participants to enjoy learning and have fun while learning, activities should not overwhelm participants (Bell et al. 2009). Bell et al. (2009) added that participant engagement in OST STEM programs increases when activities include social aspects (e.g., teamwork, conversations), opportunities for participants to explore STEM phenomena, and have fun doing STEM. Conversely, Fredricks (2011) argued that OST STEM program curriculum that is challenging, interesting, connected to participants' lives, and provides opportunities for participants to develop and explain their own ideas positively influences participants' engagement in OST STEM programs. The NRC (2015) argued that a primary concern of selecting activities for inclusion in OST STEM programs should be to ensure that activities build on participant's past learning experiences and promote connections between in-school and out-of-school learning (NRC, 2015). According to Stocklmayer, Rennie, and Gilbert (2010), activities that are included in OST STEM programs should provide opportunities for participants to learn about STEM concepts and engage in the processes of doing STEM (e.g., use STEM skills). Kesidou and Koppal (2004) recommended that OST STEM program activities should be: (a) aligned with the learning goals of OST STEM programs and appropriate content standards, (b) relevant to participants' culture and prior knowledge, (c)

responsive to participants' interests, and (c) use evidence-based instructional practices such as inquiry-based instruction.

Despite the varied recommendations from researchers regarding the types of activities OST STEM programs should include, most researchers agreed that OST STEM program content should not be solely focused on supporting academic outcomes (Durlak, Weissberg, & Pachan, 2010; Lauer et al. 2006). Rather OST STEM program content should provide a variety of activities that support participants' affective and cognitive developmental needs. Lauer et al.'s (2006) meta-analysis of the effects of OST program on high-risk participants indicated that including both academic and social activities developed participants' cognitive understandings and affective development (Lauer et al. 2006). Similarly, Innes et al. (2012) found that OST STEM programs that included collaborative hands-on, authentic activities provided increased social interactions among participants and increased participant learning outcomes.

Inquiry-based activities and citizen science projects. Several researchers have recommended including inquiry-based science activities and citizen science projects into OST STEM programs (Bell et al. 2009; Milgram, 2011; Muller et al. 2013). Luehmann (2009) argued that involving participants in the active processes of science that resemble how scientists work may help participants develop more meaningful understanding of scientific phenomena (Luehmann, 2009). Luehmann (2009) developed five recommendations for enhancing OST STEM programs: (a) provide access to meaningful scientific questions, (b) provide motivational contexts and practices, (c) provide opportunities to learn scientific concepts, (d) provide opportunities to learn scientific reasoning, and (e) provide opportunities to develop science identities (Luehmann, 2009).

Gibson and Chase (2002) argued that participants who engage in inquiry-based activities maintain higher interest in and more positive attitudes toward science careers. Additionally, Bell et al. (2009) posited that the nature of participating in informal science education programs is defined by doing science, engaging in scientific discourse, and using scientific tools. Similarly, Milgram (2011) argued that participants gain tangible technical skills and scientific skills by completing inquiry-based activities.

Bonney, Phillips, Enck, Shirk, and Trautmann (n.d.) argued that the nature of citizen science projects makes them an ideal activity for OST STEM programs. Citizen science projects involve individuals in the process of an authentic scientific investigation, typically through following a protocol to collect data and then contributing the data to a community database that is analyzed to understand scientific phenomena of interest to their community (Bell et al. 2009; Bonney et al. n.d.). Research regarding the outcomes of citizen science projects has found that citizen science project participants tend to gain scientific knowledge, develop positive attitudes towards science, and increase affiliation with a scientific community (Bonney et al. n.d.). Additionally, Bell et al. (2009) found that participation in citizen science programs positively influenced participants' scientific identity development.

Engineering design process. OST STEM programs that provide participants with opportunities to engage in the processes of engineering design and engage with engineers have been shown to significantly improve the participants' perception of engineers (Innes et al. 2012). These programs have also been shown to increase participants' interest in STEM, STEM self-efficacy, and familiarity with engineering (Innes et al. 2012). For example, making and tinkering is a growing movement to engage youth in creative

investigations and engineering design. According to Vossoughi and Bevan (2014) making is growing in popularity because it integrates practical, physical and playful aspects of inquiry and engineering design creating a low barrier for participation and a more open environment for exploration. However, critics of making have argued that making may not promote conceptual understanding and may not be as rigorous as more traditional inquiry-based or engineering design activities and if promoted within an already disadvantaged group may serve to reproduce inequalities (Vossoughi & Bevan, 2014).

Culturally-responsive instruction. Cultural divides between the lived experiences of children from non-dominant cultural groups (e.g., African-American, Hispanic, Native American) and the methods which STEM content is traditionally presented have been found to contribute to lower cognitive and affective outcomes for participants from non-dominant cultures (Milgram, 2011). Bell et al. (2009) and Milgram (2011) both argued that content can be made more accessible to learners when it is portrayed in contexts relevant to participants, as social, lived experiences, and inclusive of the diversity of the participants. Similarly, the NRC (2015) explained that “when programs explicitly connect STEM to recognizable problems in a community and leverage the participants’ cultural resources and practices, the possibilities for STEM learning experiences are expanded” (p. 21). This practice, also called culturally-responsive instruction, locates STEM content in socially and culturally relevant contexts (NRC, 2015). According to Bell et al. (2009), culturally-responsive instruction has been found to be particularly effective for engaging youth from groups traditionally underrepresented in STEM fields (e.g. African-American, Hispanic, Native American, and women).

Parental engagement. According to the NRC (2015), effective OST STEM programs engage participants and their families in first-hand experiences with STEM phenomena. The NRC (2015) argued that involving parents in STEM activities with their children increases parents' awareness of their children's interests and ambitions in STEM and increases the parents' abilities to advocate for and support their children's STEM pursuits. The Afterschool Alliance (2015) concurred with the NRC's argument and recommended that OST STEM programs provide parents with (a) information about the role the program can play to support their child's STEM learning and (b) information about how to make connections between the program, in-school learning, and other STEM learning opportunities. Similarly, Milgram (2011) argued that OST STEM programs should provide information and resources to assist parents as they support their child's STEM pursuits.

Attributes of the SEMAA. The SEMAA provides STEM enrichment experience for participants and their parents through the delivery of three core components: (a) STEM curriculum enhancement activities (hands-on activities, inquiry-based activities, engineering design challenges, and technology activities such as Lego robotics), (b) Aerospace education laboratory, and (c) Family Café. However, little is known about how these components are implemented at each SEMAA site. Additionally, previous evaluation studies have not used participants' and their parents' perspectives to characterize the attributes, process, and implementation of the SEMAA.

Participants' Attitudes Towards Science and Science Motivation Factors

Researchers have found that the intended outcomes of many OST STEM programs include to develop participants' (a) positive attitudes towards science, (b)

motivation to pursue additional science learning activities, and (c) interest in science and science careers (Bell et al. 2009; Krishnamurthi et al. 2013). However, Martinez et al. (2010) argued that most participants who self-select to participate in voluntary OST STEM programs do so because they already possess positive attitudes towards science, motivation to pursue science learning activities, and interest in science and science careers. Therefore, attitudinal and motivational constructs should be identified as both potential entry factors into OST STEM programs as well as potential outcomes of OST STEM program. Martinez et al. (2010) recommended that sustaining or refining science attitudes, motivation factors, and interests may be more appropriate goals for OST STEM programs. Additionally, researchers have argued that assessments of participants' attitudes towards science, science motivation factors, and interests in science prior to the start of a STEM learning experience can be used by instructors to guide and individualize instruction (Glynn, Taasobshirazi, & Brickman, 2009; Kind, Jones, & Barmby, 2007).

Attitudes towards science. Kind, Jones, and Barmby (2007) defined attitudes towards science as “the feelings that a person has about an object, based on their beliefs about that object” (p. 873). A common focus of OST STEM program research and evaluation has been to determine if participation in OST STEM programs impacts participants' attitudes towards science (Bell et al. 2009). A common assumption of this research and evaluation is that the attitudes towards science that participants exhibit during an OST STEM program will transfer to in-school STEM learning (Bell et al. 2009). Kind et al. (2007) argued against this assumption noting that attitudes towards science are not necessarily transferable across different contexts and domains of science (Kind, Jones, & Barmby, 2007). For example, a child may have positive attitudes towards

science in an OST STEM programs, but these feelings may not transfer to positive attitudes towards science in school. Likewise, positive attitudes towards physical sciences do not necessarily transfer to positive attitudes towards life sciences.

Science motivation factors. Motivation is generally defined as the “internal state that arouses, directs, and sustains behavior” (Koballa & Glynn, 2007, p. 85). Specifically, science motivation factors refer to the disposition of students to find science relevant, worthwhile, and beneficial (Glynn, Taasobshirazi, & Brickman, 2009). Although the majority of research focused on science motivation factors has been conducted in school contexts, a few studies have explored the relationship between participation in OST STEM programs and science motivation factors. Simpkins, Davis-Kean, and Eccles’s (2006) longitudinal study found evidence that secondary school students’ motivation to persist in science could be related to participation in OST STEM programs as youth. Similarly, Falk, Storksdieck, and Dierking (2007) found parents encouraging their children to participate in OST STEM programs increased their child’s motivation to learn science.

Interest in science. Researchers have argued that OST STEM programs provide opportunities for learners to explore and refine their interests in STEM and STEM careers (Bell et al. 2009; Gibson & Chase, 2002; Simpkins, Davis-Kean, & Eccles, 2006). Koballa and Glynn defined interest as “curiosity” or “a readiness to pursue” an activity or behavior (2007, p. 88). Koballa and Glynn (2007) argued that interest is considered a construct of motivation and is used to describe the processes, activities, and actions that initiate and maintain learning behavior. Interest is generally considered to be an effective motivator and refers to either a selective preference for a particular domain of study or

focused attention upon a particular situation (Palmer, 2009). Pintrich and Schunk (1996) argued that interest is related to increased memory, greater comprehension, and deeper cognitive engagement and thinking. Additionally, interest has been found to play an important role in the development of intrinsic motivation to pursue learning (Krapp, 2002; Krapp & Prenzel, 2011; Palmer, 2009).

SEMAA's roll in participants' attitudes towards science and science

motivation factors. According to the SEMAA's official website, the SEMAA seeks to strengthen participants' interest in STEM, inspire continued participation in advanced STEM courses, and encourage the pursuit of STEM careers (Dunbar, 2013). However, a prior national evaluation study of the SEMAA found that the SEMAA did not have an impact on participants' interests in STEM nor their college degree or career ambitions (Martinez et al. 2010). Martinez et al. (2010) suggested that positive attitudes toward STEM, motivation to learn STEM, and interest in pursuing STEM learning and careers may be prerequisites for participants to enroll in the SEMAA, because participants started the SEMAA with high levels of interest in STEM and STEM careers. The participants' high level of interest in STEM and STEM careers was maintained throughout the SEMAA, but did not increase (Martinez et al. 2010). This research study will further explore Martinez et al.'s (2010) argument by assessing the SEMAA participants' attitudes towards science and science motivation factors. The assessment may provide evidence that could be used by SEMAA program developers to refine the SEMAA's goals related to increasing participants' interests in STEM, STEM college degrees and STEM careers.

Equitable Access to OST STEM Programs

Policymakers and researchers have emphasized the importance of providing children with positive, structured OST STEM programs and have advocated for equitable access to high quality OST STEM programs for all children (NRC, 2015; Afterschool Alliance, 2016). This argument has been substantiated by research that has linked positive academic achievement, social development, and psychological functioning with participation in OST STEM programs and high risk behavior and poorer academic outcomes with time spent unsupervised or in unstructured programs (Fredricks, 2011). These findings are particularly troubling for children from low-income families who are less likely to have an afterschool caregiver at home and are at a higher risk for academic failure (Lauer et al. 2006). Traphagen and Traill (2014) argued that a child's access to STEM experiences, resources, and materials may be limited by community, culture, logistical, financial, and philosophical constraints.

In response to this advocacy from policymakers and researchers, many OST STEM programs have been specifically designed and implemented to provide equitable access to STEM programs for children from underserved (e.g., low-income, rural) and underrepresented (e.g., African-American, Hispanic, Native American, and women) communities in STEM professions (Bell et al. 2009; NRC, 2015). The following section provides a brief summary of the growing body of research focused on equitable access to OST STEM programs.

Low-income communities. Milgram (2011) argued that providing opportunities for achievement through OST STEM programs can overcome the emotional challenges and feeling of inadequacy that are often characteristic of low-income children and build

children's STEM self-efficacy. However, funding issues pose a significant challenge to ensuring equitable access for low-income children to high-quality STEM education (Milgram, 2011). Children from low-income communities are more likely to attend schools that have lower funding for STEM activities and often come from families with less financial resources to support participation in these activities outside of school (Milgram, 2011). Policy-makers and researchers have argued that OST STEM programs can provide opportunities for participants who attend poorly funded schools to engage with STEM materials and resources and engage in hands-on activities than they otherwise would not have access to (Berliner, 2009; Luehmann, 2009). For example, Luehmann's (2009) study of urban children who participated in an OST STEM programs that included science inquiry-based activities, found that the participants expressed appreciation for the increased access to scientific resources and equipment because they attended under-resourced schools that were challenged to provide students with opportunities to engage in scientific inquiry in classroom learning (Luehmann, 2009).

Providing safe, structured environments for low-income children has been a significant factor in the development and promotion of OST programs (Lauer et al. 2006). Recognizing that low-income children are more likely to be unsupervised by an adult caregiver afterschool and are more likely to engage in high risk behaviors, the federal government has made significant investments in OST programming directed towards low-income children (Bevan & Michalchik, 2013; Lauer et al. 2006). For example, Title 1 of the Elementary and Secondary Education Act and the 21st Century Community Learning Centers were developed to provide extended learning opportunities for low-income children in a safe, structured environment (Durlak, Weissberg, & Pachan,

2010; Lauer et al. 2006). As a result of the federal government's investment in OST programs, low-income children typically have more access to government-funded afterschool STEM programs than their higher-income peers (Afterschool Alliance, 2015).

Several researchers have conducted studies to identify effective attributes of OST STEM programs for low-income children (Luehmann, 2009; Lauer et al. 2006). For example, providing extended learning opportunities for low-income students that include connections to regular academic programs has been identified as a promising practice by the U.S. Department of Education (Lauer et al. 2006). Milgram (2011) argued that frequent in-person contact with parents, low participant to instructor ratio, rigorous academic and workforce skills development, hands-on experiences, and collaboration between community-based organizations and schools have been associated with positive outcomes for low-income children (Milgram, 2011).

The Afterschool Alliance (2016) argued that the geographic isolation of rural children often limits their exposure to STEM resources and materials and recommended that access to high-quality OST STEM programs could provide rural children with exposure to STEM to which they otherwise would not have access. According to the Foster and Shiel-Rolle (2011) many rural communities do not have access to OST STEM programs. The Afterschool Alliance (2016) identified four primary barriers children from rural communities face that make participation in OST STEM programs challenging: (a) affordability, (b) availability, (c) accessibility, and (d) knowledge of afterschool programs.

Historically underrepresented groups in STEM professions. Policymakers and researchers have argued that OST STEM programs can play an important role in expanding the participation of children from historically underrepresented communities in STEM by providing: (a) access to resources and experiences beyond what school can provide, (b) instructors who are community members and can facilitate participants' connections to other resources, and (c) inclusive approaches to learning that encourage participants to identify as STEM learners (Alvarez, Edwards, & Harris, 2010; Bell et al. 2009; NRC, 2015). For example, Luehmann's (2009) study of children from groups historically underrepresented in STEM professions found that participation in an OST STEM program increased participants' engagement with science concepts, provided support for learning in school, addressed the learning needs of diverse participants, increased participants' intrinsic motivation to learn science both in-school and outside of school, and developed participants' ability to identify as scientists. Additionally, Bevan and Michalchik (2013) found that children who participated in high-quality OST STEM programs built social networks with like-minded peers, STEM professionals, and other positive adult role models which enabled them to identify themselves as achievers in STEM contexts and to take ownership of their STEM understanding.

The NRC (2015) posited that OST STEM programs that: (a) include participants' interests, experiences, and cultural practices (e.g. language, experiences, values); (b) develop participants' understanding of STEM as socially meaningful and culturally relevant; (c) support participants' development of STEM identity; and (d) position instructors as co-investigators with participants hold potential to attract and retain children from underrepresented communities in STEM professions.

Bell et al. (2009) outlined three strategies for providing OST STEM programs that attract and retain children from groups traditionally underrepresented in STEM fields: (a) including members of diverse cultures in program development and implementation, (b) designing programs to serve the entire family, and (c) developing peer networks. Bang and Medin (2010), applied Bell et al.'s recommendations to OST STEM programs that target Native American children and advocated for a community-based design that included participation of community members, teachers, elders, parents, experts, and children in the design and implementation of OST STEM programs to attract and retain children from Indigenous communities. Bang and Medin (2010) argued that developing OST STEM programs using a community-based design process creates a learning environment for both participants to learn science content and instructors to learn about culture and Indigenous ways of knowing. Bang and Medin's (2010) study of the community-based design process found that OST STEM programs that used the community-based design process resulted in increases in Native American participants' self-determination, ownership of science knowledge, and community engagement.

Despite girls' equal or higher achievement in STEM than boys, a gender gap exists between the number of boys and girls interested in physical sciences, engineering, and computer sciences (Bell et al. 2009; Milgram, 2011). Researchers have suggested several reasons for the persistence of this gender gap including: (a) fewer girls identify with these STEM professions, (b) girls tend to have lower beliefs about their STEM abilities, (c) lack of positive STEM learning experiences for girls, (d) lack of family and school support, and (e) lack of peer learning groups (Bell et al. 2009; Milgram, 2011). Dabney et al. (2012) and Milgram (2011) both argued that participation in OST STEM

programs can counterbalance these contributing factors by providing positive STEM learning experiences and female role models or mentors with whom girls can identify. In response to the gender gap and arguments for providing more positive STEM learning experience for girls, several afterschool programs have been designed specifically for girls (Afterschool Alliance, 2015). However, the Afterschool Alliance's (2015) national parent survey, *America After 3PM*, revealed that despite an increase in the number of OST STEM programs offered specifically for girls, girls were less likely to participate in an OST STEM program than boys. Milgrams' (2011) identified seven strategies that showed promise for recruiting girls to participate in OST STEM programs: (a) collaborating with school counselors, (b) personally encouraging girls to participate, (c) developing promotional materials that feature women, (d) including female STEM professionals as instructors or presenters, (e) using pink as part of recruitment materials, (f) appealing to female interests such as making a difference in the world, (e.g. engineering water purification systems for developing regions of the world), and (g) focusing on teamwork and collaboration. Milgram (2011) argued that it may seem controversial to use the color pink. However, researchers have found that women and girls identify with the color pink and it is effective in recruitment materials.

Equitable access to the SEMAA. The SEMAA is a federally-funded OST STEM program that is design to specifically target students from underserved and underrepresented groups in STEM fields. However, prior the prior national evaluation of the SEMAA did not assess issues related to equitable access to the SEMAA (Martinez et al. 2010). This study will use the participants' and their parents' perceptions of the SEMAA to identify potential barriers to equitable participation. This study will also

assess participants' and their parents' reasons for enrolling and their perceptions of the enrollment process.

OST STEM Program Research and Evaluation Approaches

As federal funding for OST STEM programs has grown, so have the questions about return on investment and responsible stewardship of resources (Bell et al. 2009, Lauer et al. 2006). However, policy-makers and researchers have argued that the body of empirical research focused on OST STEM programs is limited and fragmented (Bell et al. 2009; Krishnamurthi et al. 2013; NRC, 2015). Researchers have specifically noted that the nature of participants' experiences in OST STEM programs remains largely unexamined and few research studies in the field of OST STEM programs have included participants' perspectives (Krishnamurthi et al., 2013; Luehmann, 2009). Policymakers, researchers, program administrators, and educators have called on the research community to develop a focused research agenda for OST STEM programs that includes research and evaluation studies that (a) document the characteristics of OST STEM programs, (b) assess the strengths of the program designs, and (c) assess program outcomes (Bell et al. 2009; Lauer et al. 2006; Hussar, Schwartz, Bioselle, & Noam, 2008; NRC, 2015). The NRC (2015) recommended that researchers should consider individual, program, and community-level constructs to fully understand how OST STEM programs contribute to participants' STEM interests and understanding.

The NRC (2015) also identified two common mistakes that evaluators have made when assessing the quality and impact of OST STEM programs: (a) assessing only short-term participant learning outcomes as indicators of program effectiveness and (b) ignoring the individual differences in program's contextual factors to generate

comparative or aggregated data. The NRC (2015) recommended that program evaluators should take a broader view of assessment and explore more complex and varied program outcomes.

The National Science Foundation's 2008 *Framework for Evaluating Impacts of Informal Science Education Projects*, outlined five domains of participant outcomes for OST STEM programs: (a) increased knowledge or understanding of STEM concepts, processes, or careers, (b) increased or sustained engagement or interest in STEM concepts, processes, or careers, (c) expressing positive behaviors related to STEM concepts, processes, or careers, (d) increased STEM skills, and (e) promoting positive dispositions towards STEM topics and capabilities. The domains were developed to encourage program developers and evaluators to consider multiple areas of impact and to provide a framework for program developers and evaluators to articulate and differentiate program goals (Friedman, 2008).

Qualitative methods used to characterize OST STEM programs and assess participant outcomes. Many researchers have adopted qualitative research methods to conduct OST STEM research and evaluation (Bell et al. 2009; Hussar et al. 2008; Rennie, Feher, Dierking, & Falk, 2003). Rennie et al. (2003) argued that the flexible, low-stakes nature of OST STEM programs requires innovative research designs for analyzing program processes and outcomes. Similarly, Innes et al. (2012) cautioned that grading assignments or measuring participants' learning outcomes using traditional pre-post surveys may lead to participants' anxiety, feelings of inadequacy, and undo performance pressure. Bell et al. (2009) concurred with these arguments stating that OST STEM

program research and evaluation methods should not interfere with participants' expectations about learning in an OST environment.

The emerging body of OST STEM program research and evaluation has primarily focus on assessing affective program outcomes (e.g., attitudes, behaviors, engagement, or interest) (Hussar et al. 2008; NRC, 2015). However, a few studies have been conducted to assess STEM knowledge and career outcomes (Hussar et al. 2008). Bell et al. 2009 outlined four considerations that researchers should be aware of when assessing outcomes of OST STEM programs: (a) outcomes typically include a broad range of behaviors, are complex, and holistic, (b) outcomes can be unanticipated, emergent, and guided by the participants, (c) different outcomes can become evident at different points in time (e.g., short-term outcomes, intermediate outcomes, long-term outcomes), and (d) outcomes can occur at different scales (e.g., participant, facilitator, social group, family, institution, community).

Qualitative self-report tools (questionnaires, interviews, focus groups, drawing tasks, concept mapping, and sorting tasks) are typically used to measure OST STEM program outcomes (Bell et al. 2009). However, researchers have also used innovative qualitative methods such as observation tools, discourse analysis, constructivist tools (e.g., concept mapping, social learning network analysis), biographical and narrative approaches, creative writing assignments, and product-oriented assessment models (e.g., portfolio assessment, participant work samples) (Barron, n.d.; Bell et al. 2009; Rennie et al. 2003). These qualitative methodologies can also be used for formative program assessment and formative assessment of participants' progress (Barron, n.d.). Some common indicators that have been used to qualitatively characterize learning outcomes in

OST STEM programs are: identifying, describing, interpreting, applying, listing, synthesizing, analyzing, explaining, perceiving, conceptualizing, connecting, and levels of metacognition (Bell et al. 2009).

Summary

This chapter summarized the emerging field of research focused on OST STEM programs and positioned the role of OST STEM programs within the broader framework of formal and informal education. The literature reviewed in this chapter provided the foundation for the research design and interpretations of this multiple case study of the SEMAA. Research focused on the use of STEM ecosystem models grounded in Bronfenbrenner's ecological model of human development provided guidance for positioning the SEMAA into a broader context of formal and informal STEM learning experiences and for interpreting the participants' perceived connections between their experiences in the SEMAA and their learning in-school. The literature reviewed in this chapter also provided a foundation for understanding participants' descriptions of the characteristics of the SEMAA in terms of the SEMAA's operations and infrastructure, instructors, learning environment, curriculum and instruction, and parental engagement. Additionally, this review of the literature provided a foundation for assessing the SEMAA participants' attitudes towards science and science motivation factors as a tool for selecting curriculum and instruction aligned to participants' characteristics.

CHAPTER III

METHODOLOGY

This chapter will describe the research design of this study. This study of the SEMAA used the multiple-case study research design as defined by Yin (2012). Yin (2012) described a multiple-case study as “a single empirical inquiry or study that contains two or more cases” (p. 131). According to Creswell (2007), using multiple cases enhances the possibility for transferability findings because a range of representative cases is provided. All seven SEMAA sites selected to participate in this research study were bound by their shared implementation of the three SEMAA components in a summer camp setting. However, each single-case study represented a unique location.

The selection of multiple-case study was informed by the purpose and theoretical framework this study. Multiple-case study utilizes qualitative methods that allowed the participants and their parents to describe their perceptions of the SEMAA using their own words. This inductive method was used to reveal characteristics about the processes and implementation of the SEMAA that emerged from the data collected from the participants and their parents. According to Yin (2012), “multiple-case design is usually more difficult to implement than a single-case design, but the ensuing data can provide greater confidence in your findings” (p. 7).

This chapter begins with a description of the methodology, study participants, setting, data collection procedures, and data analysis procedures of this study. Next, the ethical considerations and steps that were taken to ensure trustworthiness of the study are presented. Finally, this chapter will present my qualifications and potential biases as a research instrument.

Research Design

Qualitative methodology. This research study relied on qualitative methodology. According to Miles, Huberman, and Saldaña (2014), “qualitative data, with their emphasis on people’s lived experiences, are fundamentally well suited for locating the meanings people place on the events, processes, and structures of their lives and for connecting these meanings to the social world around them” (p. 11). Additionally, “qualitative data are useful when one needs to supplement, validate, or illuminate quantitative data gathered from the same setting” (Miles, Huberman, and Saldaña, 2014, p. 12). Qualitative methodology was appropriate for this research because it allowed individuals who directly experienced the SEMAA to respond to questions using their own words, which provided a more robust understanding of participants’ and their parents’ perceptions of the SEMAA than could have been acquired with the use of quantitative methods.

Case study. A case study approach was used to answer the research questions posed by this study. Creswell (2007) described case study as “a qualitative approach in which the investigator explores a bounded system and reports a case description and case-based themes” (p. 73). This study collected data from participants and their parents from seven SEMAA sites that were bound by their shared implementation of the three

SEMAA components (curriculum enhancement activities, aerospace education laboratory, and Family Café) in a summer camp setting.

Case study was an appropriate methodology because the context, design, implementation, and participation in the SEMAA were beyond the control of the researcher. According to Yin (2002), “case studies are the preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context” (p. 1). Direct descriptions and explanations from individuals who participated in the SEMAA and their parents were gathered to generate a rich, descriptive understanding of their perceptions of the SEMAA.

Multiple-case study design. This research investigation utilized a multiple-case study design that included seven single-case studies. According to Yin (2012), using a multiple-case design rather than a single-case design improves the likelihood of producing credible results and avoiding a common criticism of case study research.

Analytic conclusions independently arising from two cases, as with two experiments, will be more powerful than those coming from a single case alone. You also can avoid a common criticism about single-case design: that the choice of the single case can reflect some unusual but artifactual condition about the case rather than any substantively compelling situation. (Yin, 2012, p. 133-134)

The use of multiple cases to inform this research study provided a broader scope of evidence than would have been possible if a single case was the focus of this study. Additionally, the use of multiple cases permitted a more intense examination of the

participants' and parents' perceptions of the SEMAA and a broader assessment of the participants' attitudes towards science and science motivation factors.

Challenges of case study. Case study methodology has been scrutinized for lack of rigor and systematic procedures, providing little basis for transferability, and requiring a lengthy process involving a massive amount of data collection and analysis (Yin, 2012). In response to these criticisms, Yin (2012) provided strategies to ameliorate the potential shortcomings of case study methodology. First, Yin's case study model employed a technical approach to designing an empirical inquiry that utilized systematic procedures for collecting and analyzing multiple sources of evidence. Yin also recommended creating a case study database to manage the voluminous data collected. This case study followed Yin's recommendations by strategically selecting multiple sources of evidence that were directly aligned to the purpose and research questions of the study. Additionally, systematic data analysis procedures were explicitly described and followed.

Participants

The study participants were the SEMAA participants and their parents. For the purpose of this study the term "participants" was generally defined as children who had completed at least fifth grade and who had participated in at least one SEMAA program. The term "parent" was defined as one of the SEMAA participant's primary adult caregivers. The parent was typically the participant's mother or father. However, the term parent also included grandmother, grandfather, or other adult relative. The demographic and background information of the SEMAA participants and their parents who participated in the study are described in detail in chapter four.

Setting

The SEMAA is one of several Kindergarten through twelfth grade education programs provided by the NASA. The NASA's Glenn Research Center Education Programs Office located in Cleveland, Ohio manages the national operation of the SEMAA. Contractor support is conducted by Paragon TEC, Inc., which provided implementation support for SEMAA through their National SEMAA Office (Dunbar, 2013). SEMAA strategically partnered with minority serving institutions and other higher education institutions, science centers, and Kindergarten through twelfth grade school districts to facilitate the program. These partnering institutions are called SEMAA sites. Twenty-five different SEMAA sites have existed since the project's inception in 1993 (Martinez et al. 2010). During the summer of 2015, the program was operated at eight SEMAA sites (Figure 2). Seven of these eight SEMAA sites agreed to participate in this research study.



Note: Red paddles denote SEMAA sites that participated in this study.

Figure 2. Summer 2015 SEMAA site locations.

SEMAA sites received (a) initial funding; (b) aerospace education laboratory equipment, technology, and software; (c) curriculum enhancement resources; and (d) training materials for family involvement, partnership development, and program sustainability from NASA at the start of their program. The SEMAA sites are expected to develop partnerships and conduct fundraising efforts to enhance project operations and sustain their programs beyond the initial NASA funding. In total, the SEMAA sites have garnered over \$3.9 million in both financial and in-kind support from a network of over two hundred partners (Dunbar, 2013).

The SEMAA is intended to promote K-12 grade student participation and retention in STEM by engaging participants and their parents in hands-on, inquiry-based activities. Recent project reports indicated that 22,462 participants and 5,236 parents participated in the SEMAA during the 2014-2015 academic year (Slone, 2015).

The goals for the SEMAA listed on the project's official NASA website are to:

- 1) Inspire a more diverse student population to pursue careers in STEM-related fields;
- 2) Engage students, and parents/adult family members, and teachers by incorporating emerging technologies; and
- 3) Educate students using rigorous STEM curriculum enhancement activities designed and implemented as only NASA can. (Dunbar, 2013).

The SEMAA sites strive to accomplish these goals by implementing three core components: (a) STEM curriculum enhancement activities (hands-on activities, inquiry-based activities, engineering design challenges, and technology activities such as Lego robotics), (b) Aerospace education laboratory, and (c) Family Café. Table 1 provides the

descriptions of these three components as listed on the project’s official NASA website (Dunbar, 2013).

Table 1. Descriptions of SEMAA components

<u>Component</u>	<u>Description</u>
STEM curriculum enhancement activities	The NASA SEMAA project uses a series of unique hands-on, inquiry-based classroom curriculum enhancement activities. In addition to being aligned with national math, science and technology standards, these activities encompass the research and technology of each of NASA's four mission directorates (Aeronautics Research, Exploration Systems, Science and Space Operations). On average, NASA SEMAA students participate for a total of 36 hours each year, 21 hours during the academic year and 15 hours during the summer. NASA SEMAA graduates who have participated in the entire K-12 program will have completed 441 hours of advanced studies in STEM prior to their enrollment in a post-secondary institution.*
Aerospace education laboratory	Developed by NASA and equipped with 10 workstations, the Aerospace Education Laboratory, or AEL, is an electronically enhanced, computerized classroom that puts cutting-edge technology at the fingertips of NASA SEMAA middle- and high school-aged students. Each computerized research station provides students with real world challenges relative to both an aeronautics and microgravity scenario. Examples of the real aerospace hardware and software contained in the AEL include an Advanced Flight Simulator; a laboratory-grade, research wind tunnel; and a working, short-wave receiver and hand-held Global Positioning System for aviation. In addition to being an extraordinary tool for educating middle and high school students, the AEL serves as an excellent training facility for pre-service teachers on the NASA SEMAA curriculum.*
Family Café	Unique to the NASA project, the Family Café is an interactive forum that promotes sustained family involvement at each of the NASA SEMAA sites around the country. The Family Café engages SEMAA parents and adult family members in up to 21 hours of Family Focus Group sessions each year, during which time participants are engaged in dialogue focused on relevant parenting and STEM education information. In addition to Focus Groups, the Family Café hosts a multitude of Family Night activities and other special events that promote parent and adult family member participation in student learning.*

* Description excerpt from the official NASA SEMAA website (Dunbar, 2013).

The SEMAA is delivered through four models: (a) Saturday model, (b) in-school model, (c) after-school model, and (d) summer model. The SEMAA sites generally provided four sessions per year, of which three were held during the school year and one was held during the summer. According to Martinez et al. (2010) the SEMAA sites that implemented the Saturday model typically held seven to eight, 180 minute classes per session. Sites that implemented the in-school and after-school models varied greatly in the amount and length of sessions. Summer models typically consisted of week-long (five days) summer camps. Summer camps were not residential and provided content for four to six hours per day for one week.

SEMAA participants are selected through an application process. According to Martinez et al.'s (2010) national program evaluation of the SEMAA, sites reported between 431 – 3,100 participants each year. Martinez et al found that SEMAA participants typically began the project with a high level of interest in STEM and STEM careers and this level of interest is maintained over the course of participation.

Parents of the SEMAA participants are encouraged to participate in Family Café sessions. Family Café are typically held in concurrence with SEMAA participant activities and generally included guest speakers, workshops, and hands-on activities. Topics include aerospace or STEM content, supporting participants' academic and career ambitions, health care, financial management, and other parenting skills (Martinez et al. 2010).

Data Collection

Questionnaires were administered to the SEMAA participants and their parents to collect data about their perceptions of the program. Open-ended questions were used to

collect qualitative data about the participants’ and their parents’ perceptions of the SEMAA. However, it was determined that qualitative data alone would not be sufficient to understand the participants’ and their parents’ reasons for enrolling in the SEMAA nor participants’ attitudes towards science and science motivation factors. Therefore, a choice list was used to collect participants’ and their parents’ reason for enrolling in the SEMAA. Additionally, quantitative data were collected from analysis of the Attitudes Towards Science Measures (Kind, Jones, & Barmby, 2007) and the Science Motivation Questionnaire II (Glynn, Brickman, Armstrong, and Taasobshirazi, 2011) that were administered to the participants to understand their attitudes towards science and science motivation factors. According to Yin (2012), case study research “can call on both qualitative and quantitative” data sources (p. 178). Yin (2012) explained that qualitative and quantitative data can work in complement to provide a more robust understanding of a phenomena. Table 2 provides a list of the data sources and analysis procedures aligned to this study’s research questions.

Table 2. Research questions aligned to the data sources and analysis procedures

<u>Research Question</u>	<u>Data Collection and Analysis</u>	
	<u>Data Source</u>	<u>Analysis Procedure</u>
1. What are the parents’ perceptions of the SEMAA?	Parent questionnaire (Open-ended and closed-end questions)	Qualitative analysis Descriptive statistics
2. What are the participants’ perceptions of the SEMAA?	Participant questionnaire (Part 3 - Open-ended and closed-end questions)	Qualitative analysis Descriptive statistics
3. What are the SEMAA participants’ attitudes towards science and science motivation factors?	Participant questionnaire (Part 1 - Attitudes Towards Science Measures, Part 2 - Science Motivation Questionnaire II, and Part 3 - Open-ended questions)	Qualitative analysis Descriptive statistics

Parent questionnaire. The parent questionnaire used in this study was adapted from Martinez et al. (2010) national SEMAA parent questionnaire that was developed and administered during the 2010 national program evaluation of the SEMAA. The questionnaire contained three sections: (a) SEMAA Experience, (b) Parents' Perceptions of the SEMAA, and (c) Background Information. The first section, SEMAA Experience, consisted of four multiple choice questions that asked the parents about the type of SEMAA their child participated in and the grades during which their child participated. Section two, Parents' Perceptions of the SEMAA, included a choice list of reasons why the parent supported their child's participation in the SEMAA. The second section also included a series of Likert-scale questions about their child's attitudes towards science and a series of thirteen open-ended questions about the parents' perceptions of the SEMAA. Section three, Background Information, included five multiple choice questions about their child's demographics. See Appendix A for the parent questionnaire used in this study.

Participant questionnaire. The participant questionnaire used in this study contained four sections: (a) Attitudes Towards Science, (b) Science Motivation Factors, (c) Participants' Perceptions of the SEMAA, and (d) Background Information. Each section of the participant questionnaire is described in detail below. A copy of the participant questionnaire used in this study is provided in Appendix B.

Attitudes Towards Science Measures. Study participants' attitudes towards science were assessed using the *Attitudes Toward Science Measures* instrument developed by Kind, Jones, and Barmby (2007). Many instruments to measure attitudes towards science were reviewed prior to selecting the Attitudes Towards Science

Measures. Although many of these instruments were found to be appropriate for the levels and topics of interest to this study, the instrument that was selected was uniquely appropriated because it was specifically design to consider secondary school students' attitudes towards science in out-of-school learning contexts.

The instrument was comprised of thirty-seven Likert-scale questions that asked the participants to rate their level of agreement with a series of statements about their attitudes towards science. The rating choices were: (a) 1 = strongly disagree, (b) 2 = disagree, (c) 3 = neither agree or disagree, (d) 4 = agree, and (e) 5 = strongly agree. The instrument consisted of seven subscales that were aligned to factors research has shown to influence positive attitudes towards science. The subscales were: (a) Learning science in school, (b) Self-concept in science, (c) Practical work (Doing Experiments) in science, (d) Science outside of school, (e) Future participation in science, (f) Importance of science, and (g) Combined interest in science (composed of the items on the learning science in school, science outside of school, and future participation in science subscales combined).

The questionnaire was developed for use with secondary school students in England. Accordingly, minor word changes were needed to translate the questionnaire from British English to American English. For example, the phrase "practical work" was translated to "doing experiments." Cronbach's alpha internal consistency associated with each subscale were recalculated using IBM Statistical Package for Social Sciences (version twenty-one) to ensure the reliability of the instrument remained acceptable. The Cronbach's alpha for each subscale were determined to be greater than 0.7, indicating

that the instrument's internal reliability remained acceptable (Table 3). According to Tavakol and Dennick (2011), acceptable values of alpha are 0.70 or higher.

Table 3. Cronbach's α values for each attitude subscale

<u>Measure</u>	Cronbach's α	
	<u>Barmby, Kind, & Jones, 2008</u>	<u>Current Study</u>
Learning science in school	0.89	0.74
Self-concept in science	0.85	0.74
Practical work (doing experiments) in science	0.85	0.71
Science outside of school	0.88	0.83
Future participation in science	0.86	0.86
Importance of science	0.77	0.70
Combined interest in science	0.93	0.92

Science Motivation Questionnaire II. Study participants' science motivation factors were assessed using the *Science Motivation Questionnaire II* developed by Glynn, Brickman, Armstrong, and Taasobshirazi (2011). The instrument included twenty-five Likert scale questions that asked participants to rate the frequency of their agreement with statements about their engagement with science. The choices were: (a) 0 = never, (b) 1 = rarely, (c) 2 = sometimes, (d) 3 = usually, and (e) 4 = always. The instrument consisted of five subscales that were aligned to factors that research has shown to motivate participants to participate and persist in science. The subscales were: (a) Intrinsic motivation, (b) Career motivation, (c) Self-determination, (d) Self-efficacy, and (e) Grade motivation. Glynn et al. (2011) used confirmatory factor analysis was used to establish the validity of each subscale. The Cronbach's alpha for each subscale were greater than 0.8, indicating the instrument has high internal reliability (intrinsic motivation = 0.89, career motivation = 0.92, self-determination = 0.88, self-efficacy = 0.83, and grade motivation = 0.81) (Glynn et al. 2011).

Participants' perceptions of the SEMAA. The third section of the participant questionnaire gathered data on participants' perceptions of the SEMAA using multiple strategies. Participants' reasons for participating in the SEMAA were collected using a choice list that was developed by Abt Associated Inc. during the 2010 national program evaluation of the SEMAA (Martinez et al. 2010). A series of seven open-ended questions were developed specifically for this research study to collect participants' perceptions of the SEMAA. Additionally, this section included four questions that asked the participants about their college and career interests. These questions included a combination of fill-in the blank, yes/no, and open-ended response items to provide a more robust understanding of participants' college and career interests and the role the SEMAA played to influence their decisions.

Background information. The background information section of the participant questionnaire included a series of five multiple choice questions regarding the participant's demographics and past participation in the SEMAA.

Data collection access. Acquiring data for research studies typically requires obtaining permission and access from a gatekeeper. Creswell (2007) describes a gatekeeper as "an individual who is a member of or has insider status with a cultural group" (p. 125). For this study, permission and access was obtained from the NASA Glenn Research Center Education Director. The Education Director was initially contacted through e-mail requesting permission to conduct the study. An initial meeting was held with the Education Director and the Deputy Education Director at NASA Glenn Research Center prior to the start of the research study. During the initial meeting, the researcher provided information regarding the purpose of the study, why the SEMAA was chosen, what would happen

during the study, and how much time the study required. NASA personnel were reassured the study did not hold potential to disrupt the SEMAA implementation. Information about how the study would be documented and reported was also provided. Additionally, the researcher shared how the SEMAA and participants may benefit from the study. Following the initial meeting, the NASA personnel informed the SEMAA Site Directors about the study and provided the SEMAA site contact information to the researcher.

Data collection process. Due to the large geographic dispersion of the SEMAA sites, it was not feasible to recruit participants and administer the questionnaire in-person. Therefore, study recruitment and questionnaire administration was conducted in cooperation with the SEMAA Site Directors. The researcher met with the SEMAA Site Directors via a teleconference to explain the purpose of the questionnaire and the data collection procedures. Following the teleconference, study materials (copies of the participant and parent questionnaire, informed consent information sheets, IRB approval sheet, and a study timeline) were e-mailed to the SEMAA site Directors. Paper copies of the participant and parent questionnaires and informed consent information sheets were shipped to each site via FedEx. The SEMAA Site Directors distributed the questionnaires and informed consent information to the participants and parents during the summer 2015 SEMAA. As an incentive to complete the questionnaires, a package of NASA Earth-based cinnamon basil seeds was given to the participants and parents upon return of their completed questionnaires. The SEMAA Site Directors returned the completed participant and parent questionnaires to the researcher via FedEx.

Sampling strategy. Purposeful sampling technique was employed to select individuals from which data were obtained to inform this study. According to Creswell

(2007), purposeful sampling “will intentionally sample a group of people that can best inform the researcher about the research problem under examination” (p. 118). The form of purposeful sampling that was used was typical cases. Patton (2014) defined the process of typical case sampling as “selecting and studying several cases that are average to understand, illustrate, and/or highlight what is typical, normal, and average” (p. 268).

SEMAA site sampling. Purposeful sampling was used to select the SEMAA sites that represented typical implementation of the SEMAA model in a summer camp setting. Program documents (e.g., annual SEMAA site technical reports, summer camp agendas) were reviewed and discussions were held with the NASA SEMAA Program Manager to identify eight SEMAA sites that were typical cases of the SEMAA. However, only seven of these SEMAA sites agreed to participate in the study.

Participant sampling. Individuals were purposefully selected to provide their perceptions of the SEMAA based on their past participation in the program. The SEMAA participants and their parents are central to the program. SEMAA participants hold a wealth of insight into the program and provided their perceptions about the affective, social, and contextual factors that influenced their participation and persistence in the SEMAA.

Exclusions. Although the SEMAA provided programming for children in Kindergarten through twelfth grade, this research study only included the perceptions of children who had completed at least fifth grade. The nature of this research required participants to complete questionnaires that were not appropriate for elementary school children. Therefore, the study participants were restricted to participants who would be in middle school (grade 6 – 8) or high school (grades 9 – 12) during the next academic year.

Data Analysis

Multiple-case study research relies on the cross-case synthesis of two or more single-case studies that are bounded by a commonality to reveal an issue (Yin, 2012). According to Yin (2012), multiple-case study data analysis requires two stages. First, data from each case study is analyzed individually. During this stage each case is treated as an independent study. Qualitative data analysis methods are applied (e.g., open coding) to develop case-based themes. Next, a cross-case synthesis is conducted to analyze the data across cases. According to Yin (2012) cross-case synthesis “brings together the findings from individual case studies” (p. 158). Cross-case synthesis analyzes data across multiple individual cases to identify convergences and non-convergences of findings (Yin, 2012). The following section describes the process that was used for each of the two stages of data analysis.

Single-case study qualitative data analysis. The data analysis procedures were identical for each of the seven single-case studies. Qualitative data analysis processes were used to analyze the open-ended response questions on both the participant and the parent questionnaires. To begin, responses were recorded on a separate spreadsheet for each question. Next each response was read and labeled using open coding to organize data into categories. According to Creswell (2007), open coding “involves taking data and segmenting them into categories of information” (p. 239-240). The open coding process was repeated multiple times to slowly reduce the number of categories that would become the major themes for each single-case study. Examples of open codes that emerged during data analysis are: (a) learning STEM, (b) doing STEM, (c) participant

behavior, (d) social or friends, (e) relevance, (f) SEMAA is fun, (g) everything, and (h) nothing.

Cross-case synthesis. The cross-case synthesis conducted to analyze the data across the seven single-case studies followed Yin's (2012) two-step process: (a) organize the data from individual case studies into a word table, and (b) analyze the data across cases to search for commonalities and differences. First, the data from the seven single-case studies were put into a word table. Next, evaluation coding was used to reveal convergences and non-convergences of findings across the seven single-case studies. Miles, Huberman, and Saldaña (2014) explained that "evaluation coding is appropriate for policy, critical, action, organizational, and evaluation studies particularly across multiple cases and extended periods of time" (p. 76). Evaluation coding was conducted by reading the findings of each single-case study multiple times and applying labels. Two levels of codes were applied that would eventually be used to create overall emergent themes for the multiple-case study. The first level of evaluation codes included three descriptors: (a) positive responses (+), (b) negative responses (-), and (c) neutral responses (+/-). After applying the first level of evaluation codes, the findings were organized into groups based on the descriptors. The data were then read multiple times and labeled with subcodes (second level codes) that were used to create categories of findings and identify convergence and non-convergence of findings across the seven cases.

Direct interpretation technique and naturalistic generalizations. The open coding process used during the single-case study qualitative data analysis and the evaluation coding processes used during the cross-case synthesis involved multiple

readings and labeling of the data. These processes largely relied on a direct interpretation technique. According to Creswell (2007), direct interpretation technique is “a process of pulling the data apart and putting them back together in more meaningful ways” (p. 163). During data analysis, the researcher looked for patterns of ideas, words, and phrases in the responses to the open-ended questions. However, single incidences of key ideas, words, or phrases were not overlooked and included in the data analysis processes. Naturalistic generalization, a process of consolidating data into themes was used following the open coding and evaluation coding processes. Naturalistic generalizations were used to compare and contrast the seven cases to each other and to theory and research in the field of OST STEM programs to generate the findings and conclusions of this study.

Quantitative data analysis. Descriptive statistics were used to analyze the quantitative data collected by the Attitudes Towards Science Measures and the Science Motivation Questionnaire II. Data collected from each single-case study were analyzed individually. Following analysis for each site individually, the data were synthesized across the seven SEMAA sites. The first step of the quantitative analysis was to transfer all quantitative data to separate spreadsheets for each question. The spreadsheets were created using Microsoft Excel version 15.19.1. Descriptive statistics, including mean, median, and mode were calculated for each subscale of the quantitative instruments using Excel’s statistical functions.

Descriptive statistics included calculating the mean, median, and mode of each subscale on the Attitudes Towards Science Measures and the Science Motivation Questionnaire II. The range of scores on each subscale of the Attitudes Towards Science

was 1.00 – 5.00. Positive attitudes towards science were indicated by median scores greater than 3.00 on each subscale of the Attitudes Towards Science Measures (Barmby, Kind, & Jones, 2008). The range of scores on each subscale of the Science Motivation Questionnaire II was 0.00 – 20.00. Positive alignment to motivation factors were indicated by median scores equal to or greater than 15.00 on each subscale of the Science Motivation Questionnaire II Glynn, Brickman, Armstrong, and Taasoobshirazi (2011).

Reporting the Findings

Absent from this dissertation are the findings of the single-case studies that were part of this research study. Due to overwhelming convergence of findings across cases and the voluminous data that were produced to create seven single-case studies, it was determined that presenting the single-case studies was not necessary. Therefore, the findings presented in chapter four represent the cross-case synthesis of this multiple case study. Excerpts of the word tables that were used in the cross-case synthesis are located in Appendices C and D.

Trustworthiness

Trustworthiness is a measure of the rigor of a qualitative study. The trustworthiness of this study was achieved through taking steps to ensure credibility, dependability, confirmability, and transferability. The following section describes how this research study addressed each of the four components of trustworthiness.

Credibility. Credibility refers to the internal validity of a qualitative study and assesses the accuracy of the interpretations and findings. Bloomberg and Volpe (2008) described credibility as “whether the participants’ perceptions match up with the researcher’s portrayal of them” (p. 77). Acknowledging my bias as a research instrument

and on-going self-reflection to monitor my subjective perspectives served to promote credibility of the study. Peer review and multiple methods of data collection were also used to ensure trustworthiness of the study.

Dependability. Dependability refers to the reliability of a qualitative study. Bloomberg and Volpe (2008) explained dependability as “whether one can track the processes and procedures used to collect and interpret data” (p. 78). Maintaining detailed, organized records of data collection and a detailed description of data analysis and coding processes contributed to the dependability of the study. Peer review was used to ensure data analysis and coding processes were logical and thorough.

Confirmability. Confirmability refers to the objectivity of a qualitative study. According to Miles, Huberman, and Saldaña (2014), confirmability is the “relative neutrality and reasonable freedom from unacknowledged researcher biases – at a minimum, explicitness about the inevitable biases that exist” (p. 311). Confirmability was established by explicitly acknowledging and remaining cognizant my role as a research instrument, relationship to the study, and potential biases. Additionally, peer review was used to minimize the influence of my potential bias in the interpretation of the data.

Transferability. Transferability refers to the external validity of a qualitative study. According to Miles, Huberman, and Saldaña (2014), transferability refers to the extent that the conclusions of a study may be applied to other contexts. Transferability to other settings was promoted in this study by utilizing a large sample size and triangulating data that were obtained from multiple sources. Additionally, transferability was increased by conducting a cross-case synthesis of seven single-case studies.

Ethical Considerations

According to Bloomberg and Volpe (2008), social/behavioral researchers have responsibility “to ensure that all human subjects retain autonomy and the ability to judge for themselves what risks are worth taking for the purpose of furthering scientific knowledge” (p. 76). In alignment with this guidance, ethical considerations were made to protect participants throughout and following the research study. Approval to conduct this study was obtained from the OSU Institutional Review Board prior to the start of the investigation to ensure alignment of the investigation to all regulations regarding research involving human subjects. Additionally, the researcher completed Responsible Conduct of Research and Human Subjects Research Training for Social/Behavioral Research Investigators training courses from the Collaborative Institutional Training Initiative prior to beginning this research study. All study participants were provided with an informed consent sheet, were given the opportunity to withdraw from the study at anytime without consequences, and were given access to notes and summaries at anytime per their request.

Confidentiality. Throughout the study, participant privacy was held in the highest regard. Participants’ and their parents’ confidentiality was protected during this study, because the questionnaires were completed anonymously. Data were aggregated and presented as generalizations. Locations of the SEMAA sites were presented at the state level.

Informed consent. A waiver of written documentation of informed consent was obtained from the Oklahoma State University because “the research presented no more than minimal risk and involved procedures that do not require written consent when

performed outside the research setting” (Oklahoma State University, 2016, n.p.). An informed consent sheet was prepared and distributed to participants and their parents with the questionnaires. Questionnaire completion was voluntary and individuals were able to withdraw from the research study at any time without consequences. A copy of the IRB approval is located in Appendix E.

Peer review. According to Bloomberg and Volpe (2008), qualitative research focuses on “how well the researcher has provided evidence that her or his descriptions and analysis represent the reality of the situations and persons studied” (p. 77). Peer review was used to ensure the interpretation of the open-ended responses accurately reflected participants’ and their parents’ meaning. Two program evaluators with prior experience conducting evaluations of the SEMAA provided peer reviews of the findings and interpretations.

Reciprocity. Reciprocity is addressed in qualitative methodology by acknowledging and ameliorating power imbalances between the researcher and the subjects. According to Creswell (2007), qualitative researchers are “sensitive to power imbalances during all facets of the research process” (p. 24). Individual differences rather than traditional categories of gender and race should be respected (Creswell, 2007). Throughout the study a conscious effort was made to minimize power relationships between the study participants and the researchers. The use of open-ended questions prioritized participants’ voices. Additionally, peer review was utilized to ensure the researcher interpreted participants’ meaning accurately.

Reflexivity. A qualitative researchers’ background and cultural, social, political, and philosophical stances influence their interpretations and writing. Creswell (2007)

states “all researchers shape the writing that emerges, and qualitative researchers need to accept this interpretation and be open about it in their writings” (p. 179). Reflexivity allows the researcher to position herself within the context of the study and explicitly reveal their background, values, and stances through an analytical, self-awareness process. “Locating oneself assertively and deliberately within a text reflects ethical, rhetorical, and theoretical choices on the part of the researcher” (Chiseri-Strater, 1996, p. 127). Openly revealing preconceptions brought to the research study provides a transparency to readers, affording them an opportunity to critically review interpretations considering the author’s background, relationship to the context, and cultural, social, political, and philosophical stances.

Creswell (2007) recommends case study researchers be reflexive about their position in the study throughout the research project to provide the audience with multiple levels of understanding and to critically review interpretations. In accordance with Creswell’s (2007) recommendation, reflexivity was included throughout the design, implementation, interpretation, and writing phases of this case study. As a reflexive researcher, I hope to provide an openness about my relationship to the context of the study and how my background and views influenced the interpretation of the findings. In this section reflexivity and the complications and biases that may result from my background and cultural, social, and philosophical stances are addressed.

Researcher as an instrument. I am a middle-aged, Caucasian, female scholar. My research tends to be grounded in feminism and social justice. I am passionate about providing high-quality education for all children and have particular interest in

encouraging children from diverse backgrounds, genders, ethnicities, races and social economic status to pursue careers in STEM fields.

My past experience as a science teacher and a NASA aerospace education specialist make me uniquely qualified to assess the SEMAA participants' and their parents' perceptions of the SEMAA. My experiences teaching STEM in both formal and informal settings have given me insight into to functions and operations of multiple contexts for STEM learning. As a secondary science teacher for seven years, I gained first-hand experience with the challenges of engaging adolescents in science and became interested in investigating strategies to motivate children to pursue STEM learning. I observed how using NASA educational resources in my classroom sparked student interest by adding a relevant context to science content.

This involvement with NASA education in my classroom led me to a career working for NASA. I served as an aerospace education specialist contracted through Oklahoma State University (OSU) to provide support services to NASA education projects at NASA Glenn Research Center, in Cleveland, OH from 2004-2011. Through these endeavors, I worked with educators from across the country and assisted them as they translated NASA missions and research into learning opportunities for students. I have worked directly with administrators and teachers from twenty-seven schools located in six states to design and implement STEM education reform initiatives. Additionally, I conducted professional development and student programs for NASA education at schools and professional conferences in twenty states and the District of Columbia.

From 2011 - 2015, I served as a supervisor for six cooperative agreements OSU held to implement NASA education projects including NASA Teaching From Space,

NASA Explorer Schools, NASA Digital Learning Network, NASA Interdisciplinary National Science Project Incorporating Research and Education Experience (INSPIRE), NASA Kennedy Space Center Educator Resource Center, and NASA Johnson Space Center Strategic Education Alliance. I am currently working at NASA Glenn Research Center, contracted by Paragon TEC, Inc. to serve as the technical lead for research and evaluation on several NASA education programs including the NASA Out-of-School Time Learning Network, the 21st Century Community Learning Centers partnership between NASA and the U.S. Department of Education, and the Minority University Research and Education Program (MUREP) Aerospace Academy.

Relationship to the context. During my time as a teacher and NASA aerospace education specialist, I worked with the SEMAA on a number of efforts. While teaching, I worked with the SEMAA personnel to provide a family science night attended by over seven hundred students, parents and community members at my school and took student groups on field trips to participate in the SEMAA aerospace education laboratory simulations at NASA Glenn Research Center. While working on the NASA Explorer Schools project, I worked with the SEMAA personnel to provide aerospace day camps at two schools in Ohio. Additionally, SEMAA personnel developed a partnership and sustainability handbook modeled after the SEMAA partnership and sustainability component and a family involvement handbook that I helped to implement at several NASA Explorer School sites. Through these activities, I gained a cursory knowledge of the SEMAA operations and a familiarity with SEMAA personnel.

Potential bias. My past experiences with NASA education and the SEMAA have been largely positive and I have seen first-hand the positive influence NASA education

has on students' interest and efficacy in STEM. I am concern my positive attitude toward my past experiences with NASA education may influence my interpretation of study participants' meanings. During the investigation, I will be conscious of my bias towards shining a positive light on the SEMAA based on previous experiences and will use peer reviews to minimize my potential bias. Additionally, using an objective scientific approach to conduct this qualitative research study including the use of rigorous data collection and analysis will help to minimize this bias.

Conclusion

This chapter presented the case study approach that was used to assess the participants' and their parents' perceptions of the SEMAA and the participants' attitudes towards science and science motivation factors. Data access, collection, and analysis procedures were explained. The sampling strategy and study participants were also described. Additionally, this chapter explained how trustworthiness of the study was established and my qualification and potential bias as a research instrument.

CHAPTER IV

FINDINGS

This chapter reports the findings of the multiple case study that was conducted to characterize the SEMAA using participants and their parents' perspectives and to characterize the participants' attitudes towards science and science motivation factors. The multiple case study included single-case studies of seven SEMAA sites located in California, Maryland, New Mexico, New York, Ohio, Texas, and Virginia. The research questions that guided this study were: (a) what are the parents' perceptions of the SEMAA; (b) what are the participants' perceptions of the SEMAA; and (c) what are the SEMAA participants' attitudes towards science and science motivation factors?

Data to inform this study's research questions were collected using a parent questionnaire and a participant questionnaire. Yin's (2012) two-step process for analyzing data collected during multiple case studies as described in chapter three was used. First, data were analyzed within each single-case study independently. Next, a cross-case synthesis was conducted to reveal convergence and non-convergence of findings across the seven single-case studies. The findings of the cross-case synthesis indicated an overwhelming convergence of findings across all seven single-case studies. Due to the convergence of findings and voluminous narrative that was created to report

the findings of the seven single-case studies, this chapter was limited to the presentation of the findings of the cross-case synthesis.

This chapter begins with a description of the demographic and background information of the participants and their parents. Next, the findings for each research question including the categories and themes that emerged during data analysis are presented. Convergence and non-convergence of findings from the cross-case synthesis of the seven single-case studies are noted throughout the chapter.

Study Participants

Questionnaires were distributed to the summer 2015 SEMAA participants and their parents to collect their perceptions of the program including the summer 2015 SEMAA and any prior SEMAA that they attended. Across all seven single-case studies, the parent questionnaire was distributed to 737 parents. Responses were received from 174 parents. However, only 157 parent surveys were complete making the overall response rate for parent questionnaires 21.3 percent. The seventeen incomplete parent surveys were discarded. The demographic and background information of the SEMAA participants and their parents who responded to the questionnaires are described in detail below. Across all seven single-case studies, the participant questionnaire was distributed to a total of 728 participants who will be in grades six through twelve during the 2015-2016 school year. In total, responses were received from 262 participants. However, only 244 of the participant surveys were complete making the overall response rate for participant questionnaires 33.5 percent. The eighteen incomplete participant surveys were discarded.

Parents’ demographic and background information. Most parent questionnaires (seventy-seven percent) were completed by the SEMAA participants’ mothers and fourteen percent of the questionnaires were completed by the SEMAA participants’ fathers. The remaining questionnaires were completed by the SEMAA participants’ grandparent (eight percent) or another adult relative (one percent). Of the parents who responded to the questionnaire, thirty-one percent stated they had more than one child participating in the SEMAA. Thirty-one percent of the parents who responded to the questionnaire reported that they worked in a STEM profession. Ninety percent of the respondents reported that they had access to the Internet in their household and eighty-four percent of the respondents reported that their child accessed the Internet three or more times per week from their home. Fifty percent of the respondents reported that their annual household income was less than fifty thousand dollars per year.

Parents’ locations. Figure 3 depicts the national distribution of the parent questionnaire respondents. Locations represent the state where their child participated in the SEMAA.



Figure 3. National distribution of parent questionnaire respondents

Participants’ demographic and background information. Questionnaire responses were received from 244 SEMAA participants. Thirty-one percent of the participants reported they had participated in either an afterschool or Saturday SEMAA in addition to participating in the summer 2015 SEMAA. Sixty-three percent of the participants reported this was their first year participating in the SEMAA. Additionally, eighty-seven percent of the respondents reported they would be in middle school (grade six through eight) and thirteen percent of the respondents reported they would be in high school during the 2015-2016 school year. Table 4 lists the demographics of the study participants and the demographics of the overall SEMAA population.

Table 4. SEMAA participants’ demographics

<u>Demographics</u>	<u>Overall SEMAA Population</u>		<u>SEMAA Study Participants</u>	
	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
<i>Gender</i>				
Male	328	45.02	121	49.59
Female	400	54.98	123	50.41
<i>Ethnicity and race</i>				
Hispanic	54	7.40	36	14.75
American Indian	2	0.30	6	2.46
Asian	80	11.03	16	6.56
Black	463	63.60	75	30.74
White	45	6.19	53	21.72
Multiple	23	3.17	6	2.46
No Response	47	6.50	90	36.89

Participants’ locations. Figure 4 depicts the national distribution of the SEMAA participants who responded to the questionnaire. The locations represent the state where the SEMAA participants participated in the SEMAA.



Figure 4. National distribution of SEMAA participant questionnaire respondents

Research Question One: What are the Parents' Perceptions of the SEMAA?

Parents' perceptions of the SEMAA were collected in two categories: (a) parents' reasons for enrolling their child in the SEMAA and (b) parents' characterization of the SEMAA. The following section presents the findings related to these two categories.

Parents' reasons for enrolling their child in the SEMAA. Parents' reasons for enrolling their child in the SEMAA were collected using a choice list and triangulated with parents' responses to the open-ended question "What did you hope that your child would gain by being involved with the SEMAA?" Analysis of parents' responses revealed three primary reasons why the parents chose to enroll their child in the SEMAA: (a) positive past experiences with the SEMAA, (b) to support their child's confidence in and enjoyment of science and math, and (c) to provide STEM learning experiences beyond what can be provided at their school or home.

More than half of the parents explained that they had enrolled their child in the SEMAA based on their child's positive past experiences in the SEMAA. For example, one parent wrote, "The SEMAA is a great program, my daughter participated last year

and she really loves the program.” Several parents also referenced the quality of the SEMAA or the SEMAA’s affiliation with NASA as a reason for enrolling their child in the program (e.g., “It is a great program, educational, and my child enjoyed it,” “SEMAA is a good opportunity for the child to be part of a NASA program”). Additionally, when asked if they would encourage their child to enroll in the SEMAA again, all parents from all seven single-case studies replied “yes.” These findings suggest that many parents’ enrolled their child in the SEMAA based on their prior knowledge or experience with the SEMAA. These findings may also indicate that most parents would encourage their child to continue participating in future SEMAA.

Two-thirds of the parents stated that they enrolled their child in the SEMAA to support their child’s confidence in and enjoyment of science and math. Many parents explained that the SEMAA provided encouragement for their child’s STEM interests and ambitions. For example, one parent wrote, “I believe the SEMAA provided females with much needed encouragement in STEM.” Another parent stated, “The SEMAA encouraged my child to explore her interest in an engineering career and achieve her dream.” Additionally, more than half of the parents stated that they enrolled their child in the SEMAA because it was a fun learning environment (e.g., “The SEMAA is a fun program that lets my child explore her interests”). These findings suggest that many parents perceived the SEMAA provided a fun learning environment and supported their child’s confidence and enjoyment of science and math.

Many parents explained that they enrolled their child in the SEMAA because they hoped the SEMAA would provide their child with STEM learning experiences beyond what is provided at school and in the home. Typical comments included, “For my child to

explore new topics beyond what is covered in school,” “The SEMAA provides hands-on activities that my child does not have in science class at school,” and “Provides opportunities to learn during the summer that are not available in the home.” Some parents also explained that they hoped that the summer SEMAA program would prepare their child for the up-coming school year and help their child retain what they learned during the previous school-year over the summer. Some parents also stated that they hoped that the SEMAA would expose their child to STEM careers and higher education options. Additionally, some parents also expressed a hope that the SEMAA activities would provide a relevant context for science and math learning and help their child to draw connections between the content they were learning and their lives. These findings suggest that many parents enrolled their child in the SEMAA to provide STEM learning experiences beyond what is provided at school or in the home.

Parents’ characterization of the SEMAA. Parents’ perceptions of the SEMAA’s characteristics were gathered using a series of thirteen open-ended questions that were included on the parent questionnaire. Each question was analyzed individually within each of the seven single-case studies using Creswell’s (2007) open coding process described in chapter two. Next, a cross-case synthesis was conducted using Yin’s (2012) process and Miles, Huberman, and Saldaña’s (2014) evaluation coding to develop cross-case themes related to the parents’ perceptions of the SEMAA’s characteristics. Themes were aligned to six categories and are presented in the following section in this order: (a) operations and infrastructure, (b) instructors, (c) learning environments, (d) curriculum and instruction, (e) parental engagement, and (f) attitudes towards science.

Operations and infrastructure. Analysis of parents' responses related to the characterization of the SEMAA's operations and infrastructure revealed four themes: (a) the SEMAA should be longer and expanded to include more participants, (b) it is difficult to enroll in the SEMAA, (c) the SEMAA is provided at no cost to participants, and (d) the SEMAA should facilitate connections with other learning opportunities. Several parents from each of the seven single-case studies stated that the length of the SEMAA (i.e., number of days) and the length of the SEMAA classes (i.e., number of hours per day) were too short. Some parents recommended that the summer program should be expanded from one-week to multiple weeks. Other parents suggested that the SEMAA should be a year-round program. However, a few parents stated that the SEMAA was too long or it was difficult to fit into their schedules. For example, one parent wrote, "The Saturday sessions take place over a long period of time and takes up a lot of our time." Another parent wrote, "Maybe shorter sessions or a break so that every Saturday for two months isn't taken up." A few parents also commented that the SEMAA began too early in the morning and recommended having evening sessions.

Some parents also expressed concerns about the location of the program, the age of participants, and access for special needs children. Several parents stated that the location of the SEMAA was too far from their homes. Some of these parents recommended that the SEMAA be offered at more locations in different neighborhoods. A few parents criticized the SEMAA for not offering programs for high school students (e.g., "My son was disappointed that the SEMAA was not offered for his age in the summer"). Additionally, some parents expressed concerns that there were not enough spaces in the SEMAA for all the children who would like to participate. A few parents

from one single-case study commented that they would like the SEMAA to provide facilities to accommodate special needs children. These findings indicated that most parents would like the SEMAA program to be longer, more accessible, and inclusive of more children.

Several parents expressed challenges with the enrollment process. Specifically, some parents stated that they had difficulty enrolling their child because the enrollment periods were irregular (e.g., did not occur at the same time each year, used a different process from year to year). For example, one parent wrote, “Irregular enrollment is difficult, continuity in enrollment would help the program.” Another parent wrote, “The demand for the program is high but supply is short, it is hard to get kids enrolled before the session is full because we do not know when the enrollment is going to happen.” Parents from three of the single-case studies stated that they would like the SEMAA to use an electronic registration form to make the enrollment process easier. These findings indicate that some parents would like the SEMAA to improve the enrollment process.

Several parents stated that they appreciated that the SEMAA was provided at no cost to the participants. For example, one parent wrote, “It’s a free program that inspires my kids to like science and technology, what’s not to like?” Another parent stated, “The SEMAA is a safe learning environment for kids during non-school hours and it’s free!” This suggests that offering the SEMAA at no cost may be important for some parents.

A few parents stated they would like the SEMAA to build connections to other learning opportunities. Specifically, some parents stated that they would like the SEMAA to provide information about other science resources available to their children. Additionally, some parents stated they would like the SEMAA to make connections

between what the participants are learning in the SEMAA and what they are learning in school. These findings suggest that some parents would like the SEMAA to make explicit connections between what is learned at the SEMAA, what is learned in school, and other STEM learning opportunities.

Instructors. Analysis of parents' responses related to the characterization of the SEMAA instructors revealed two themes: (a) some instructors did not utilize effective classroom management and instructional strategies and (b) some instructors were STEM professionals. A few parents from two of the single-case studies commented that the SEMAA classes were disorganized and repetitive. For example, one parent wrote, "The disorganization of the class led to too much down time in class." Another parent stated, "there has been some repetition and some busy work." These findings suggest that the SEMAA instructors may benefit from training regarding effective instructional strategies for OST STEM programs.

A few parents stated that the SEMAA provided their children with opportunities to conduct practical hands-on investigations with STEM professions. For example, one parent wrote, "My child gained an awareness of science and technology in practical and hands-on experiences with intellectuals from various STEM fields." Another parent stated, "She gained a greater knowledge of science and math by learning from experts and professors in STEM." These findings suggest that some parents perceived that the SEMAA provided opportunities for their children to learn directly from STEM professionals.

Learning environment. Analysis of parents' responses related to the characterization of the SEMAA's learning environment revealed three themes: (a) the

SEMAA provided a safe learning environment, (b) the SEMAA provided a fun learning environment, and (c) the SEMAA provided opportunities for participants to build social networks and develop team work skills. Several parents stated that the SEMAA provided a safe, structured learning environment for their children. For example, one parent wrote, "He got to learn with other kids in a safe environment." Another parent stated "The SEMAA provided a safe, structured, and free environment for kids to work on heady topics during non-school hours." This finding suggest that some parents perceived that the SEMAA provided a safe learning environment.

More than half the parents from all seven single-case studies stated that the SEMAA provided a fun learning environment for their children. Typical comments included, "The SEMAA is a fun program and for academic growth and interest" and "She acquires more knowledge in the subject matter and has fun as well." These finding indicate that some parents perceived that the SEMAA provided a fun learning environment.

Some parents explained that the SEMAA had introduced their child to other children who shared an interest in STEM. Specifically, several parents stated that their child had made new friends at the SEMAA who also enjoyed learning science and math. For example, one parent wrote, "My child met other students from other schools who are also interested in science and it underscored the importance of learning...It shows that other kids are working on school type subjects in their free time." Another parent wrote, "She was able to get involved with other children that have the same interest." Some parents stated that the SEMAA provided their child with opportunities to learn teamwork skills. For example, one parent stated, "My child learned how important it is to work with

others to solve problems.” Additionally, a few parents from two of the single-case studies stated that their child did not like the SEMAA because he/she did not have friends in the SEMAA. These findings suggest that some parents perceived that the SEMAA provided opportunities for their child to meet like-minded children who shared an interest in learning. These findings also indicated that some parents perceived that their child learned teamwork skills at the SEMAA.

Curriculum and instruction. Analysis of parents’ responses related to the characterization of the SEMAA’s curriculum and instruction revealed two themes: (a) the SEMAA provided participants with opportunities to learn science and math concepts, (b) the SEMAA provided participants with STEM enrichment beyond in-school learning, (c) the SEMAA exposed participants to STEM higher education options and careers, (d) the SEMAA provided participants with opportunities to engage with STEM content through hands-on activities, and (e) the SEMAA may benefit by including take-home family activities.

Many parents explained that their child learned new STEM concepts at the SEMAA (e.g., "My child has the opportunity to explore new concepts involving science and technology"). Several of these parents also listed specific STEM content that they perceived their child learned at the SEMAA. For example, parents listed Earth and space science concepts (e.g., “how stars are born”), life science (e.g., “parts of the brain from dissecting”), physical science (e.g., “how to make circuits”), technology (e.g., “building and programming robots”), engineering (e.g., “how to build a solar car”), and math (e.g., “how to solve math equations”). Many parents stated that their child liked learning about STEM concepts at the SEMAA (e.g., “She liked being exposed to different science and

math concepts”). A few parents explained that the SEMAA illustrated the relevance of science to their lives (e.g., "The SEMAA increased his awareness of how science is important in day-to-day life," "how science relates to real world uses, i.e. careers and functions”). These findings suggest that some parents perceived that the SEMAA provided opportunities for participants to learn science and math concepts.

Many parents explained that the SEMAA provided learning opportunities beyond what their child’s school could provide. For example, several parents felt the SEMAA activities allowed their child to explore learning in more depth than their regular classrooms (e.g., "Enrich them with SEMAA knowledge, provide them more experiment opportunities as the school and home may not have the materials," "She learned about science and technology more in depth than in school"). Other parents explained that their child was exposed to concepts before their children learned them in school and was given access to activities and equipment to which he/she otherwise would not have been exposed. Typical comments included, "The SEMAA adds value to his overall education due to the fact that he gets those extras such as the projects that are not covered in schools due to extreme testing," "I think she has learned new things that she probably didn't learn at school and she's excited about the program," and "Access to materials such as dissecting animals and tools." Several parents also stated that the SEMAA helped their child achieve higher grades in school. For example, "My child was better prepared to learn science and math in school and was reflected in his grades" and "The SEMAA helped her improve her understanding and achieve higher grades." These findings suggest that the parents perceived that the SEMAA provided STEM enrichment beyond what was provided by their child’s school or what they could provide in their home.

Several parents stated the SEMAA had exposed their children to STEM careers and STEM professions. For example, several parents described opportunities their child had to meet STEM professionals and learn directly from them. Some parents also explained that their child was given opportunities to engage in activities that STEM professionals do (e.g., doing science experiments, completing engineering design challenges, flying an airplane). Additionally, some parents also perceived that the SEMAA provided experiences that would support their child's future higher education pursuits. For example, a few parents stated that holding the SEMAA on a college campus exposed their child to a higher education environment. A few parents also stated that the SEMAA encouraged their child to consider a STEM career (e.g., "I enjoy seeing him enjoy science and think about careers that he may want to have," "SEMAA is like an express train to drive my child to the science field," "my children will like to become doctors, SEMAA allows my kids to explore such subjects"). These findings indicate that some parents perceived that the SEMAA provided participants with exposure to STEM careers and STEM professionals. Additionally, these findings suggest that some parents perceived that the SEMAA supported their child's STEM career ambitions.

Several parents explained that the SEMAA had provided their child with opportunities to engage with STEM content through hands-on activities. Specifically, parents described how their child had completed science experiments, engineering design activities, and robotics activities. Typical comments included, "Exposure to new and advanced scientific materials and hands-on experiences," "He gets to experiment and learn different technology," and "They are learning hands-on and applying learned skills at the same time." Some parents also stated their child learned problem-solving skills and

had opportunities to use their creativity to develop solutions to problems and create new inventions. Typical comments included, “He used creativity and learned the way things work,” and “She learned how to problem solve and how to use your mind.” However, a few parents felt the hands-on activities lacked rigor (e.g., “more aerospace, less toys”). These findings suggest that some parents perceived that the SEMAA provided participants with opportunities to engage with STEM content through hands-on activities.

Several parents stated that they would have liked the SEMAA to provide take-home STEM activities or projects that the parents could work on with their child at home. Some of these parents elaborated by explaining this would help them understand what their child was learning at the SEMAA and provide parents with ways to support their child’s learning. Typical comments included, “The SEMAA should have take-home activities for the parents to reiterate what they are learning,” “I would like to know what the students were learning at the time so I could work with him at home,” “I encourage a mini science fair so that the kids can do some home science projects,” and “For the kids to be able to keep at least one project to work on at home.” These findings suggest that some parents would like the SEMAA to include take-home family activities that would equip parents to support their child’s learning.

Parental engagement. Analysis of parents’ responses related to the characterization of the SEMAA’s parental engagement revealed three themes: (a) the SEMAA provided resources and support to parents through the Family Café, (b) the SEMAA valued parental involvement, and (c) some parents would like to be more involved with the SEMAA. Several parents perceived that the Family Café provided support for parental involvement in their child’s STEM learning. Specifically, many

parents stated that the Family Café was an effective way to support parental involvement because it provided training and support resources to parents and opportunities for parents to develop social networks with other parents of children interested in STEM. Typical comments included, “the Family Café goes out of the way to include us and explain to us and guide us,” and “I enjoyed the Family Café and learned some interesting things and met new people.” Several of these parents elaborated stating that they enjoyed the Family Café and valued the information that they received. For example, one parent wrote “So much wonderful information is given in the Family Café.” A few parents also stated that they would like the SEMAA to offer more Family Cafés. For example, one parent wrote, “More frequent Family Café, because the Family Café is often interesting and provides opportunities for parents to learn and grow also.” These findings suggest that the parents perceived that the Family Café provided resources that they could use to support their child’s interests and ambitions in STEM.

Several parents explained that they felt valued by the SEMAA staff and were included in SEMAA activities. Some parents shared that they appreciated the responsiveness of the SEMAA staff and felt the staff provided effective communication with parents. Typical comments included, “Staff was helpful, friendly, responded quickly and answered questions,” and “I like the hands-on way the staff is with the families, easy to talk to and they take time out to get to know the parents as well as the students.” However, a few parents stated they would like more communication from the SEMAA staff about: a) the program, b) when the program will be available, and c) information about other science resources in their area. For example, one parent wrote, “More information on the curriculum should be available online prior to the start of the

program." Another parent stated, "Provide more communication to parents about when programs are available." These findings indicate that some parents felt the SEMAA valued their involvement in the SEMAA and the SEMAA provided resources for parents to support their child's STEM learning. However, a few parents perceived that the SEMAA staff could improve communication about the program with parents.

Some parents stated they would have liked to be more involved with the SEMAA and offered suggestions for how they would like to be involved in the future. Parents' suggestions for future parental involvement included: a) participating in activities with their child, b) providing administrative assistance, c) instructing a lesson, d) assisting with lessons, and e) chaperoning a fieldtrip. One parent suggested that the SEMAA could provide a sign-up sheet to recruit parent volunteers. These findings suggest that some parents may want to provide more support for the SEMAA.

Attitudes towards science. Analysis of parents' responses related to the characterization of the SEMAA's role in developing participants' attitudes towards science revealed one theme: the SEMAA provides support for participants' positive attitudes towards science and math and support for participants' self-confidence in science and math. Several parents explained that the SEMAA supported their child's positive attitudes towards science and math. Typical comments included, "The SEMAA made him excited to learn new science things, he loves the program" and "The SEMAA gave her the outlook that science is fun and not something that should be viewed as confusing and difficult." Additionally, some parents perceived that the SEMAA had supported their child's confidence in science and math. For example, one parent wrote, "The SEMAA gave him confidence in learning science and math, I hear the confidence

he has when he is explaining what he learned.” These findings indicate that some parents perceived that the SEMAA supported their child’s positive attitudes towards science and math. Additionally, these findings suggest that some parents perceived that the SEMAA supported their child’s confidence in science and math.

Research question one summary. In summary, analysis of the parents’ perceptions of the SEMAA indicated that in general the parents positively regarded the SEMAA. Parents indicated that they enrolled their child in the SEMAA based on positive past experiences, to support their child’s confidence in and enjoyment of science and math, and to provide STEM learning experiences beyond what is available at their child’s school or in their home. Parents’ characterization of the SEMAA’s operations and infrastructure, instructors, learning environments, curriculum and instruction, parental involvement, and support for their child’s attitudes towards science revealed several themes. These themes will be discussed in relationship to relevant prior research literature in the field of OST STEM programs in chapter five.

Research Question Two: What are the Participants’ Perceptions of the SEMAA?

Participants’ perceptions of the SEMAA were collected in three categories: (a) participants’ reasons for enrolling in the SEMAA, (b) participants’ characterization of the SEMAA, and (c) the SEMAA’s role in participants’ STEM college degree and career ambitions. The following section presents the themes aligned to each of these three categories and provides a summary of the supporting data that were used to inform each theme.

Participants’ reasons for enrolling in the SEMAA. Participants’ reasons for participating in the SEMAA were collected using a choice list and triangulated with participants’ responses to the open-ended question “If a friend asked you about the SEMAA and whether or

not they should participate, what would you tell them?” Analysis of participants’ responses revealed a variety of affective (e.g., positive feelings, enjoyment, fun), cognitive (e.g., educational, learning), and social (e.g., making new friends) factors that led participants to enroll in the SEMAA. Further analysis of participants’ responses revealed four themes related to why participants enrolled in the SEMAA: (a) positive feelings about previous participation in the SEMAA; (b) the SEMAA is a fun, educational program; (c) participants liked doing or learning about science and math; and (d) to make new friends. First, many participants choose to enroll in the SEMAA based on their prior experience with the program. For example, more than half of the participants who responded to the questionnaire explained that they enrolled because they had previously participated in the SEMAA. Several participants also shared that they enjoyed their previous experiences in the SEMAA and were excited to continue with the program. Second, many participants stated that they chose to enroll in the SEMAA because they perceived that the SEMAA was a fun, educational activity. Specifically, fifty-nine percent of the participants stated they were participating in the SEMAA because the SEMAA was a fun way to learn STEM (e.g., “The SEMAA is so much fun and it helps with your science and math skills”). Participants also included that they enrolled because they did “cool experiments” or “learned cool things” in the SEMAA. Third, over half of the participants who responded to the questionnaire reported that they enrolled in the SEMAA because they enjoyed science and math, that they wanted to learn more science and math and do more science and math activities. Fourth, many respondents explained that they enrolled in the SEMAA to make new friends. For example, one respondent wrote, “to meet a lot of new friends and have fun.” In summary, these results suggested that participants enrolled in

the SEMAA for a variety of affective, cognitive, and social factors. These factors included positive past experiences with the program, the perception that the SEMAA is a fun, educational program, participants' desire to learn about or do science and math, and participants want to meet new friends.

Participants' characterization of the SEMAA. Participants' perceptions of the SEMAA's characteristics were gathered using a series of seven open-ended questions that were included on the participant questionnaire. Each question was analyzed individually within each of the seven single-case studies using Creswell's (2007) open coding process described in chapter two. Next, a cross-case synthesis was conducted using Yin's (2012) process and Miles, Huberman, and Saldaña's (2014) evaluation coding to develop cross-case categories and themes related to the participants' perceptions of the SEMAA's characteristics. Themes were aligned to four categories and are presented in the following section in this order: (a) operations and infrastructure, (b) instructors, (c) learning environments, and (d) curriculum and instruction.

Operations and infrastructure. Analysis of participant's responses related to the characterization of the SEMAA's operations and infrastructure revealed two themes: (a) the SEMAA should be longer and expanded to include more participants, and (b) the SEMAA would benefit from having more or newer materials and equipment. Overall, many participants perceived that the SEMAA should be a longer experience and offered in more locations. For example, some participants suggested that the SEMAA should be offered year-round or be extended for more weeks. One participant noted that the SEMAA should be expanded to include more participants (e.g., "Accommodate more people for classes or more of the same classes to invite more students to participate").

Several participants stated that the length of the sessions each day were too short and they did not have enough time to complete their activities. Some participants also explained that the SEMAA was too far from their homes and began too early in the morning. One of these participants' elaborated that they rode three different buses to get to the SEMAA and it was difficult to wake-up early enough to be at the SEMAA on time.

These finding indicated that some of the participants would have liked to continue participating in the SEMAA for longer periods of time each day and over a longer timeframe. These findings also suggested that some participants' faced challenges traveling between their homes and the SEMAA location. This finding may indicate that the location of the SEMAA may be a barrier for some children to participate in the program. Additionally, these findings suggested that some of the participants would like to see the SEMAA be expanded so that other children could have an opportunity to participate in the program.

Several participants expressed a desire for the SEMAA to provide more hands-on activities or have more resources available to complete hands-on activities. Some participants commented that they did not have enough materials to complete their projects and a few participants stated that they voluntarily brought materials from home to complete their projects when the SEMAA did not have enough materials. For example, one participant stated, "I wish there were more Little Bits, so that we could invent different things." Another participant explained, "I think there should be more things to build with, when we ran out I brought things from home to build my car." Some participants also explained that the SEMAA's equipment was old, broken, or missing

pieces and needed to be updated with newer equipment. Several participants also stated that they would have liked to be able to take at least one project home.

These findings suggested that the SEMAA would benefit from having more or newer materials and equipment. Hands-on activities are a central component of the SEMAA and require adequate materials and equipment. These findings indicate that the SEMAA may not be able to provide adequate resources, up-to-date equipment, and sufficient materials for participants to complete activities.

Instructors. Analysis of the participants' responses related to the characterization of the SEMAA's instructors revealed two themes: (a) the SEMAA instructors developed positive social relationships with participants and (b) some of the SEMAA instructors did not utilize effective classroom management and instructional strategies. Many participants expressed that they positively regarded their instructors and provided evidence that their instructors made an effort to know them as individuals. Several participants wrote that their favorite part of the SEMAA was their instructor. For example, one participant wrote "My favorite part of the SEMAA was [instructor's name], she was fun, I wish I could have her again." Another participant wrote, "[instructor's name] helped me learn science, she made me confident I can succeed in my dreams to become a neurosurgeon." Some of the participants described strategies that the instructors used to encourage the participants. For example, some participants stated that they were recognized with a certificate or praised for their accomplishments. These findings suggest that some of the SEMAA instructors were personable and used effective strategies to develop positive social relationships with the participants. Additionally, these findings

may indicate that some of these participants appreciated that their instructors' took time to personally encourage their ambitions.

Several participants from two of the seven single-case studies expressed concerns about their instructors' classroom management and instructional strategies. For example, several participants criticized their instructor's inability to correct the negative behavior of some participants (e.g., "the teacher didn't stop the loud kids in the class and ruined the experience for the rest of the class," "students did not listen to the teacher"). Some participants stated that their class was "disorganized" or that there was "a lot of down time." One participant stated, "stop going over the same things and change up the experiments." Additionally, one participant stated that she was disappointed in the SEMAA, explaining "I was supposed to have fun, it was boring." Other participants comments included, "I didn't learn anything," "there was a lot of busy work and repetition," and "the teacher didn't explain things clearly." These findings suggested that some of the SEMAA instructors did not utilize effective classroom management or instructional strategies. This may indicate that some of the SEMAA instructors could benefit from professional development regarding effective practices for teaching in OST STEM programs.

Learning environments. Analysis of the participants' responses related to the characterization of the SEMAA's learning environments revealed two themes: (a) the SEMAA provided a fun learning environment, and (b) the SEMAA provided opportunities for participants to build social networks and develop team work skills. Nearly all participants across all seven single-case studies expressed that the SEMAA made learning about science and math fun. Typical statements were "We had hands-on

learning and did many fun science experiments,” “It is a fun and exciting way to learn and experiment,” “Doing very fun projects,” and “It combines fun with education.” This finding indicates that overall, the SEMAA participants enjoyed the SEMAA and in particular, they enjoyed the SEMAA activities.

Many of the participants stated that their favorite part of the SEMAA was meeting new friends who shared their interests and working on projects with their friends. Typical comments included, “The SEMAA is really fun and we make new friends and learn,” and “We can learn in groups with others that also want to learn.” Several participants also explained that they learned team work skills as they completed activities in small groups. For example, one participant wrote, “I learned to respect my teammates and collaborate.” Another participant wrote, “I learned teamwork and the many challenges faced of space flight, and as groups they can be overcome with strange solutions especially in space.” These findings suggest that some participants met and became friends with like-minded peers. Specifically, the participants reported that they enjoyed working in small groups with their friends who shared their interest in learning and doing STEM. These findings also suggest that some of the participants perceived that they learned team work skills by conducting small group activities during the SEMAA.

Curriculum and instruction. Analysis of the participants’ responses related to the characterization of the SEMAA’s curriculum and instruction revealed four themes: (a) the SEMAA provided participants with opportunities to learn science and math concepts, (b) the SEMAA provided participants opportunities to use science and engineering practices and skills, (c) the SEMAA lessons included instructional practices that engaged

participants in STEM learning, and (d) the SEMAA participants did not enjoy “school-like” activities.

Nearly all participants from all seven single-case studies reported that they learned new science and math concepts while participating in the SEMAA. Some of the specific science content that participants listed was: physical science (e.g., water filtration, rocketry, aerodynamics, sound, satellites and communication, electricity and circuits), Earth and space science (e.g., solar system, planets, microgravity, stars), and biology (e.g., effects of space on the human body, anatomy and physiology). Some of the math concepts that participants listed were math equations and how to do mental math. Typical responses also included stating science facts (e.g. “I learned that the biggest star we know of is 1 billion times the size of our sun”) or listing science concepts (e.g. “lift, drag, weight, and thrust of planes”). These findings suggest that the SEMAA provided participants with opportunities to learn science and math content. Additionally, these findings indicate that some SEMAA participants perceived they had learned new science and math concepts while participating in the SEMAA.

Nearly all participants from each of the seven single-case studies described using STEM practices to complete hands-on activities. For example, many participants stated they engaged in engineering and technology practices such as designing, building, programming, and testing Lego robots. Several participants stated that they designed, built, and tested solar cars, marble roller coasters, Makey Makey inventions, and Little Bits inventions. Additionally, some participants described using science practices to conduct experiments such as using inquiry to determine the most effective materials to use in a water filtration system. Several participants also described learning new science skills

such as dissecting and using a microscope. These findings suggest that the SEMAA provided opportunities for participants to engage in science and engineering practices and skills.

Participants described a variety of instructional practices utilized during the SEMAA lessons that engaged participants in STEM learning. The instructional practices included: (a) active learning, (b) making learning relevant to participants' lives, (c) challenging lessons, (d) novelty or surprise, and (e) choice. First, some SEMAA lessons used active learning strategies such as hands-on learning, inquiry-based learning, engineering design, and fieldtrips. Many participants described these activities as fun, exciting, cool, or interesting. Second, the SEMAA lessons were relevant to some of the participants' personal, academic, or career interests. Several participants also reported that the SEMAA made science and math meaningful by showing them how the content was relevant to their lives and could help them do better at school, prepare them for higher education, or aligned to their future careers. For example, one participant wrote, "I learned to build robots because I want to be an engineer." A few participants stated that the SEMAA taught them the value of science (e.g., "how science helps us," "why I have to take science and math in school"). Third, several participants stated that they liked learning at the SEMAA because the lessons were challenging (e.g., "building the car because it could get complicated on some steps" and "rocket balloons because it was challenging"). However, a few participants criticized that the SEMAA lessons were too challenging (e.g., "Some of the math lessons were too hard for me and I don't like doing things that are too difficult"). Fourth, many participants stated that they liked doing new things in the SEMAA (e.g., "dissecting because it is interesting and fun and I never done

it before,” “I learned the parts of the brain and I will remember since I dissected one and it was a once in a lifetime opportunity for me”). A few participants stated that they liked learning new information that was surprising to them. For example, one participant wrote “I learned that the sewage system has many more processes than someone usually thinks and it was very, very, smelly! I will remember this because it was shocking to me.” Fifth, A few participants stated that they liked that they had a choice of activities and a choice of how to do the activities. For example, one participant wrote, “I liked that I got to decide what to invent and experimenting to put different circuits together.” In summary, these findings suggest that the SEMAA lessons utilized several instructional strategies to engage participants in STEM learning.

Many participants explained that they did not enjoy the SEMAA activities that were “school-like.” For example, one participant wrote, “I did not like the SEMAA, it was too much like school.” Some participants listed specific activities that they did not like such as taking a pretest, reading and writing notes, discussions, and listening to lectures, because they felt “too much like school.” Several of these participants also stated that they would have liked to do more hands-on activities and less school-like activities. These findings suggest that the participants preferred the SEMAA to use more active learning strategies that were different from how they learned in school.

The SEMAA’s role in participants’ STEM college degree and career ambitions.

Participants were asked a series of yes/no choice questions and open-ended response questions to understand if and how the SEMAA influenced their college and career ambitions. Participants’ responses to each question were analyzed individually for

each of the seven single-case studies. Descriptive statistics were used to analyze participants' responses to yes/no choice questions. Participants' responses to open-ended response questions were analyzed using Creswell's (2007) open coding process described in chapter two. Next, a cross-case synthesis was conducted using Yin's (2012) process and Miles, Huberman, and Saldaña's (2014) evaluation coding to develop cross-case themes related to the SEMAA's role in the participants' STEM college degree and career ambitions. Data analysis revealed two themes related to SEMAA's role in the participants' STEM college degree and career ambitions: (a) the SEMAA influenced few participants' STEM college ambitions and (b) the SEMAA influenced few participants' STEM career ambitions. Although 189 SEMAA participants (76.83%) reported that they planned to go to college, only 103 participants (41.87%) reported that they planned to major in a STEM field (e.g., computer science, engineering, science, medicine, robotics, mathematics). Additionally, only sixty-three participants (25.61%) stated that the SEMAA had influenced their college ambitions. Some of the participants who stated they were interested in a STEM college degree described how the SEMAA influenced their college ambitions. For example, some participants explained that the SEMAA: (a) encouraged them to pursue a better education or job, (b) broadened their awareness of STEM careers, (c) broadened their career interest, (d) exposed them to a college environment, (e) sparked their interest in science, and (f) motivated them to learn more science. Several of the participants who reported being interested in a non-STEM college (e.g., law, business, fashion design) degree also stated that the SEMAA had influenced their college ambitions. For example, some participants who were interested in a non-STEM college degree explained that the SEMAA developed their interest in furthering

their education or developed their interest in attending the college or university that hosted the SEMAA. Many of the participants who stated that the SEMAA had not influenced their ideas about college explained that they had already established goals for their college education prior to participating in the SEMAA. Some participants also explained that the SEMAA had not influenced his/her college ambitions because: (a) the SEMAA was not aligned to their major (e.g., medicine) or (b) their family had influenced their decisions about college. These results indicate that the SEMAA influenced a few of the participants' STEM college degree ambitions. However, the SEMAA's influence on participants' STEM college degree interests was not widespread.

Across all seven single-case studies, only ninety of the participants (36.59 percent) indicated that they were interested in a STEM career and only fifty participants (20.33 percent) stated that the SEMAA had influenced their career interests. Some of the participants that stated they were interested in a STEM career also explained how the SEMAA influenced their career ambitions. For example, some participants explained that the SEMAA (a) increased their interest in science, engineering, or medicine (e.g., "well now that science is fun I might want to try a career choice with science") or (b) broadened their career interests (e.g., "SEMAA has broadened my horizons on pursuing science-based careers by showing me the numerous possibilities in the science, math, and aeronautics fields"). Some participants who stated they were interested in a non-STEM career (e.g., sports, law) also stated that the SEMAA had influenced their career ambitions. For example, some participants commented that the SEMAA had helped them identify a science or engineering career as their back-up plan to a career in sports or helped them decide not to have a career in STEM (e.g., "It made me not want to do a

robotics career”). Many of the participants who stated that the SEMAA did not influence their decision to pursue a STEM career explained that they already had decided on their careers prior to participating in the SEMAA (e.g., “I already had plans,” “because it is my life long dream”). Some participants stated that the SEMAA content was not aligned to their STEM career interests (e.g., “They do not talk about video game designing as much,” “I want to pursue medical school and the SEMAA is about space not medicine”). Additionally, one participant wrote that the SEMAA did not influence his career ambitions because he “liked learning about the astronauts, but I don’t really think I’ll be a good one.” These findings indicated that the SEMAA positively influenced some participants’ STEM career ambitions. However, the SEMAA’s influence on participants’ STEM career interests were not widespread.

Research question two summary. In summary, analysis of the participants’ perceptions of the SEMAA indicated that in general the participants positively regarded the SEMAA. Data analysis revealed a variety of affective, cognitive, or social factors typically led participants to enroll in the SEMAA. Analysis of participants’ characterization of the SEMAA’s operations and infrastructure, instructors, learning environments, and curriculum and instruction. Revealed a variety of themes. Additionally, analysis of participants’ perceptions of the SEMAA revealed that few participants perceived that the SEMAA had influenced their college degree or career ambitions. Themes associated with each of these categories will be interpreted in relationship to relevant research literature in the field of OST STEM programs in chapter five.

Research Question Three: What are the SEMAA Participants' Attitude Towards Science and Science Motivation Factors?

The SEMAA participants' attitudes towards science and science motivation factors were gathered to provide a better understanding of the participant population served by the SEMAA. The Attitudes Towards Science Measures developed by Kind, Jones, and Barmby (2007) was used to collect participant's attitudes towards sciences and the Science Motivation Questionnaire II developed by Glynn et al. (2011) was used to collect participants' science motivation factors. The data that were collected from these instruments were analyzed individually within each of the seven single-case studies. Next, the data were analyzed across the seven single-case studies. Descriptive statistics were used to analyze the data as described in chapter two. The following section provides an analysis of the participants' attitudes toward science and science motivation factors across all seven single-case studies.

Participants' attitudes towards science. Participants' attitudes towards science were assessed using Kind, Jones, and Barmby's (2007) Attitudes Towards Science Measures instrument as described in chapter three. The results indicated that in general SEMAA participants' attitudes towards science were positive across all categories as indicated by median scores greater than 3.00 on all measures and by the combined interest in science subscale median score of 3.91. However, the degree of participants' positive attitudes towards science varied across measures. (Table 5).

Table 5. Analysis of attitudes towards science scores (N = 244)

<u>Measure</u>	<u>Attitude Scores</u>					
	<u>Min</u>	<u>Max</u>	<u>M</u>	<u>Mdn</u>	<u>Mode</u>	<u>SD</u>
Learning science in school	1.17	5.00	4.03	4.17	4.00	.74
Self-concept in science	1.00	5.00	3.76	3.86	3.14	.77
Doing experiments in science	1.75	5.00	4.21	4.25	4.38	.60
Science outside of school	1.00	5.00	3.80	4.00	4.00	.90
Future participation in science	1.00	5.00	3.49	3.80	4.20	1.02
Importance of science	2.00	5.00	4.17	4.20	4.00	.59
Combined interest in science	1.18	5.00	3.79	3.91	3.88	.79

Note: The range of possible scores for each subscale was 1.00 – 5.00 (1.00 = most negative attitude; 5.00 = most positive attitude)

Participants responded most positively to the doing experiments in science subscale (*Mdn* = 4.25). This category assessed the degree to which the participants enjoyed learning science by doing experiments. Indicators in this category included: a) working in groups with their friends to complete science experiments, b) liking to do science experiment because the results are unexpected, and c) enjoying science experiments because you are given a choice in what to do (Barmby, Kind, & Jones, 2008).

Data analysis revealed that in general, SEMAA participants expressed positive attitudes about their self-concept in science and learning science both in-school and outside of school. It was noted that the median score of the learning science in-school (*Mdn* = 4.17) was found to be slightly higher than the median score for learning science outside of school (*Mdn* = 4.00). Which indicated that slightly more participants felt more positively about learning science in-school than outside of school.

Overall, the measure that received the lowest median score was future participation in science (*Mdn* = 3.80). Indicators for this measure included participants'

desire to study science in the future, study science in college, and obtain a science career. Although the mean score fell within the positive range, the large number of participants who expressed desires for non-STEM college degrees and non-STEM careers that was noted in data analysis for research question two may have influence the outcome of this measure. It was also noted that this measure had the largest standard deviation of scores, which also may reflect the range of participants' college and career ambitions.

Participants' science motivation factors. Participants' science motivation factors were collected using the Science Motivation Questionnaire II developed by Glynn et al. (2011) and analyzed according to the procedures described in chapter three. In general, participants' responses indicated that the SEMAA participants were motivated to learn science and the participants responded positively to all motivation categories as indicated by median scores that were 15.00 or higher (Table 6).

Table 6. Analysis of motivation factor scores (n = 244)

<u>Measure</u>	<u>Motivation Factor Scores</u>					
	<u>Min</u>	<u>Max</u>	<u>M</u>	<u>Mdn</u>	<u>Mode</u>	<u>SD</u>
Intrinsic motivation	0.00	20.00	14.78	15.00	15.00	3.83
Career motivation	1.00	20.00	14.94	15.00	20.00	4.35
Self-determination	0.00	20.00	14.40	15.00	15.00	3.71
Self-efficacy	1.00	20.00	16.01	16.00	20.00	3.50
Grade motivation	0.00	20.00	16.12	17.00	20.00	3.53

Note: The range of possible scores for each subscale was 0.00 – 20.00 (0.00 = low motivation; 20.00 = high motivation)

Data analysis revealed that the most highly regarded motivation factor was grade motivation (*Mdn* = 17.00). The indicator of grade motivation included: (a) scoring high on science tests, (b) importance of getting an “A” in science, and (c) doing better than

other students on science tests. This finding may indicate that the majority of the SEMAA participants were motivated to learn science to achieve higher grades in school.

Data analysis also revealed that the majority of the participants were motivated to learn science because they believed they were capable of learning science (*Mdn* self-efficacy score = 16.00). Additionally, the median scores for the intrinsic motivation, career motivation, and self-determination subscales were all found to be 15.00. This indicated that that majority of the participants were intrinsically motivated to learning science, were motivated to learn science to support their future careers, and possessed self-determination to learn science.

Research question three summary. The majority of participants expressed positive attitudes towards science and were motivated to learn science for a variety of reasons. Nearly all participants stated they had positive attitudes towards doing experiments to learn science. Specifically, participants' responses indicated that they had positive attitudes regarding doing science experiments: a) in groups with their friends, b) that had unexpected results or provided new information to them, and c) that gave them a choice of experiments or gave them a choice of how to do the experiment. The participants also expressed positive attitudes towards learning science both in-school and outside of school. Additionally, the majority of the participants expressed positive attitudes towards their science self-concepts and the importance of science. Although future participation in science received the lowest median score. The majority of participants expressed positive attitudes towards their future participation in science.

The participants' responded positively to all science motivation categories indicating that the majority of participants were motivated to learn science. The highest

rated motivation category was grade motivation, indicating that most participants were motivated to achieve high grades in science. However, a majority of participants also indicated they were motivated to learn science to support their future career and were intrinsically motivated to learn science. Additionally, most participants were found to possess self-confidence in their ability to learn science and were self-determined to learn science.

Conclusion

This chapter presented the themes that resulted from the analysis of the participants and their parents' perceptions of the SEMAA. Reasons for enrollment were explored from the both the participants and their parents' perspectives. Participants' and their parents' perspectives were also used to characterize the SEMAA in terms of the SEMAA's operations and infrastructure, instructors, learning environments, and curriculum and instruction. Additionally, parents' perspectives were used to characterize parental engagement in the SEMAA and SEMAA's support for participants' attitudes towards science, while participants' perspective were used to characterize the SEMAA's role in participants' STEM college degree and career ambitions. This chapter also presented an assessment of participants' attitudes towards science and science motivation factors. The following chapter will explore and interpret these findings in terms of the literature reviewed in chapter two.

CHAPTER V

CONCLUSIONS

Despite numerous reform efforts targeting formal STEM education, recent national reports and research studies have projected a critical shortage of STEM talent for the decade to come (Bayer Corporation, 2013; Change the Equation, 2014). Increasingly, federal agencies and other STEM stakeholders are investing in OST STEM programs as part of a comprehensive approach to STEM education with the goals of: (a) increasing participant interest and capacity in STEM fields and (b) increasing the breadth, depth, and diversity of our nation's STEM workforce (Bevan, Michalchik, Bhanot, Rauch, Semper, & Shields, 2010; Committee on Science, Engineering, and Public Policy, 2010; NRC, 2015). Catalyzed by the recent investments in OST STEM programs, the emerging body of research related to OST STEM programs has focused on program effectiveness, outcomes, and accountability requirements (Bell et al. 2009; Lauer et al. 2006). However, little research has been conducted to understand the characteristics of OST STEM programs and very few studies have included the participants' perspectives (Luehmann, 2009; NRC, 2015).

This research study begins to fill the gap in research literature regarding the characterization of OST STEM programs. The purpose of this study was two-fold: (a) to characterize the SEMAA from the participants' and their parents' perspectives and (b) to

characterized the participants' attitudes toward science and science motivation factors. The research questions that guided this study were: (a) what are the parents' perspective of the SEMAA, (b) what are the participants' perspectives of the SEMAA, and (c) what are the participants' attitudes towards science and science motivation factors?

Bronfenbrenner's ecological systems theory (EST) provided the theoretical framework of this study. EST argues that influences on an individual's environment, personal characteristics of the individual, and the resources and contexts that an individual has access to interweave to steer the individual's developmental path (Bronfenbrenner, 1993). EST underlies the STEM ecosystem approach to STEM learning. The STEM ecosystem approach seeks to understand the complex, dynamic interaction of cognitive, social, and cultural processes and outcomes that shape STEM learning across multiple contexts (Bell et al. 2009). When viewed through the lens of EST, the scope of physical and sociocultural STEM resources that an individual has access to defines their STEM learning opportunities. Therefore, having access to a wide array of opportunities to engage with STEM in formal and informal contexts adds to the robustness of STEM learning (Krishnamurthi et al. 2013).

A multiple-case study research design that included seven single-case studies was used for this investigation. Multiple-case study was selected based on the research questions and theoretical framework of this study. Multiple-case study research employs qualitative methods to collect data and inductive data analysis processes to reveal categories and themes related to the research questions (Yin, 2012). Yin's (2012) process for conducting multiple case studies was used for this study. First, data were analyzed within each single-case study independently. Next, a cross-case synthesis was conducted

to reveal convergence and non-convergence of findings across the seven single-case studies. As described by Yin (2012), the cross-case synthesis was conducted in two steps. First, data from each single-case study was organized into a word table. Next, the data were analyzed across the seven cases to search for convergences and non-convergences of findings.

Findings

Data analysis revealed several themes to inform this study's three research questions. First, analysis of parents' perceptions of the SEMAA revealed themes corresponding to two categories: (a) parents' reasons for enrolling their child in the SEMAA and (b) parents' characterization of the SEMAA in terms of the SEMAA's operations and infrastructure, instructors, learning environment, curriculum and instruction, parental engagement in the SEMAA, and SEMAA's support for participants' attitudes towards science. Second, analysis of participants' perceptions of the SEMAA revealed themes related to three categories: (a) participants' reasons for enrolling in the SEMAA, (b) participants' characterization of the SEMAA in terms of the SEMAA's operations and infrastructure, instructors, learning environment, curriculum and instruction, and (c) the SEMAA's role in participants' STEM college degree and career ambitions. Third, analysis of the Attitudes Towards Science Measures (Kind, Jones, & Barmby, 2007) and the Science Motivation Questionnaire II (Glynn et al. 2011) revealed new understanding of the participants' attitudes towards science and science motivation factors. The following section will explore these themes in terms of the research literature reviewed in chapter two.

Research question one: what are the parents' perceptions of the SEMAA?

Parents' perceptions of the SEMAA were gathered using a questionnaire. The parents' responses to the questionnaire were analyzed using Yin's (2012) data analysis process for multiple-case study to reveal themes related to the parents' perceptions of the SEMAA. The following section describes these themes in relation to research literature in the field of OST STEM programs.

Parents' reasons for enrolling their child in the SEMAA. Three themes were revealed related to the parents' reasons for enrolling their child in the SEMAA: (a) positive past experiences with the SEMAA, (b) to support their child's confidence in and enjoyment of science and math, and (c) to provide STEM learning experiences beyond what can be provided at their school or home. First, many parents stated that they enrolled their child in the SEMAA because their child had previously participated in the SEMAA and was satisfied with his/her experience. Similarly, Martinez et al.'s (2010) national SEMAA program evaluation found that SEMAA participants who had positive experiences were more likely to continue participating in the SEMAA. Second, many parents stated that they enrolled their child in the SEMAA to provide encouragement for their child's STEM interests and support their child's confidence in science and math. This finding is aligned to prior research that indicated OST STEM programs are well-suited to effect short-term outcomes related to generating interest and engagement in STEM (Krishnamurthi et al. 2013) and that participation in STEM summer camps can positively impact participants' STEM dispositions and self-confidence (Sheridan et al. 2011; Ylmez et al. 2010). Third, some parents explained that they enrolled their child in the SEMAA to provide them with STEM learning experiences beyond what their schools

were able to provide or they as parents could provide at home. Specifically, parents stated that the SEMAA provided access to new STEM content, resources, and hands-on activities that otherwise would not be available to their child. This finding may be related to prior research that found children from low-income and urban communities are more likely to attend schools that have less funding for STEM materials and activities and often come from families with fewer financial resources to support participation in STEM activities outside of school than children from middle- or high-income families (Luehmann, 2009; Milgram, 2011). In summary, this study found that parents typically enrolled their children in the SEMAA based on positive prior experiences with the SEMAA, to provide them access to STEM content and resources to which they otherwise would not have access, and to provide encouragement and support for their child's STEM interests and self-confidence.

Parents' characterization of the SEMAA. Analysis of the parent's characterization of the SEMAA revealed themes related to six categories: (a) operations and infrastructure, (b) instructors, (c) learning environments, (d) curriculum and instruction, (e) parental engagement, and (f) attitudes towards science. Themes associated with each of these categories are discussed in terms of the relevant research literature in the following paragraphs.

Operations and infrastructure. Analysis of parents' perceptions of the SEMAA's operations and infrastructure revealed four themes: (a) the SEMAA should be longer and expanded to include more participants, (b) it is difficult to enroll in the SEMAA, (c) the SEMAA is provided at no cost to participants, and (d) the SEMAA should facilitate connections with other learning opportunities. Several parents reported that the process to

enroll their child in the SEMAA was difficult because the demand for the SEMAA was higher than the number of available spaces for participants. Many parents recommended that the SEMAA should be expanded to include more participants. This finding echoes a trend identified by the Afterschool Alliance's (2015) national parent survey, *America After 3PM* that found despite an increasing number of OST STEM programs across the U.S., the demand for these programs still exceeds the availability.

The findings of this study regarding the parents' perceptions of the SEMAA's operations and infrastructure are also aligned to the NRC's (2015) recommendation that OST STEM programs should be designed to "ensure equitable access and continuity with formal education" (p. 3). For example, many parents noted that they appreciated that the SEMAA was offered at no cost to participants. This finding provides evidence that the cost of the SEMAA was not a barrier for participation. However, several parents stated that they would like the SEMAA to be expanded to more locations because the SEMAA was too far from their homes, making transporting their child to the SEMAA difficult. This may indicate that transportation and location of the SEMAA was a barrier for some participants. Several researchers have found that program cost and location have served as barriers to equitable participation (Afterschool Alliance, 2016; Innes et al. 2012; Milgram, 2011). These barriers can be particularly challenging for low-income families who may lack funds for enrollment or lack adequate transportation (Afterschool Alliance, 2016). Prior reports and research have encouraged OST STEM providers to minimize barriers such as program cost and location that may prevent individuals from participating in OST STEM programs (Innes et al. 2012; Milgram, 2011; NRC, 2015).

Specifically, Innes et al. (2012) recommended that OST STEM programs be provided at no cost or reduced cost to promote participation of children from low-income families.

Several parents stated that they would like the SEMAA to provide connections to other STEM learning opportunities and between what their children were learning in the SEMAA and what they were learning at school. This finding mirrors the NRC's (2015) recommendation that OST STEM programs should be aligned to formal education. This finding is also aligned to prior research that recommended intentional connections should be made between in-school and OST STEM learning as part of an ecosystem approach to developing STEM knowledge and skills (Bell et al. 2009; NRC, 2015; Tran, 2011).

Instructors. Analysis of parents' perceptions of the SEMAA instructors revealed two themes: (a) some instructors did not utilize effective instructional strategies and (b) the SEMAA provided opportunities for participants to learn from STEM professionals. First, some parents from two of the seven single-case studies stated that there were times when the SEMAA classes were disorganized and the instructor was repetitive, leading to down-time in class or their children being bored. Researchers have argued that the quality and qualifications of OST STEM program instructors are an important mediating factor for program outcomes (Fredricks, 2011; Jensen & Sjaastad, 2013). Jensen and Sjaastad (2013) argued that OST STEM program instructors must be equipped with evidence-based pedagogical skills, content knowledge, and the ability to create a positive learning environment. The NRC (2015) recommend providing on-going professional development to OST STEM instructors regarding effective practices for OST STEM teaching and learning. Second, some parents commented that the SEMAA provided their children with opportunities to conduct practical hands-on investigations with STEM professionals.

Researchers have associated the inclusion of STEM professionals in OST STEM program instruction with with increases in participants' ability to identify with STEM careers and more realistic perceptions of STEM professionals (Jensen & Sjaastad, 2013; Muller et al. 2013; Wyss, Heulskamp, & Siebert, 2012).

Learning environment. Analysis of parents' perceptions of the SEMAA's learning environment revealed three themes: (a) the SEMAA provided a safe learning environment, (b) the SEMAA provided a fun learning environment, and (c) the SEMAA provided opportunities for participants to build social networks and develop teamwork skills. Parents perceptions that the SEMAA provided a safe, fun, and social learning environment aligned to the NRC's (2015) list of contextual factors that promoted children's meaningful participation in OST STEM programs: (a) safety (physical and psychological), (b) belonging (social, community affiliation), and (c) positive learning environment. The findings also aligned with prior research that argued a primary purpose of federally-funded OST programs has been to provide a safe, structured environment for low-income children during afterschool hours and summer months when children are likely to be unsupervised by an adult caregiver (Bevan & Michalchik, 2013; Durlak, Weissberg, & Pachan, 2010; Lauer et al. 2006). Prior research has associated positive learning environments and a sense of belonging with higher participant engagement and retention (Fredricks, 2011; Jensen & Sjaastad, 2013; NRC, 2015). Specifically, Jensen and Sjaastad (2013) found that OST STEM programs that provided a fun, social, and engaging context had success in retaining participants. Additionally, researchers have found higher levels of engagement in OST STEM programs among participants who

developed positive social relationships with other participants in the program (Fredricks, 2011; Jensen & Sjaastad, 2013).

Curriculum and instruction. Analysis of parents' perceptions of the SEMAA's curriculum and instruction revealed five themes: (a) the SEMAA provided participants with opportunities to learn science and math concepts, (b) the SEMAA provided participants with STEM enrichment beyond in-school learning, (c) the SEMAA exposed participants to STEM higher education options and careers, (d) the SEMAA provided participants with opportunities to engage with STEM content through hands-on activities, and (e) the SEMAA may benefit from including take-home family activities. The findings revealed from analysis of the parents' perceptions of the SEMAA's curriculum and instruction aligned to prior research in the field. For example, many parents stated that the SEMAA's curriculum and instruction provided their child with opportunities to engage in hands-on science and engineering activities that increased their knowledge of STEM concepts and skills. Similarly, Stocklmayer, Rennie, and Gilbert (2010) argued that OST STEM program activities should provide opportunities for children to learn about STEM concepts and engage in the processes of doing STEM (e.g., use STEM skills). Some parents also explained that the SEMAA activities taught their child new science and math concepts and how science and math are relevant to their lives. This finding is similar to Kesidou and Koppal's (2004) recommended that OST STEM program activities should be relevant to participants' culture and prior knowledge and responsive to participants' interests. Some parents stated that the SEMAA's curriculum and instruction allowed their child to explore STEM concepts in more depth than their regular classrooms. Similarly, the NRC (2015) argued that OST program curriculum

should build upon children's past learning experiences and promote connections between in-school and out-of-school learning. Additionally, the NRC (2015), posited that effective OST STEM programs engage children and their families in first-hand experiences with STEM phenomena. Similarly, the parents recommended that the SEMAA provide take-home STEM activities or projects that the parents could work on with their child at home. Some parents stated that being able to work on projects with their child at home would have helped them understand what their child was learning at the SEMAA and better equip them to support their child's learning.

Parental engagement. Analysis of parents' perceptions of the SEMAA's parental engagement revealed three themes: (a) the SEMAA provided resources and support to parents through the Family Café, (b) the SEMAA valued parental involvement, and (c) some parents would like to be more involved with the SEMAA. The findings regarding the parents' perceptions of the SEMAA's parental engagement align well with prior research in the field. According to the NRC (2015), involving parents in STEM activities with their children increases parents' awareness of their children's interests and ambitions in STEM and increases the parents' abilities to advocate for and support their children's STEM pursuits. Additionally, the Afterschool Alliance (2015) recommended that OST STEM programs should provide information and resources to parents that may equip them to support their child's STEM learning and make connections between the OST STEM program, school learning, and other STEM learning opportunities. Similarly, Milgram (2011) argued that OST STEM programs should provide information and resources to assist parents as they support their child's STEM pursuits.

Attitudes towards science. Analysis of parents' perceptions of the SEMAA's role in their child's attitudes towards science revealed one theme: the SEMAA provides support for participants' positive attitudes towards science and math and support for participants' self-confidence in science and math. These findings aligned to prior research that found the intended outcomes of many OST STEM programs include to develop participants' positive attitudes towards science and motivation to pursue additional science learning activities (Bell et al. 2009; Krishnamurthi et al. 2013). However, Marinez et al. (2010) argued that most participants who self-select to participate in voluntary OST STEM programs do so because they already possess positive attitudes towards science. Therefore, a more appropriate goal for OST STEM programs may be to support or sustain participants' positive attitudes towards science.

Research question two: what are the participants' perceptions of the SEMAA? Participants' perceptions of the SEMAA were gathered using a questionnaire that was administered to the summer 2015 SEMAA participants. Analysis of the participants' perceptions of the SEMAA revealed themes related to three categories: (a) participants' reasons for enrolling in the SEMAA (b) participants' characterization of the SEMAA, and (c) the SEMAA's role in participants' STEM college degree and career ambitions. The following section presents the themes aligned to each of these three categories and similarities between the participants' and their parents' perceptions are noted.

Participants' reasons for enrolling in the SEMAA. Analysis of participants' responses revealed a variety of affective (e.g., positive feelings, enjoyment, fun), cognitive (e.g., educational, learning), and social (e.g., making new friends) factors that

led participants to enroll in the SEMAA. Further analysis of participants' responses revealed four themes related to why participants enrolled in the SEMAA: (a) positive feelings about previous participation in the SEMAA; (b) the SEMAA is a fun, educational program; (c) participants liked doing or learning about science and math; and (d) to make new friends. These findings align to prior research that has characterized OST STEM programs as having voluntary participation, a low-stakes learning environment, learner-centered instruction, participatory pedagogies, and social interactions (Stocklmayer, Rennie, & Gilbert, 2010).

Participants' characterization of the SEMAA. Analysis of the participants' characterization of the SEMAA revealed several themes related to the SEMAA's operations and infrastructure, instructors, learning environments, and curriculum and instruction. Themes associated with each of these categories are discussed in terms of the relevant research literature in the following paragraphs.

Operations and infrastructure. Analysis of participants' perceptions of the SEMAA's operations and infrastructure revealed two themes: (a) the SEMAA should be longer and expanded to include more participants and (b) the SEMAA would benefit from having more or newer materials and equipment. These findings are similar to the parents' perceptions of the SEMAA's operations and infrastructure. Both the participants and their parents stated that the length of classes (i.e. hours per day) and the length of the SEMAA session (i.e. number of days) should be longer. These findings are aligned to prior research that argued, participants who have positive experiences in OST STEM programs are more likely to express a desire to continue participating in the program (Fredricks, 2011; Jensen & Sjaastad, 2013; NRC, 2015). Both the participants and their

parents stated that the SEMAA should be expanded to include more participants and be offered at more locations. Similar to the parents, the participants also described the difficulty they had travelling to the SEMAA from their homes. The findings are aligned to prior research that posited, the demand for OST STEM programs exceeds the availability and that the distance to OST STEM programs can be a barrier for some children to participate in the programs (Afterschool Alliance, 2016).

Some participants commented that they did not have enough materials to complete their projects and a few participants stated that they voluntarily brought materials from home to complete their projects when the SEMAA did not have enough materials. Several participants also stated that they would have liked to be able to take at least one project home. These findings suggest that the SEMAA would benefit from having more or newer materials and equipment. Hands-on activities are a central component of the SEMAA and require adequate materials and equipment (Berliner, 2009; Luehmann, 2009) These findings indicate that the SEMAA may not be able to provide adequate resources, up-to-date equipment, and sufficient materials for participants to complete activities.

Instructors. Analysis of participants' perceptions of the SEMAA instructors revealed two themes: (a) the SEMAA instructors developed positive social relationships with participants and (b) some of the SEMAA instructors did not utilize effective classroom management and instructional strategies. First, many participants' expressed that they positively regarded their instructors and provided evidence that their instructors: (a) made an effort to know them as individuals, (b) provided them with encouragement, and (c) developed positive social relationships with them. This finding is in alignment

with prior research that indicated participants in OST STEM programs instructed by personable instructors had more positive feeling towards the programs, were more engaged in activities, and had higher expectancies for their future success in STEM (Fredricks, 2011; & Jensen & Sjaastad, 2013). Specifically, Fredricks (2011) study of factors that contributed to participant engagement in OST STEM programs revealed that positive personality characteristics of instructors (e.g., fairness, warmth and closeness with participants, caring and supportive, acknowledge individuality of participants) and instructors' abilities to develop positive interpersonal relationships with participants contributed to increased participant engagement in OST STEM programs.

Second, several participants criticized their instructor's inability to correct the negative behavior of some participants. These findings suggested that some of the SEMAA instructors did not utilize effective classroom management or instructional strategies. This may indicate that some of the SEMAA instructors could benefit from professional development regarding effective practices for teaching in OST STEM programs. This finding is also in alignment with Fredrick's (2011) study of factors that promoted engagement in OST STEM programs. Fredrick argued that OST STEM program participants were more engaged when instructors exhibited strong instructional management practices, provided clear and consistent rules and expectations, provided consistent feedback and facilitated smooth transitions to increase the cohesiveness between activities.

Learning environments. Analysis of participants' perceptions of the SEMAA's learning environment revealed two themes: (a) the SEMAA provided a fun learning environment and (b) the SEMAA provided opportunities for participants to build social

networks and develop teamwork skills. These findings echoed some of the parents' perceptions of the SEMAA's learning environment and indicated that both the participants' and their parents' perceived the SEMAA's learning environment was fun and social. These findings also aligned with prior research that found a common goal of OST STEM programs is for participants to have fun while learning (Bell et al. 2009). Bell et al. (2009) argued that providing opportunities for participants to have fun while doing STEM and opportunities for participants to work in social groups positively influenced participant engagement in OST STEM programs. Additionally, several researchers have recommended that OST STEM program instructors should intentionally foster positive social relationships and facilitate peer networks using instructional strategies such as small group activities (Bell et al. 2009; Fredricks, 2011; Jensen & Sjaastad, 2013; Milgram, 2011).

Curriculum and instruction. Analysis of participants' perceptions of the SEMAA instructors revealed four themes: (a) the SEMAA provided participants with opportunities to learn science and math concepts, (b) the SEMAA provided participants opportunities to use science and engineering practices and skills, (c) the SEMAA lessons included instructional practices that engaged participants in STEM learning, and (d) the SEMAA participants did not enjoy "school-like" activities (e.g. taking a pretest, reading, writing notes). These findings are similar to prior research that revealed qualities of effective and appropriate OST STEM program activities. Specifically, activities should reflect the nature of OST STEM program learning environments by providing opportunities for choice, autonomy, ownership, active involvement, wonder, and discovery (Fredricks, 2011; Kesidou & Koppal, 2004; Stocklmayer, Rennie, & Gilbert, 2010). Activities should

also be age appropriate, varied, interesting and enjoyable, challenging, connected to real world, and flexible (Fredricks, 2011; Kesidou & Koppal, 2004; Stocklmayer, Rennie, & Gilbert, 2010). Several researchers have recommended including inquiry-based science and engineering design activities that engage participants in the active processes of science and engineering and resemble how scientists and engineers work (Bell et al. 2009; Innes et al. 2012; Luehmann, 2009; Milgram, 2011; Muller et al. 2013).

The SEMAA's role in participants' STEM college degree and career ambitions.

Analysis of participants' perceptions of the SEMAA's role in participants' STEM college degree and career ambitions revealed two themes: (a) the SEMAA influenced few participants' STEM college degree ambitions and (b) the SEMAA influenced few participants' STEM career ambitions. First, less than half of the SEMAA participants reported that they planned to major in a STEM field and only a quarter of participants stated that the SEMAA had influenced their college ambitions. Similarly, 36.59 percent of the SEMAA participants stated that they were interested in a STEM career and 20.33 percent of the SEMAA participants stated that the SEMAA had influenced their career ambitions. Prior research has found that a common goal of OST STEM programs is to increase participants' interest in STEM college degrees and careers (Bevan & Michalchik, 2013). However, Krishnamurthi et al.'s (2013) research to understand which outcomes OST STEM programs are best suited to achieve found that experts did not have confidence in OST STEM programs' ability to affect long-term outcomes related to the pursuit of additional STEM learning and careers.

Research question three: what are the attitude towards science and motivation factors of the SEMAA participants? Analysis of participants' attitudes toward science using Kind, Jones, & Barmby's (2007) Attitudes Towards Science Measures indicated that in general SEMAA participants had positive attitudes towards science. Further analysis found that participants enjoyed learning science by doing experiments and expressed positive attitudes about their self-concept in science and learning science both in-school and outside of school. Overall, the measure that received the lowest median score was future participation in science. Indicators for this measure included participants' desire to study science in the future, study science in college, and obtain a science career. These findings reflect prior research that has argued positive attitudes towards science are both a prerequisite and an outcomes of OST STEM programs (Martinez et al. 2010).

Analysis of participants' science motivation factors using Glynn et al.'s (2011) Science Motivation Questionnaire II, indicated that the SEMAA participants were motivated to learn science and that most participants responded positively to all motivation categories (e.g., intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation). However, grade motivation was the most highly rated category, indicating that most of the SEMAA participants were motivated to learn science to earn higher grades on tests and in science classes. This finding provides evidence aligned to prior research that recommended that OST STEM programs should be build connections to formal education (Bell et al. 2009; NRC, 2015).

Limitations

The limitations of this study resulted from the participant and parental questionnaire response rates and the methods of data collection and analysis that were used. First, the low response rate for both the participant and parental questionnaire limits the findings of this study. Second, this study relied on self-reported data collected using a questionnaire. The self-report nature of the data collection may be a source of error, because the respondents may not have answered all of the questions honestly. Third, qualitative data analysis considers the researcher as an instrument. Therefore, the credibility of the researcher may limit the internal validity of a qualitative study (Bloomberg & Volpe, 2008). This study utilized peer reviews to minimize threats to internal validity. Fourth, the qualitative data analysis methods used to conduct case study research have been criticized for lack of rigor and systematic procedures providing little basis for transference (Yin, 2012). To minimize these criticisms Yin's (2012) systematic process for data collection and analysis were followed. Additionally, transferability (i.e. external validity) of this study was increased by the use of seven single-case studies and a large sample size to inform the themes and implications of this study. According to Yin (2012), the use of multiple cases increases the likelihood of producing credible results because the "analytic conclusions independently arising from two cases, as with two experiments, will be more powerful than those coming from a single case alone" (p. 133 – 134). Similarly, Creswell (2007) explained that using multiple cases enhances the possibility for transferability of findings because a range of representative cases is provided (Creswell, 2007). However, although this multiple-case study took measures to

increase the likelihood of transferability, readers should critically reflect on this study before applying the results beyond the SEMAA.

Implications for Practices

This study characterized the SEMAA from the participants' and their parents' perspectives and characterized the participants' attitudes towards science and science motivation factors. The findings presented in this chapter have implications for OST STEM program developers. The following section presents seven implications of this study related to OST STEM program (a) recruitment and retention, (b) operations and infrastructure, (c) instructors, (d) learning environment, (e) curriculum and instruction, (f) parental engagement, and (g) outcomes.

Recruitment and retention. Providing a positive learning environment that is fun and allows participants to explore their interests and meet new friends may support recruitment and retention of participants. Both participants' and their parents agreed that positive past experiences influenced their decisions to reenroll in the SEMAA.

Participants and their parents described the SEMAA as a fun, educational program and stated that they were attracted to the SEMAA because it provided opportunities for participants to explore their interests in science and math in more depth than was provided at their school or home. Additionally, participants stated that they were attracted to the SEMAA because they made new friends who shared their interests in science and math. In particular, the SEMAA provided opportunities for participants to engage in STEM processes through hands-on activities.

Operations and infrastructure. OST STEM program developers should ensure their program design allows for equitable access for individuals from underserved groups

or groups traditionally underrepresented in STEM fields and does not inadvertently create barriers that may prevent some individuals from participating. Both participants and their parents stated that the SEMAA should be longer, offered at more locations, and include more participants. Further analysis revealed that these findings were related to participation barriers (e.g. difficulty enrolling, transportation to the SEMAA). Specifically, OST STEM program developers should consider participant cost, location, and access for special needs participants.

Learning environment. OST STEM program learning environments should be safe, fun, and social. Both participants and their parents agreed that the SEMAA provided a fun learning environment that supported participants' STEM interests and facilitated the development of friendships and social networks between like-minded participants. Additionally, parents liked that the SEMAA provided a safe, structured learning environment for their children.

Instructors. OST STEM program providers should ensure that program instructors are personable, knowledgeable about STEM, and equipped to implement effective strategies for OST STEM teaching and learning. Both participants and their parents agreed that some of the SEMAA instructors were not equipped to implement effective strategies for OST STEM teaching and learning. This was evidenced by times of disorganization, down-time, participants being bored, and participants' misbehavior. Participants also stated that they appreciated receiving encouragement from their instructors and the personal relationships that they developed with their instructors. Additionally, parents stated that they appreciated that their child had opportunities to learn from STEM experts.

Curriculum and instruction. OST STEM programs should include learner-centered, participatory activities that provide opportunities for participants to engage in STEM practices, explore their interests, and identify with STEM professions. Both participants and their parents agreed that they liked that the SEMAA included hands-on STEM activities beyond what their schools provided. Conversely, participants did not like doing “school-like” activities (e.g. taking a pretest, reading, writing notes) at the SEMAA.

Parental engagement. OST STEM programs should include opportunities for parental engagement. Parents stated that the SEMAA provided effective family engagement opportunities and support through the Family Café. Additionally, parents stated that they would like to be more involved in the SEMAA (e.g. volunteer, participate in activities with their child) and would like the SEMAA to provide take-home STEM activities that they could complete with their children.

OST STEM program outcomes. OST STEM programs should be positioned as a component of an individuals’ broader STEM learning ecosystem. Therefore, OST STEM program outcomes should contribute to an individual’s holistic development of STEM knowledge, skills, attitudes, and ambitions. Findings of this study indicated that most participants had positive attitudes towards science, were confident in the science abilities, and were motivated to learn science (e.g., intrinsic motivation, self-determination, career motivation, or grade motivation). Additionally, this study found that the SEMAA only influenced the STEM college degree and career ambitions of a few participants. These findings indicate that attitudes, motivation, interest, and college and career ambitions may be both outcomes of the SEMAA for some participants and entry factors for other

participants.

Future Research

The emerging field of research related the OST STEM programs has begun to provide understanding of the attributes and outcomes of OST STEM programs. This study provided new understanding of the SEMAA from the perspectives of the participants and their parents. However, this study was limited to a qualitative investigation of one model for OST STEM programs. Future researchers should use both quantitative and qualitative methods to explore multiple models of OST STEM programs. These studies should serve to provide new understanding of the program designs, implementation processes, and outcomes of a variety of OST STEM programs from the perspectives of the program developers, participants, parents, and other stakeholders. These studies will help to grow the body of research literature on OST STEM programs and provide new understanding about the attributes and outcomes of OST STEM programs.

Conclusions

In conclusion, this study characterized the SEMAA from the perspectives of the participants and their parents and characterized the participants' attitudes toward science and science motivation factors. Reasons for enrolling in SEMAA and the SEMAA's operation and infrastructure, instructors, learning environment, and curriculum and instruction were explored from both the participants' and their parents' perspectives. Parents' perspectives about the SEMAA's parental engagement opportunities and the SEMAA's support for their children's attitudes towards science were also explored.

Additionally, participants' perspectives regarding SEMAA's support for their college and career ambitions were revealed.

Analysis of the findings in terms of prior research in the field of OST STEM programs revealed six implications for OST STEM program providers: (a) providing a positive learning environment that is fun and allows participants to explore their interests and meet new friends may support recruitment and retention of participants, (b) OST STEM program developers should ensure their program design allows for equitable access and does not inadvertently create barriers that may prevent some individuals from participating, (c) OST STEM program learning environments should be safe, fun, and social, (d) OST STEM program instructors should be personable, knowledgeable about STEM, and equipped to implement effective strategies for OST STEM teaching and learning, (e) OST STEM programs should include learner-centered, participatory activities that provide opportunities for participants to engage in STEM practices, explore their interests, and identify with STEM professions, (f) OST STEM programs should include opportunities for parental engagement, and (g) OST STEM program outcomes should be to contribute to an individual's holistic development of STEM knowledge, skills, attitudes, and ambitions. These implications may provide guidance for future SEMAA and other OST STEM program developers.

REFERENCES

- Afterschool Alliance. (2015). America after 3pm: Full STEM ahead: Afterschool programs step up as key partners in STEM education. Retrieved from <http://www.afterschoolalliance.org/AA3PM/STEM.pdf>
- Afterschool Alliance. (2016). America after 3pm: The growing importance of afterschool in rural communities. Retrieved from http://www.afterschoolalliance.org/AA3PM/Afterschool_in_Rural_Communities.pdf
- Alvarez, C. A., Edwards, D., & Harris, B. (2010). STEM Specialty Programs: A Pathway for Under-Represented Students into STEM Fields. *NCSSMST journal*, 16(1), 27-29.
- Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science Education*, 94(6), 1008-1026.
- Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International journal of science education*, 30(8), 1075-1093.
- Barron, B. (n.d.). Formative assessment for STEM learning ecosystems: Biographical approaches as a resource for research and practice. National Research Council Committee on Out-of-School Time STEM. Washington, DC: National Research Council.

- Bayer Corporation. (2013). *U.S. STEM Workforce Shortage: Myth or Reality?* Media, PA: International Communications Research.
- Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (Eds.). (2009). *Learning Science in Informal Environments: People, Places, and Pursuits*. Committee on Learning Science in Informal Environments National Research Council. Washington DC: National Academies Press.
- Berliner, David C. (2009). *Poverty and Potential: Out-of-School Factors and School Success*. Boulder and Tempe: Education and the Public Interest Center & Education Policy Research Unit. Retrieved from <http://nepc.colorado.edu/publication/poverty-and-potential>
- Bevan, B. (2016). STEM learning ecologies: Relevant, responsive, and connected. Retrieved from <http://csl.nsta.org/2016/03/stem-learning-ecologies/>
- Bevan, B., & Michalchik, V. (2013). Where It Gets Interesting: Competing Models of STEM Learning after School. *Afterschool Matters*, 17, 1-8.
- Bevan, B., Michalchik, V., Bhanot, R., Rauch, N., Semper, R., & Shields, P. (2010). *Out-of-school time STEM: Building experience, building bridges*. San Francisco: Exploratorium.
- Bloomberg, L.D. & Volpe, M. (2008). *Completing Your Qualitative Dissertation: A Roadmap From Beginning to End*. Los Angeles: Sage Publications.
- Bonney, R., Phillips, T. B., Enck, J., Shirk, J., & Trautmann, N. (n.d.). *Citizen science and youth education*. National Research Council Committee on Out-of-School Time STEM. Washington, DC: National Research Council.

- Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American psychologist*, 32(7), 513.
- Bronfenbrenner, U. (1993). Ecological models of human development. In M. Gauvain & M. Cole (Eds.), *Readings on the Development of Children* (2nd ed.) (37-43). New York, NY: W.H. Freeman and Company.
- Change the Equation (CTEq). (2014). Vital signs. Retrieved from <http://vitalsigns.changetheequation.org/#us-United%20States-Pipeline>
- Chiseri-Strater, E. (1996). Turning in upon ourselves: Positionality, subjectivity, and reflexivity in case study and ethnographic research. In P. Mortensen & G. Kirsch (Eds.), *Ethics and representation in qualitative studies* (115-133). Urbana: National Council of Teachers of English.
- Committee on Science, Engineering, and Public Policy; Policy and Global Affairs; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2010). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. National Academies Press. Washington, D.C.
- Creswell, J. W. (2007). *Qualitative Inquiry and Research Design, Second Edition*. Thousand Oaks, CA: Sage Publications.
- Crotty, M. (1999). *The foundations of social research: Meaning and perspective in the research process*. London: Sage.
- Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their

- association with career interest in STEM. *International Journal of Science Education, Part B*, 2(1), 63-79
- DeJarnette, N. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. *Education*, 133(1), 77-84.
- Dunbar, B. (2013). SEMAA: Science, engineering, mathematics and aerospace academy. National Aeronautics and Space Administration. Retrieved from <http://www.nasa.gov/offices/education/programs/national/semaa/home/>
- Durlak, J. A., Weissberg, R. P., & Pachan, M. (2010). A meta-analysis of after-school programs that seek to promote personal and social skills in children and adolescents. *American journal of community psychology*, 45(3-4), 294-309.
- Falk, J. H., Storksdieck, M., & Dierking, L. D. (2007). Investigating public science interest and understanding: Evidence for the importance of free-choice learning. *Public Understanding of Science*, 16, 455-469.
- Foster, J. S., & Shiel-Rolle, N. (2011). Building Scientific Literacy through Summer Science Camps: A Strategy for Design, Implementation and Assessment. *Science Education International*, 22(2), 85-98.
- Fredricks, J. A. (2011). Engagement in school and out-of-school contexts: A multidimensional view of engagement. *Theory into practice*, 50(4), 327-335.
- Friedman, A. (Ed). (2008). *Framework for evaluating impacts of informal science education projects*. Arlington, VA: National Science Foundation.
- Gibson, H. L., Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education*, 86(5), 693-705.

- Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, 48(10), 1159-1176.
- Glynn, S. M., Taasoobshirazi, G. and Brickman, P. (2009), Science Motivation Questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, 46: 127–146. doi: 10.1002/tea.20267
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research*. (pp. 105-117). Thousand Oaks, CA: Sage.
- Hussar, K., Schwartz, S., Bioselle, E., & Noam, G. (2008). Toward a systematic evidence-base for science in out-of-school time. Retrieved from http://www.peecworks.org/PEEC/PEEC_Inst/01796300-001D0211.0/Hussar%20et%20al%202008%20Assessment%20of%20Science%20OST.pdf
- Innes, T., Johnson, A. M., Bishop, K. L., Harvey, J., & Reisslein, M. (2012). The Arizona Science Lab (ASL): Fieldtrip based STEM outreach with a full engineering design, build, and test cycle. *Global Journal of Engineering Education*, 14(3), 225-232.
- Jensen, F., & Sjaastad, J. (2013). A Norwegian out-of-school mathematics project's influence on secondary students' STEM motivation. *International Journal of Science and Mathematics Education*, 11(6), 1437-1461.
- Kesidou, S., & Koppal, M. (2004). Supporting goals-based learning with STEM outreach. *Journal of STEM Education: Innovations and Research*, 5(3/4), 5.

- Kidron, Y., & Lindsay, J. (2014). The effects of increased learning time on student academic and nonacademic outcomes: Findings from a meta-analytic review. Retrieved from <http://achieve.lausd.net/cms/lib08/CA01000043/Centricity/Domain/469/The%20effects%20of%20ILT.pdf>
- Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education*, 29(7), 871-893.
- Koballa, T. R. & Glynn, S. M. (2007). Attitudinal and motivational constructs in science learning. In: Abell, S. K. & Lederman, N. G. (eds). *Handbook of research on science education*. Lawrence Erlbaum Associates, Mahwah, 75-102.
- Krapp, A. & Prenzel, M. (2011): Research on Interest in Science: Theories, methods, and findings, *International Journal of Science Education*, 33:1, 27-50.
- Krapp, A. (2002). Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction*, 12(4): 383–409.
- Krishnamurthi, A., Bevan, B., Rinehart, J., & Coulon, V. R. (2013). What Afterschool STEM Does Best: How Stakeholders Describe Youth Learning Outcomes. *Afterschool Matters*, 18, 42-49.
- Lauer, P. A., Akiba, M., Wilkerson, S. B., Apthorp, H. S., Snow, D., & Martin-Glenn, M. L. (2006). Out-of-school-time programs: A meta-analysis of effects for at-risk students. *Review of educational research*, 76(2), 275-313.

- Luehmann, A. L. (2009). Students' perspectives of a science enrichment programme: Out-of-school inquiry as access. *International Journal of Science Education*, 31(13), 1831-1855.
- Martin, M. O., Mullis, I. V., Foy, P., & Stanco, G. M. (2012). *TIMSS 2011 International Results in Science*. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.
- Martinez, A., Cosentino de Cohen, C., Carter Smith, W., Maree, K., Parsad, A., Shlager, C., . . . Jurist Levy, A. (2010). The national evaluation of NASA's science, engineering, mathematics, and aerospace academy (SEMAA) program. Bethesda, MD: Abt Associates Inc.
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). Los Angeles: Sage Publications.
- Milgram, D. (2011). How to Recruit Women and Girls to the Science, Technology, Engineering, and Math (STEM) Classroom. *Technology and Engineering Teacher*, 71(3), 4-11.
- Muller, C. L., Roberts, S., Wilson, R. C., Remedios, J. J., Illingworth, S., Graves, R., ... & Desai, A. (2013). The Blue Marble: a model for primary school STEM outreach. *Physics Education*, 48(2), 176.
- Mullis, I. V., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 International Results in Mathematics*. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.

- Nadelson, L. S., & Callahan, J. (2011). A comparison of two engineering outreach programs for adolescents. *Journal of STEM Education: Innovations and Research*, 12(1/2), 43.
- National Aeronautics and Space Administration (NASA). (2013). Harvard recognizes NASA SEMAA as a top government innovator. Retrieved from <http://www.nasa.gov/offices/education/programs/national/semaa/home/harvard-recognizes-semaa.html#.VtxvrMe5bUo>
- NASA. (2014). NASA Strategic Plan 2014. NASA Headquarters: Washington, DC. NP-2014-01-964-HQ
- National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards Mathematics*. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School Officers.
- National Research Council (NRC). (2015). *Identifying and Supporting Productive STEM Programs in Out-of-School Settings*. Committee on Successful Out-of-School STEM Learning. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
- National Research Council. *NASA's Elementary and Secondary Education Program: Review and Critique*. Washington, DC: The National Academies Press, 2008. Print.
- National Science Foundation (NSF). (2008). Framework for evaluating impacts of informal science education projects. Retrieved from <http://www.informalscience.org/framework-evaluating-impacts-informal-science-education-projects>

- Oklahoma State University. (2016). IRB waiver of written documentation of informed consent. Retrieved from <https://compliance.okstate.edu/irb/waiver-written-documentation-informed-consent>.
- Next Generation Science Standards (NGSS) Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
- Palmer, D. H. (2009), Student interest generated during an inquiry skills lesson. *Journal of Research in Science Teaching*, 46: 147–165. doi: 10.1002/tea.20263
- Patton, M. Q., (2014). *Qualitative Research and Evaluation Methods* (4th ed.). Los Angeles: Sage Publications.
- Pintrich, P. R. & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications*. Englewood Cliffs, NJ: Merrill Prentice-Hall.
- President’s Council of Advisors on Science and Technology (PCAST). (2010). *Report to the President Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) For America’s Future*. Executive Office of the President. Washington D.C.
- Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an agenda for advancing research on science learning in out-of-school settings. *Journal of Research in Science Teaching*, 40(2), 112-120.
- Sheridan, P. M., Szczepankiewicz, S. H., Mekelburg, C. R., & Schwabel, K. M. (2011). Canisius College summer science camp: Combining science and education experts to increase middle school students’ interest in science. *Journal of Chemical Education*, 88(7), 876-880.

- Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, 42(1), 70-83. doi:10.1037/0012-1649.42.1.70
- Slone, W. (2015). *2015 National SEMAA Annual Report*. (Unpublished report). Paragon TEC, Inc., Cleveland, OH.
- Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, 46(1), 1-44.
- Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, 2, 53.
- Tran, N. A. (2011). The relationship between students' connections to out-of-school experiences and factors associated with science learning. *International Journal of Science Education*, 33(12), 1625-1651.
- Traphagen, K. & Traill, S. (2014, February). How cross-sector collaborations are advancing STEM learning. Retrieved from http://www.noycefdn.org/documents/STEM_ECOSYSTEMS_REPORT_140128.pdf
- Vossoughi, S., & Bevan, B. (2014). Making and tinkering: A review of the literature. National Research Council Committee on Out-of-School Time STEM. Washington, DC: National Research Council, 1-55.
- Wyss, V. L., Heulskamp, D., & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental and Science Education*, 7(4), 501-522.

Yin, R. K., (2002). *Case study research: Design and methods* (3rd ed.). Los Angeles: Sage Publications.

Yin, R. K., (2012). *Applications of Case Study Research* (3rd ed.). Los Angeles: Sage Publications.

Yilmaz, M., Ren, J., Custer, S., & Coleman, J. (2010). Hands-on summer camp to attract K–12 students to engineering fields. *Education, IEEE Transactions on*, 53(1), 144-151.

APPENDIX A

PARENT QUESTIONNAIRE

The following questions will give you an opportunity to tell us more about your experience with SEMAA. Please answer openly and truthfully.

Part One: SEMAA Experience

Please circle your answer to each of the following questions.

1. Do you have more than one child in the SEMAA? (yes, no)
 - a. Yes
 - b. No

2. Do you have more than one child in the SEMAA who is in grades 5 – 12?
 - a. Yes
 - b. NoIf yes to number 2, please answer the following questions about your oldest child in the SEMAA.

3. What type of the SEMAA did your child participate in this school year? (Select all that apply)
 - a. Saturday program
 - b. After-school program
 - c. In-school program
 - d. Summer program
 - e. Other (please specify) _____.

4. During which grade(s) did your child participate in the SEMAA (Select all that apply)
- | | |
|------|-------|
| a. K | h. 7 |
| b. 1 | i. 8 |
| c. 2 | j. 9 |
| d. 3 | k. 10 |
| e. 4 | l. 11 |
| f. 5 | m. 12 |
| g. 6 | |

Part Two: Parents' Perceptions of the SEMAA

1. What are your reasons for supporting your child's participation in the SEMAA?
(Check all that apply)
- a. My child attended the SEMAA previously
 - b. My child's brother/sister attended the SEMAA previously
 - c. My child is excited about the SEMAA
 - d. My child's brother/sister is excited about the SEMAA
 - e. My child's friend participated in the SEMAA
 - f. My child's friend is excited about the SEMAA
 - g. I am looking for a fun, hands-on program for my child
 - h. I am looking for something educational for my child
 - i. I want my child to have something to do on the weekend
 - j. My child does not like science or math
 - k. My child enjoys science or math
 - l. I want my child to do better in school in general
 - m. I want my child to do better in science/math in particular
 - n. My child is good at science/math
 - o. I want to build my child's confidence in science/math
 - p. Other (please specify) _____
2. What is the educational benefit, if any, of your child being involved with the SEMAA?
3. What did your child learn the most about in the SEMAA?
4. What did your child like best about participating in the SEMAA?
5. What did you as a parent/guardian like best about the SEMAA?
6. What did your child like least about participating in the SEMAA?
7. What did you, as a parent/guardian, like least about the SEMAA?
8. What would you change about the SEMAA?

9. What did you hope that your child would gain by being involved with the SEMAA?
Were these hopes met by the SEMAA?
10. Do you want your child to continue to be involved with the SEMAA?
a. Yes
b. No
Please explain.
11. Do you plan to encourage your child to participate in the SEMAA next school year?
a. Yes
b. No
Please explain?
12. Did SEMAA staff provide you with opportunities to be involved in making decisions about the content or structure of the SEMAA?
a. Yes
b. No
If yes, please explain how you were involved. If no, would you have liked to be involved in the design of the SEMAA? Explain.
13. As a parent/guardian, do you feel the SEMAA valued you as a participant in the program?
a. Yes
b. No
Please explain.
14. As a parent/guardian, would you like to participate in future SEMAA activities?
a. Yes
b. No
If yes, how would you like to be involved?

Section Three: Background Information

1. What is your child's ethnicity?
a. Hispanic or Latino
b. Not Hispanic or Latino
c. Choose not to answer
2. What is your child's race? Mark one or more:
a. American Indian or Alaska Native
b. Asian
c. Native Hawaiian or other Pacific Islander
d. Black or African American
e. White
f. Choose not to answer

3. What was your child's grade during the 2014-2015 school year?
- a. 5
 - b. 6
 - c. 7
 - d. 8
 - e. 9
 - f. 10
 - g. 11
 - h. 12
4. What is your child's gender?
- a. Female
 - b. Male
5. What is your relationship to this child?
- a. Mother/Stepmother
 - b. Father/Stepfather
 - c. Grandfather
 - d. Grandmother
 - e. Other female relative
 - f. Other male relative
 - g. Female guardian
 - h. Male guardian
 - i. Other (please specify) _____

APPENDIX B

PARTICIPANT QUESTIONNAIRE

The following questions will give you an opportunity to tell us more about your experience with SEMAA. Please answer openly and truthfully.

Section One: Attitudes Towards Science

Please circle one response for each row to indicate if you Strongly Agree (SA), Agree (A), Disagree (D), or Strongly Disagree (SD) with each statement.

- a. I look forward to doing science experiments
- b. I would like to become a science teacher
- c. I feel helpless when doing science
- d. I find science difficult
- e. I am just not good at science
- f. Science and technology are helping the poor
- g. We learn interesting things in science lessons
- h. We learn science better when we do experiments
- i. Science and technology are important for society
- j. I would like more experiments in my science lessons
- k. I would like to do more science activities outside school
- l. There are many exciting things happening in science and technology
- m. Science lessons are exciting
- n. I like science experiments because I can decide what to do myself
- o. I learn science quickly
- p. I would like to join a science club
- q. I look forward to my science lessons

- r. I like science better than most other subjects at school
- s. I would like to study science in college
- t. I would like to have a job working with science
- u. The benefits of science are greater than the harmful effects
- v. Doing experiments in science is exciting
- w. In my science class, I understand everything
- x. It is exciting to learn about new things happening in science
- y. We learn science better when we do experiments
- z. I would like to do more science at school
- aa. I like watching science programs on TV
- bb. Doing experiments is good because I can work with my friends
- cc. Doing science experiments is boring
- dd. I would like to become a scientist
- ee. I like science experiments because you don't know what will happen
- ff. Science is one of my best subjects
- gg. I get good marks in science
- hh. I would like to study more science in the future
- ii. I like reading science magazines and books
- jj. I like to visit science museums
- kk. Science is boring
- ll. Science and technology make our lives easier and more comfortable

Section Two: Science Motivation Factors

Please circle one response for each row to indicate if you Always (A), Usually (U), Sometimes (S), Rarely (R), or Never (N) agree with each statement.

- a. The science I learn is relevant to my life
- b. I like to do better than other students on science tests
- c. Learning science is interesting
- d. Getting a good science grade is important to me
- e. I put enough effort into learning science
- f. I use strategies to learn science well
- g. Learning science will help me get a good job
- h. It is important that I get an "A" in science
- i. I am confident I will do well on science tests
- j. Knowing science will give me a career advantage
- k. I spend a lot of time learning science
- l. Learning science makes my life more meaningful
- m. Understanding science will benefit me in my career
- n. I am confident I will do well on science labs and projects
- o. I believe I can master science knowledge and skills
- p. I prepare well for science tests and labs
- q. I am curious about discoveries in science

- r. I believe I can earn a grade of “A” in science
- s. I enjoy learning science
- t. I think about the grade I will get in science
- u. I am sure I can understand science
- v. I study hard to learn science
- w. My career will involve science
- x. Scoring high on science tests and labs matters to me
- y. I will use science problem-solving skills in my career

Section Three: Participants’ Perceptions of the SEMAA

1. Why did you want to become involved in the SEMAA this school year? (Check all that apply)
 - a. I participated in the SEMAA before
 - b. My brother or sister participated in the SEMAA
 - c. I am excited about the SEMAA
 - d. My brother or sister is excited about the SEMAA
 - e. My friend participated in the SEMAA
 - f. My friend is excited about the SEMAA
 - g. I wanted to make new friends who like science and math
 - h. I was looking for a fun, hands-on program
 - i. I was looking for something educational
 - j. I wanted to have something to do on the weekend
 - k. I don’t like science or math
 - l. I enjoy science or math
 - m. I wanted to do better in school in general
 - n. I wanted to do better in science or math
 - o. I am good at science and math
 - p. I want to be more confident in science and math
 - q. Other (please/specify) _____
2. What sort of things did you do in the SEMAA?
3. What did you learn the most about in the SEMAA?
4. What is something you did or learned in the SEMAA that you will remember for a long time? Why?
5. What did you like best about participating in the SEMAA?
6. What did you like least about participating in the SEMAA?
7. What would you change about the SEMAA?

8. If a friend asked you about the SEMAA and whether or not they should participate, what would you tell them?
9. Do you plan to go to college?
 - a. Yes
 - b. No
10. If you plan to go to college, what will be your major? _____ Why?
11. Has the SEMAA influenced your ideas about attending college?
 - a. Yes
 - b. NoWhy or why not?
12. What career are you most interested in pursuing? _____ Why?
13. Has the SEMAA influenced your ideas about your future career choices?
 - a. Yes
 - b. NoWhy or why not?

Section Four: Background Information

1. What was your grade during the 2014-2015 school year? Circle your grade below.
 - a. 5
 - b. 6
 - c. 7
 - d. 8
 - e. 9
 - f. 10
 - g. 11
 - h. 12
2. What is your gender?
 - a. Male
 - b. Female
3. What is your Ethnicity?
 - a. Hispanic/Latino(a)
 - b. Non-Hispanic/Latino(a)
 - c. Choose not to answer

4. What is your race? Mark one or more:
 - g. American Indian or Alaska Native
 - h. Asian
 - i. Native Hawaiian or other Pacific Islander
 - j. Black or African American
 - k. White
 - l. Choose not to answer

5. Do you qualify for free or reduced price lunch?
 - a. Yes
 - b. No
 - c. I don't know
 - d. Choose not to answer

6. Select the location of your SEMAA site: _____

7. What type of SEMAA did you participate in? (Check one or more)
 - a. Saturday program
 - b. After-school program
 - c. In-school program
 - d. Summer Program
 - e. Other please list

8. During which grade(s) did you participate in SEMAA? (Circle one or more grades)
 - a. K
 - b. 1
 - c. 2
 - d. 3
 - e. 4
 - f. 5
 - g. 6
 - h. 7
 - i. 8
 - j. 9
 - k. 10
 - l. 11

APPENDIX C

PARENTAL PERCEPTIONS

CROSS-CASE SYNTHESIS WORD TABLE EXCERPT

<u>Evaluation Codes</u>	<u>Case Number</u>	<u>Descriptor</u> (+), (-), or (+/-)	<u>Frequency and Examples</u>
Relationship to formal STEM education (e.g., academic achievement, school)	1	N/A	No comments related to this category
Relationship to formal STEM education (e.g., academic achievement, school)	2	+	<p>Three parents stated the educational benefit of the SEMAA was to prepare their child to learn STEM in school or to provide a STEM enrichment experience beyond what their school provided.</p> <ul style="list-style-type: none"> • <i>Being well prepare for school</i> • <i>STEM enrichment beyond learning in school</i>
Relationship to formal STEM education (e.g., academic achievement, school)	3	+	<p>One site three parent stated the educational benefit of the SEMAA was to help her child understand the science she was learning in school.</p> <ul style="list-style-type: none"> • <i>Get the basics of science to advance for eighth grade</i>

Relationship to formal STEM education (e.g., academic achievement, school)	4	+	<p>Ten parents stated the educational benefit of the SEMAA was to prepare their children to learn STEM in school or to provide a STEM enrichment experience beyond what their school provided.</p> <ul style="list-style-type: none"> • <i>Consistent support for science when she's not with her peers at school</i> • <i>I believe the program gave him to learn science on a different level and structure from normal classroom instruction</i> • <i>he loved the hands-on learning and going into more detailed information than he got in class!</i>
Relationship to formal STEM education (e.g., academic achievement, school)	5	+	<p>Three parents stated the educational benefit of the SEMAA was to provide a STEM enrichment experience beyond what their school provided.</p> <ul style="list-style-type: none"> • <i>Enrichment in science and math</i> • <i>Learning beyond the classroom, learning that will help her understand more advanced topics in school</i>
Relationship to formal STEM education (e.g., academic achievement, school)	6	+	<p>Four parents stated the educational benefit of the SEMAA was to prepare their children to learn STEM in school or to provide a STEM enrichment experience beyond what their school provided.</p> <ul style="list-style-type: none"> • <i>Exposure and practical experience beyond school, to set a precedent towards her familiarity and practical expectations</i> • <i>It fills the gaps (need) he has for more science education</i> • <i>Learn more than what they teach at school</i> <p>Three parents explained they wanted their children to be equipped to earn higher grades in school</p> <ul style="list-style-type: none"> • <i>Improve understanding and achieve higher grades</i>

Relationship to formal STEM education (e.g., academic achievement, school)	7	+ Three site seven parents stated the educational benefit of the SEMAA was to provide a STEM enrichment experience beyond what their school provided. <ul style="list-style-type: none"> • <i>My child gets to learn more about science and math than in the classroom expanding his knowledge and confidence</i> • <i>He is exposed to different types of curriculum</i>
Social, behavioral, or attitudinal benefits	1	+ Two parents stated the educational benefit of the SEMAA was it had a positive influence on their attitudes towards science. <ul style="list-style-type: none"> • <i>I would like for her to continue in the outlook that science is fun and not something that should be viewed as confusing and difficult</i>
Social, behavioral, or attitudinal benefits	2	+ Four parents explained that the educational benefit of the SEMAA was to develop positive attitudes towards science in their children. <ul style="list-style-type: none"> • <i>Get a more positive vibe of math and science</i> • <i>Excitement for science</i> <p>Two parents stated an educational benefit of the SEMAA was teaching their child how to work with others.</p> <ul style="list-style-type: none"> • <i>He has learned to work with others</i> • <i>My son will benefit tremendously from the program by learning science math and interacting with other students and teachers</i>
Social, behavioral, or attitudinal benefits	3	+ Two parents explained that the educational benefit of the SEMAA was to develop their children's interest in STEM. <ul style="list-style-type: none"> • <i>He is interested in this field</i>

Social, behavioral, or attitudinal benefits	4	+	<p>Two parents explained that the educational benefit of the SEMAA was to develop positive attitudes towards STEM in their children.</p> <ul style="list-style-type: none"> • <i>He has an opportunity to be excited about science and math</i> <p>One parent felt the SEMAA helped to build their child's self-confidence in science and math.</p> <ul style="list-style-type: none"> • <i>He enjoyed making things. It brought his confidence up</i> <p>Three parents felt the educational benefit of the SEMAA was for their children to meet like-minded children who shared an interest in STEM.</p> <ul style="list-style-type: none"> • <i>She was able to get involved with other children that have the same interest</i>
Social, behavioral, or attitudinal benefits	5	+	<p>Four parents stated the educational benefit of the SEMAA was for their child to gain excitement for learning STEM or enjoyment for learning</p> <ul style="list-style-type: none"> • <i>Excitement and knowledge for STEM</i> • <i>I wanted her to enjoy learning with hands-on activities and to see some cool things that scientists can do</i>

Social, behavioral, or attitudinal benefits	6	<p>+ Six parents explained that the educational benefit of the SEMAA was to develop positive attitudes towards STEM in their children.</p> <ul style="list-style-type: none"> • <i>Encourage a love for science, math, and engineering</i> • <i>See the fun and excitement in science</i> <p>Two parents felt the SEMAA helped to build their children's self-confidence in science and math.</p> <ul style="list-style-type: none"> • <i>Building confidence in the science and math curriculum</i> <p>Three parents felt the educational benefit of the SEMAA was for their children to meet like-minded children who shared an interest in STEM.</p> <ul style="list-style-type: none"> • <i>Being associated and around people who love learning</i> • <i>Meet different children and work with them doing different experiments and fun stuff</i>
Social, behavioral, or attitudinal benefits	7	<p>+ One parent stated the SEMAA helped to build her child's self-confidence in science and math.</p> <ul style="list-style-type: none"> • <i>My child gets to learn more about science and math than in the classroom expanding his knowledge and confidence</i>

APPENDIX D

PARTICIPANT PERCEPTIONS

CROSS-CASE SYNTHESIS WORD TABLE EXCERPT

<u>Theme</u>	<u>Case Number</u>	<u>Descriptor (+), (-), or (+/-)</u>	<u>Frequency and Examples</u>
Learning about STEM	1	+ Seven participants stated they learned the most about physics, five stated they learned the most about science, and one stated math. One participant stated	<ul style="list-style-type: none">• <i>I learned about different types of science</i>
Learning about STEM	2	+ Five participants stated they learned the most about science concepts. Specific concept listed were the solar system and earthquakes. Participants wrote they learned about	<ul style="list-style-type: none">• <i>Science</i>• <i>Space</i>• <i>NASA things</i>

Learning about STEM	3	<p>+ Forty-three participants stated they learned the most about science content. Specific content included physical science (sound, satellites and communication), Earth and space science (solar system, planets, microgravity, stars), and biology (effects of space on the human body). Three participants stated they learned the most about math.</p> <p>Eleven participants stated they learned about science concepts including space, constellations, microgravity, and some of the effects of space on the human body.</p> <ul style="list-style-type: none"> • <i>We learned about microgravity and space travel</i> • <i>I learned about microgravity and how it effects our bodies</i> <p>Four participants wrote they learned math</p> <ul style="list-style-type: none"> • <i>Learned about math</i> • <i>Did math problems</i>
Learning about STEM	4	<p>+ Eleven participants stated they learned the most about science concepts. Specific concept listed were the animals, aerodynamics, and the solar system.</p> <p>Fifteen participants wrote the part of the SEMAA they liked best was learning science.</p> <ul style="list-style-type: none"> • <i>Learning about science</i> • <i>I liked learning about all the types of training astronaut did</i> <p>Two participants stated they learned math</p> <ul style="list-style-type: none"> • <i>Did math equations</i> • <i>Our math was all mental math</i>
Learning about STEM	5	<p>+ Three participants stated they learned the most about space science concepts (e.g. planets, microgravity).</p> <p>One participant wrote</p> <ul style="list-style-type: none"> • <i>I learned that one billion suns can fit in VY-Canis Majoris. I will remember that because that is a lot</i>

Learning about STEM	6	+ Fourteen participants stated they learned the most about science concepts (e.g. rocketry, astronomy, and the solar system).
		One participant stated she learned the most about math.
Learning about STEM	7	+ Nine site seven participants stated they learned the most about science concepts (e.g. weather, water filtration, aerodynamics, how space effects the human body).
		<ul style="list-style-type: none"> • <i>Learned about the solar system and astronomy</i> • <i>In SEMAA we dissected a cow heart and did exercise, and studied with microscopes to understand how our bodies change and adapt in space rather than on Earth</i>
Doing STEM	1	+ Seventeen participants stated they liked the hands-on science and engineering activities.
		<ul style="list-style-type: none"> • <i>You can do experiments</i> • <i>The STEM lab</i> • <i>Building the car</i>
Doing STEM	2	+ Twenty-one participants stated they liked the hands-on science, technology, and engineering activities.
		<ul style="list-style-type: none"> • <i>I got to build with lego and different machines</i> • <i>Doing experiments</i> • <i>Building and programming</i>
Doing STEM	3	+ Twenty-four participants stated they liked the hands-on science, technology, and engineering activities.
		<ul style="list-style-type: none"> • <i>I like the experiments that we do</i> • <i>The hands-on activities</i> • <i>Making stuff</i> <p>One participant stated she liked learning more about math. Additionally, one participant stated she liked going on the fieldtrip to a g mission the best.</p>

Doing STEM	4	+ Five participants stated what they liked best about the SEMAA was the hands-on science activities. <ul style="list-style-type: none"> • <i>The experiments</i> • <i>We did a lot of hands-on experiences</i> • <i>Great experiments</i> <p>One participant wrote the part of the SEMAA they liked best was learning about animals. Additionally, three participants stated they liked going on the fieldtrips to a science museum.</p>
Doing STEM	5	+ Four participants stated what they liked best about the SEMAA was the hands-on science and technology activities. <ul style="list-style-type: none"> • <i>The hands-on things</i> • <i>Ozobots</i> • <i>Lego Mindstorms</i>
Doing STEM	6	+ Fifteen participants stated that what they like best about the SEMAA was the hands-on science activities. <ul style="list-style-type: none"> • <i>Making planes</i> • <i>The hands-on activities</i> • <i>All the experiments</i> <p>One participant stated she like "learning about the planets." Another participant wrote the part he liked best about the SEMAA was visiting the planetarium.</p> <ul style="list-style-type: none"> • <i>Learned about aerodynamics, astronomy, and the solar system</i>
Doing STEM	7	+ Seven participants stated what they liked best about the SEMAA was the hands-on science, technology, and engineering activities. <ul style="list-style-type: none"> • <i>I like that most activities are hands-on which make things more interesting</i> • <i>Build a robot and have the fight</i> • <i>Engineering projects</i> • <i>In SEMAA we dissected a cow heart and did exercise, and studied with microscopes</i>

APPENDIX E

IRB APPROVAL

Oklahoma State University Institutional Review Board

Date: Thursday, April 30, 2015 IRB

Application No ED1562

Proposal Title: NASA Science Engineering Mathematics and Aerospace
Academy Research Study

Reviewed and Expedited
Processed as:

Status Recommended by Reviewer(s): Approved Protocol Expires: 4/29/2016

Principal Investigator(s)

Catherine Graves 311 Cordell North

Toni Ivey 226 Willard Hall

Stillwater, OK 74078

Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46. The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone:405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,



Hugh Cretham
Chair
Institutional Review Board

VITA

Catherine Elizabeth Graves

Candidate for the Degree of

Doctor of Philosophy

Thesis: CASE STUDY OF THE SCIENCE, ENGINEERING, MATHEMATICS, AND
AEROSPACE ACADEMY: PARTICIPANT AND PARENTAL
PERCEPTIONS

Major Field: Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Education, Science Education option at Oklahoma State University, Stillwater, Oklahoma in July, 2016.

Completed the requirements for the Master of Science in Biology and Education at University of Toledo, Toledo, Ohio in 2000.

Completed the requirements for the Bachelor of Science in Education at Bowling Green State University, Bowling Green, Ohio in 1997.

Completed the requirements for the Bachelor of Science in Biology at Bowling Green State University, Bowling Green, Ohio in 1995.

Experience:

Senior Project Coordinator, Technical Lead for Evaluation, NASA Glenn
Research Center, July 2015 – Present, Paragon TEC, Inc

Lead Education Specialist, NASA Education Projects, June 2004 – July 2015,
Oklahoma State University

Science Teacher, Lorain Middle School, August 2000 – June 2004, Lorain City
Schools

Science Teacher, Bowling Green High School, December 1997 – June 2000,
Bowling Green City Schools

Professional Memberships:

Golden Key International Honor Society

Phi Kappa Phi Honor Society

Kappa Delta Pi International Honor Society